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The Impact of COVID-19 Pandemic on Sustainable Development Goals

Edited by
Ştefan Cristian Gherghina and Liliana Nicoleta Simionescu

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Contents

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Editorial

The Impact of COVID-19 Pandemic on Sustainable Development Goals

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In December 2019, a new kind of coronavirus, termed novel coronavirus (2019-nCoV or COVID-19), was noticed in Wuhan, China, and has now rapidly spread throughout China and the world [1]. On 30 January 2020, the World Health Organization's (WHO) Director-General designated the novel coronavirus outbreak a public health emergency of international concern (PHEIC), and on 11 March 2020, the WHO officially recognized the COVID-19 outbreak as a pandemic [2]. Throughout the COVID-19 pandemic's severe urgency stage, which spanned three years, there was an extended state of emergency, with high rates of death and burden on health care systems [3]. The COVID-19 pandemic caused substantial death rate rises in 2020 on a scale not experienced since World War II in Western Europe or since the dissolution of the Soviet Union in Eastern Europe [4]. On 28 September 2020, the reported mortality toll from COVID-19 reached one million deaths globally, and on 26 January 2021, the number of registered COVID-19 cases exceeded 100 million [5]. Furthermore, as of 17 December 2023, over 772 million confirmed cases and almost 7 million deaths have been reported globally [6]. The pandemic exposed a lack of emergency preparedness in the healthcare sector, particularly in OECD nations that had been expected to be more resilient [7]. The dramatic rise in mortality connected with COVID-19 was reflected in lower life expectancy around the world [8]. In this regard, the GBD 2021 Demographics Collaborators [9] reported that global life expectancy at birth fell by 1.6 years from 2019 to 2021, whereas Cao et al. [10] estimated a decrease of 1.8 years.

The 2030 Agenda for Sustainable Development [11], adopted by all United Nations Member States in 2015, lays out a common vision for stability and growth for individuals and the environment, with 17 Sustainable Development Goals (SDGs) and 169 objectives at its core. Unfortunately, when the SDG Decade of Action commenced in 2020, COVID-19 had already emerged as a global outbreak and impeded accomplishments toward the SDGs [12]. The global pandemic has since delayed advancement toward SDGs, worsened geographical disparities, limited connections, and boosted aversion to globalization because of curfews and geopolitical issues [13]. The global outbreak had an immediate effect on medical services, human health, and wellness, and pandemic containment had an indirect impact on wealth, schooling, food availability, and the ecosystem, particularly through social regulations, business and school closures, and travel bans abroad [14]. The COVID-19 pandemic hindered achievement of the SDGs by 8.2%, with socio-economic sustainability dropping by 18.1% and environmental sustainability improving by 5.1%, in contrast to normal operational patterns [15]. Thore [16] observed that the global outbreak had an even greater effect on nations that had already overlooked and neglected human well-being deficits in fields such as senior care, personal security, and sanitation. Moreover, the pandemic deepened existing disparities, triggering higher demonstrations of racism, xenophobia, extremism, polarizing populism, protectionism, misinformation, and disinformation, along with the unethical use of digital technologies [17]. Naidoo and Fisher [18] estimated it will be improbable to achieve two-thirds of the SDGs. On a global scale, Elsamadony et al. [19] noticed that the most harmed goals during the pandemic were

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inequality (Goal 5) and economy (Goal 8). In a similar vein, Shuai et al. [20] emphasized that SDGs pertaining to economic growth have been affected the most severely, including SDG 8 (Decent Work and Economic Growth) and SDG 2 (Zero Hunger), whereas SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land) were enhanced due to limited human interactions during the period of the pandemic. Specifically, the pandemic-related economic collapse increased the number of people living in severe poverty to around 119 and 124 million in 2020. The crisis heightened gaps, leading to a drop of 255 million full-time employment in 2020 and 101 million children and young people falling under the minimal reading competency level [21]. The global outbreak exacerbated existing inequities within and between countries, inflicting havoc on the poorest individuals and nations and undermining advances reached in lowering income disparities preceding the financial crisis [22]. Hence, the fundamental objective of "leave no one behind" has been undermined by expanding disparities [23]. As of April 2020, the COVID-19 pandemic has had major effects on about 1.6 billion workers in the informal economy, triggering a 60% drop in their incomes [24].

Because of COVID-19's elevated propagation velocity and the risk that asymptomatic or presymptomatic people could be diseased, several nations implemented lockdown measures to reverse exponential disease transmission patterns [25]. The COVID-19 pandemic has transformed working from home into a common practice for countless employees, pushing many workers and businesses to shift to online work for the first time and with no prior planning [26]. Additionally, COVID-19 lockdowns have led to global school suspensions, mandating virtual learning (home schooling) as a result [27]. However, stay-at-home regulations to fulfill social isolation demands have been shown to have a detrimental effect on overall mental and physical wellness, as well as an upsurge in the prevalence of physical and mental health disorders [28]. The surge in domestic violence throughout the worldwide outbreak additionally highlights the significance of gender equality and women's empowerment (SDG 5 and SDG 10) [29]. On the other hand, a sharp decrease in carbon emissions has occurred, since nearly all industries, means of transport, and other enterprises were forced to cease their operations [30]. It was estimated that by early April 2020, daily global carbon dioxide emissions would have decreased by −17% from average 2019 levels [31].

Moreover, the COVID-19 pandemic led to the most dramatic worldwide economic collapse in almost a century. In 2020, 90 percent of nations witnessed economic downturns, the worldwide economy contracted by 3 percent, and global poverty soared for the first time in a generation [32]. The pandemic was projected to force 97 million more individuals to live on less than $1.90 per day in 2021, while 163 million more would live on less than $5.50 per day [33]. Moreover, global external debt as a percentage of gross domestic product reached 114% in 2020, one of the highest levels seen since 1990 [34].

Given this background, this book comprises 11 papers published in this Special Issue, entitled "The Impact of the COVID-19 Pandemic on Sustainable Development Goals", and the aim of these was to generally focus on the broad implications of COVID-19 for SDG achievement. One article (Contribution 1) centered on how the COVID-19 pandemic has hampered and will still interfere with long-term progress toward the SDGs, as well as how collaborative development might compensate for interrupted progress while hastening recovery. The aim of another manuscript (Contribution 2) was to explore how COVID-19 hindered the initiatives and attempts of Flemish public entities to implement SDGs. Another paper (Contribution 3) concerned the case of Polish regions in particular in order to examine the influence of the COVID-19 pandemic on financial conditions and mortality. In addition, an article (Contribution 4) investigated how incorporating digital technologies improved economic performance during the COVID-19 pandemic. With reference to the workforce, the labor markets of European Union countries and the shifts that occurred before and during the spread of the pandemic were analyzed in another study (Contribution 5). In the same line of research, a different study (Contribution 6) evaluated the effect of the COVID-19 pandemic on the unemployed in Szczecin, Poland. The purpose of a subsequent paper

(Contribution 7) was to examine the impact of teleworking on employee well-being. Further investigations aimed to explore the effects of coronavirus on education. Because the COVID-19 period of virtual schooling provided significant insights for universities to consider in order to continue online instruction and support many more learners with university education, another paper (Contribution 8) investigated accounting students' perceptions of distance instruction in the Philippines. For the School of Engineering of the University of León, another study (Contribution 9) assessed student satisfaction in face-to-face and "forced" virtual environments during COVID-19. Other research (Contribution 10) focused on healthcare professionals in Turkey and investigated in what way the pharmaceutical industry's commitment to operating salesforce automation tools with customer relationship management and e-detailing components could offer a varied detailing and ongoing medical learning program during the pandemic. By focusing on the teaching staff of the Basque Country, Spain, another study (Contribution 11) investigated the feelings teachers experienced when conducting Emergency Remote Teaching while restricted to their residences.

In a nutshell, COVID-19 has postponed advances toward the SDGs until 2030, signaling to humanity that no individual is safe unless entire societies are secure. Thus, all states must establish long-term global partnerships in order to simultaneously achieve said SDGs [35]. Those involved in foreign relations must emphasize multilateral cooperation alongside transparent dialogue [36]. In this aim, the articles in this Special Issue can broaden our knowledge of the many implications of the COVID-19 pandemic on the Sustainable Development Goals while providing promising prospective research paths.

Author Contributions: Conceptualization, Ș.C.G. and L.N.S.; methodology, Ș.C.G. and L.N.S.; software, Ș.C.G. and L.N.S.; validation, Ș.C.G. and L.N.S.; formal analysis, Ș.C.G. and L.N.S.; investigation, Ș.C.G. and L.N.S.; resources, Ș.C.G. and L.N.S.; data curation, Ș.C.G. and L.N.S.; writing—original draft preparation, Ș.C.G. and L.N.S.; writing—review and editing, Ș.C.G. and L.N.S.; visualization, Ș.C.G. and L.N.S.; supervision, Ș.C.G. and L.N.S.; project administration, Ș.C.G. and L.N.S.; funding acquisition, Ș.C.G. and L.N.S. All authors have read and agreed to the published version of the manuscript.

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2. Mestdagh, B.; Sempiga, O.; Van Liedekerke, L. The Impact of External Shocks on the Sustainable Development Goals (SDGs): Linking the COVID-19 Pandemic to SDG Implementation at the Local Government Level. *Sustainability* **2023**, *15*, 6234. https://doi.org/10.3390/su15076234.
3. Brzozowska, K.; Gorzałczyńska-Koczkodaj, M.; Ociepa-Kicińska, E.; Pluskota, P. The Impact of the COVID-19 Pandemic on Financial Condition and Mortality in Polish Regions. *Sustainability* **2023**, *15*, 8993. https://doi.org/10.3390/su15118993.
4. Spulbar, C.; Anghel, L.C.; Birau, R.; Ermiș, S.I.; Treapăt, L.-M.; Mitroi, A.T. Digitalization as a Factor in Reducing Poverty and Its Implications in the Context of the COVID-19 Pandemic. *Sustainability* **2022**, *14*, 10667. https://doi.org/10.3390/su141710667.
5. Bieszk-Stolorz, B.; Dmytrów, K. Assessment of the Similarity of the Situation in the EU Labour Markets and Their Changes in the Face of the COVID-19 Pandemic. *Sustainability* **2022**, *14*, 3646. https://doi.org/10.3390/su14063646.
6. Bieszk-Stolorz, B.; Markowicz, I. The Impact of the COVID-19 Pandemic on the Situation of the Unemployed in Poland. A Study Using Survival Analysis Methods. *Sustainability* **2022**, *14*, 12677. https://doi.org/10.3390/su141912677.
7. Crawford, J. Working from Home, Telework, and Psychological Wellbeing? A Systematic Review. *Sustainability* **2022**, *14*, 11874. https://doi.org/10.3390/su141911874.
8. Abeysekera, I.; Sunga, E.; Gonzales, A.; David, R. The Effect of Cognitive Load on Learning Memory of Online Learning Accounting Students in the Philippines. *Sustainability* **2024**, *16*, 1686. https://doi.org/10.3390/su16041686.

9. Martínez-García, R.; Fraile-Fernández, F.J.; Búrdalo-Salcedo, G.; Castañón-García, A.M.; Fernández-Raga, M.; Palencia, C. Satisfaction Level of Engineering Students in Face-to-Face and Online Modalities under COVID-19—Case: School of Engineering of the University of León, Spain. *Sustainability* **2022**, *14*, 6269. https://doi.org/10.3390/su14106269.
10. Yılmaz Altuntaş, E.; Yalçın, E.C. COVID-19 Pandemic Learning: The Uprising of Remote Detailing in Pharmaceutical Sector Using Sales Force Automation and Its Sustainable Impact on Continuing Medical Education. *Sustainability* **2023**, *15*, 8955. https://doi.org/10.3390/su15118955.
11. Garitano, E.T.; Portillo Berasaluce, J.; de la Serna, A.L.; Arce Alonso, A. Emotions of Educators Conducting Emergency Remote Teaching during COVID-19 Confinement. *Sustainability* **2024**, *16*, 1456. https://doi.org/10.3390/su16041456.

References

1. Zhu, H.; Wei, L.; Niu, P. The novel coronavirus outbreak in Wuhan, China. *Glob. Health Res. Policy* **2020**, *5*, 6. [CrossRef] [PubMed]
2. World Health Organization. *A Timeline of WHO's COVID-19 Response in the WHO European Region*; World Health Organization: Geneva, Switzerland, 2022.
3. Heads of Medicines Agencies, European Medicines Agency. *COVID-19 Lessons Learned. Joint Report on the Response to the Public Health Emergency*; European Medicines Agency: Amsterdam, The Netherlands, 2023.
4. Aburto, J.M.; Schöley, J.; Kashnitsky, I.; Zhang, L.; Rahal, C.; Missov, T.I.; Mills, M.C.; Dowd, J.B.; Kashyap, R. Quantifying impacts of the COVID-19 pandemic through life-expectancy losses: A population-level study of 29 countries. *Int. J. Epidemiol.* **2022**, *51*, 63–74. [CrossRef] [PubMed]
5. David, J. Sencer CDC Museum: In Association with the Smithsonian Institution. In *CDC Museum COVID-19 Timeline*; Centers for Disease Control and Prevention: Atlanta, GA, USA, 2023.
6. World Health Organization. *COVID-19 Epidemiological Update*; World Health Organization: Geneva, Switzerland, 2023.
7. Sachs, J.; Schmidt-Traub, G.; Kroll, C.; Lafortune, G.; Fuller, G.; Woelm, F. *The Sustainable Development Goals and COVID-19*; Cambridge University Press: Cambridge, UK, 2020.
8. Schöley, J.; Aburto, J.M.; Kashnitsky, I.; Kniffka, M.S.; Zhang, L.; Jaadla, H.; Dowd, J.B.; Kashyap, R. Life expectancy changes since COVID-19. *Nat. Hum. Behav.* **2022**, *6*, 1649–1659. [CrossRef]
9. GBD 2021 Demographics Collaborators. Global age-sex-specific mortality, life expectancy, and population estimates in 204 countries and territories and 811 subnational locations, 1950–2021, and the impact of the COVID-19 pandemic: A comprehensive demographic analysis for the Global Burden of Disease Study 2021. *Lancet* **2024**, *403*, 1989–2056. [CrossRef]
10. Cao, G.; Liu, J.; Liu, M.; Liang, W. Effects of the COVID-19 pandemic on life expectancy at birth at the global, regional, and national levels: A joinpoint time-series analysis. *J. Glob. Health* **2023**, *13*, 06042. [CrossRef] [PubMed]
11. United Nations. *Transforming Our World: The 2030 Agenda for Sustainable Development*; A/RES/70/1; United Nations: New York, NY, USA, 2015.
12. Yuan, H.; Wang, X.; Gao, L.; Wang, T.; Liu, B.; Fang, D.; Gao, Y. Progress towards the Sustainable Development Goals has been slowed by indirect effects of the COVID-19 pandemic. *Commun. Earth Environ.* **2023**, *4*, 184. [CrossRef]
13. Zhao, W.; Yin, C.; Hua, T.; Meadows, M.E.; Li, Y.; Liu, Y.; Cherubini, F.; Pereira, P.; Fu, B. Achieving the Sustainable Development Goals in the post-pandemic era. *Humanit. Soc. Sci. Commun.* **2022**, *9*, 258. [CrossRef] [PubMed]
14. Lekagul, A.; Chattong, A.; Rueangsom, P.; Waleewong, O.; Tangcharoensathien, V. Multi-dimensional impacts of Coronavirus disease 2019 pandemic on Sustainable Development Goal achievement. *Glob. Health* **2022**, *18*, 65. [CrossRef] [PubMed]
15. Li, C.; Deng, Z.; Wang, Z.; Hu, Y.; Wang, L.; Yu, S.; Li, W.; Shi, Z.; Bryan, B.A. Responses to the COVID-19 pandemic have impeded progress towards the Sustainable Development Goals. *Commun. Earth Environ.* **2023**, *4*, 252. [CrossRef]
16. Thore, S. Sustainable development goal deficits and the Covid 19 pandemic. *Technol. Forecast. Soc.* **2022**, *125*, 121204. [CrossRef]
17. United Nations. *The SDGs in Time of Crisis: A Sustainable, Inclusive and Resilient Recovery from COVID-19 as an Opportunity to Realize the SDGs*; United Nations: New York, NY, USA, 2021.
18. Naidoo, R.; Fisher, B. Reset Sustainable Development Goals for a pandemic world. *Nature* **2020**, *583*, 198–201. [CrossRef] [PubMed]
19. Elsamadony, M.; Fujii, M.; Ryo, M.; Nerini, F.F.; Kakinuma, K.; Kanae, S. Preliminary quantitative assessment of the multidimensional impact of the COVID-19 pandemic on Sustainable Development Goals. *J. Clean. Prod.* **2022**, *372*, 133812. [CrossRef] [PubMed]
20. Shuai, C.; Zhao, B.; Chen, X.; Liu, J.; Zheng, C.; Qu, S.; Zou, J.-P.; Xu, M. Quantifying the impacts of COVID-19 on Sustainable Development Goals using machine learning models. *Fundam. Res.* 2022, *in press*. [CrossRef]
21. United Nations. *Progress towards the Sustainable Development Goals*; United Nations: New York, NY, USA, 2021.
22. United Nations. *The Sustainable Development Goals Report*; United Nations: New York, NY, USA, 2021.
23. Shulla, K.; Voigt, B.-F.; Cibian, S.; Scandone, G.; Martinez, E.; Nelkovski, F.; Salehi, P. Effects of COVID-19 on the Sustainable Development Goals (SDGs). *Discov. Sustain.* **2021**, *2*, 15. [CrossRef] [PubMed]
24. International Labour Organization. *Impact of Lockdown Measures on the Informal Economy*; International Labour Organization: Geneva, Switzerland, 2020.

25. Haider, N.; Osman, A.Y.; Gadzekpo, A.; Akipede, G.O.; Asogun, D.; Ansumana, R.; Lessells, R.J.; Khan, P.; Hamid, M.A.; Yeboah-Manu, D.; et al. Lockdown measures in response to COVID-19 in nine sub-Saharan African countries. *BMJ Glob. Health* **2020**, *5*, e003319. [CrossRef] [PubMed]
26. Galanti, T.; Guidetti, G.; Mazzei, E.; Zappala, S.; Toscano, F. Work From Home During the COVID-19 Outbreak. The Impact on Employees' Remote Work Productivity, Engagement, and Stress. *J. Occup. Environ. Med.* **2021**, *63*, e426–e432. [CrossRef] [PubMed]
27. Morse, A.R.; Banfield, M.; Batterham, P.J.; Gulliver, A.; McCallum, S.; Cherbuin, N.; Farrer, L.M.; Calear, A.L. What could we do differently next time? Australian parents' experiences of the short-term and long-term impacts of home schooling during the COVID-19 pandemic. *BMC Public Health Vol.* **2022**, *22*, 80. [CrossRef] [PubMed]
28. Xiao, Y.; Becerik-Gerber, B.; Lucas, G.; Roll, S.C. Impacts of Working From Home During COVID-19 Pandemic on Physical and Mental Well-Being of Office Workstation Users. *J. Occup. Environ. Med.* **2021**, *63*, 181–190. [CrossRef]
29. Nundy, S.; Ghosh, A.; Mesloub, A.; Albaqawy, G.A.; Alnaim, M.M. Impact of COVID-19 pandemic on socio-economic, energy-environment and transport sector globally and sustainable development goal (SDG). *J. Clean. Prod.* **2021**, *312*, 127705. [CrossRef]
30. Bhat, S.A.; Bashir, O.; Bilal, M.; Ishaq, A.; Dar, M.U.D.; Kumar, R.; Bhat, R.A.; Sher, F. Impact of COVID-related lockdowns on environmental and climate change scenarios. *Environ. Res.* **2021**, *195*, 110839. [CrossRef]
31. Quéré, C.L.; Jackson, R.B.; Jones, M.W.; Smith, A.J.P.; Abernethy, S.; Andrew, R.M.; De-Gol, A.J.; Willis, D.R.; Shan, Y.; Canadell, J.G.; et al. Temporary reduction in daily global CO_2 emissions during the COVID-19 forced confinement. *Nat. Clim. Chang.* **2020**, *10*, 647–653. [CrossRef]
32. International Bank for Reconstruction and Development/The World Bank. *World Development Report 2022: Finance for an Equitable Recovery*; The World Bank: Washington, DC, USA, 2022.
33. Sánchez-Páramo, C.; Hill, R.; Mahler, D.G.; Narayan, A.; Yonzan, N. *COVID-19 Leaves a Legacy of Rising Poverty and Widening Inequality*; 2021. Available online: https://blogs.worldbank.org/en/developmenttalk/covid-19-leaves-legacy-rising-poverty-and-widening-inequality (accessed on 1 June 2024).
34. Miningou, É.W. *Does COVID-19-Related Debt Affect Government Expenditure on Education?* The World Bank: Washington, DC, USA, 2023.
35. Qadeer, A.; Anis, M.; Ajmal, Z.; Kirsten, K.L.; Usman, M.; Khosa, R.R.; Liu, M.; Jiang, X.; Zhao, X. Sustainable development goals under threat? Multidimensional impact of COVID-19 on our planet and society outweigh short term global pollution reduction. *Sustain. Cities Soc.* **2022**, *83*, 103962. [CrossRef] [PubMed]
36. Srinivas, J.; Kolloju, N.; Singh, A.; Naveen, S.; Naresh, S. The COVID-19 Pandemic and Its Impact on Sustainable Development Goals-2030. *J. Knowl. Econ.* **2024**. [CrossRef]

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Article

Sustainable Development Goal Attainment in the Wake of COVID-19: Simulating an Ambitious Policy Push

Taylor Hanna [1], Barry B. Hughes [1], Mohammod T. Irfan [1], David K. Bohl [1], José Solórzano [1], Babatunde Abidoye [2], Laurel Patterson [2] and Jonathan D. Moyer [1,*]

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Abstract: Even before the COVID-19 pandemic, the world was not on course to meet key Sustainable Development Goals (SDGs) including SDG 1 (No Poverty) and SDG 2 (Zero Hunger). Some significant degree of additional effort was needed before the pandemic, and the challenge is now greater. Analyzing the prospects for meeting these goals requires attention to the combined effects of the pandemic and such additional impetus. This article assesses the impact of the COVID-19 pandemic on progress toward the SDGs and explores strategies to recover and accelerate development. Utilizing the International Futures (IFs) forecasting system and recognizing the near impossibility of meeting the goals by 2030, three scenarios are examined through to 2050: A pre-COVID-19 trajectory (*No COVID-19*), the current path influenced by the pandemic (*Current Path*), and a transformative SDG-focused approach prioritizing key policy strategies to accelerate outcomes (*SDG Push*). The pandemic led to a rise in extreme poverty and hunger, with recovery projected to be slow. The *SDG Push* scenario effectively addresses this, surpassing the *Current Path* and achieving significant global improvements in poverty, malnutrition, and human development by 2050 even relative to the *No COVID-19* path. The findings emphasize the need for integrated, transformative actions to propel sustainable development.

Keywords: COVID-19; sustainable development goals; human development; poverty; hunger; forecasting human development

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1. Introduction

The Sustainable Development Goals (SDGs) serve as the global framework for driving progress toward accelerating human development. Even at their inception, the SDGs were understood as highly ambitious, and progress since 2015 has not been on pace to achieve the goals by the target date of 2030 [1]. In 2020, the outbreak of the COVID-19 pandemic led to not only more than 1.8 million deaths [2] but also shutdowns and mitigation measures worldwide, slowing economic growth. Inequality increased both across and within developing countries [3,4], and for the first time in decades, the global poverty rate increased, signaling a reversal of recent progress. While the economy has rebounded, growth has settled back to a positive but moderate pace. This along with the many other effects of COVID-19 is expected to have implications for progress toward SDG achievement across the SDG agenda [5–7].

Previous work explored how COVID-19 would impact the SDGs, with some studies broadly assessing the literature on developmental outcomes [5,8] or focusing on short-term quantitative outcomes across a wide range of indicators [9]. This research finds that the pandemic has indeed negatively affected many SDGs [8,10], setting overall progress back 8.2 percent in its first year [6]. Other research has focused on specific SDG indicators,

including global poverty [3,11–16], food affordability [17], food insecurity [14], hunger [18], and maternal and child health and undernutrition [19,20]. This literature is also focused on effects in the first few years after COVID-19. Cooper et al. [21] project moderate and severe food insecurity through to 2030, though not in comparison to a baseline without the pandemic. Other work projects the outcomes from an integrated development push on SDG achievement but without considering the effect of COVID-19 [22].

Now, more than halfway through the SDG horizon and several years out of the initial COVID-19 outbreak, we fill gaps in the literature by reassessing progress and taking stock of the path we are currently on while assessing prospects for accelerating development. This paper advances the understanding of how the COVID-19 pandemic has affected progress toward achieving the first two SDGs (SDG 1: No Poverty; SDG 2: Zero Hunger) and improving the Human Development Index (HDI), which summarizes progress towards several of the SDGs.

It then turns to explore how an ambitious push toward global development might make up for that setback. Previous work has proposed strategies for global responses that push beyond addressing the pandemic's immediate effects [23], ranking response strategies in relation to the SDGs [24], and even mapped out potential future scenarios and how SDG progress may be positively or negatively affected [25]. There remains a gap in the literature related to quantitatively assessing responses to the generally accepted developmental setback caused by COVID-19 and how these responses might alter development in the long run. We fill this gap by exploring alternative multidimensional policy strategies that can improve long-term human wellbeing in spite of the pandemic.

We find that even prior to the COVID-19 outbreak, the world was not on track to achieve the SDG agenda, reinforcing findings in the literature. We find that the effect of COVID-19 had an immediate adverse impact on progress toward the SDGs and that the shock will cast a long shadow, setting back progress for decades from where it would have otherwise been. In addition, we find that significant improvements can be made to the development trajectory that improve SDG attainment if a set of policy priorities are pursued.

COVID-19 will not be the last shock to challenge global development, and it will be important to better understand how to overcome both it and challenges in the future. Therefore, one of our scenarios explores how a substantial and transformative agenda could accelerate progress toward the SDG targets by midcentury. This offers insight into how integrated action across policy areas can further sustainable development and set the world on a new path forward. We find that this scenario, while it does not result in achieving the Goals on time in all countries, is successful in quickly making up for the damage inflicted by COVID-19 and further in propelling progress for decades to come.

This paper proceeds by first elaborating the methods used to drive the analysis with a particular emphasis on the structure of the modeling framework and scenario assumptions. Next, we present the results, highlighting how the COVID-19 pandemic is likely to change long-term development outcomes and what a successful set of policy strategies can do to further improve development outcomes beyond our *Current Path* of development. Finally, we discuss these findings and highlight methodological challenges as well as some implications of the policy strategies that are modeled.

2. Materials and Methods

2.1. International Futures

This study uses the International Futures (IFs) forecasting system for forecasting and scenario analysis. IFs is an integrated assessment modeling platform with representation of 188 countries and capability to forecast out to 2100. It features numerous endogenized and interconnected sub-models with coverage of the following systems: agriculture [26], economics, education [27], energy, environment [28], demographics, governance [29,30], health [31], infrastructure [32], international politics [33], and technology. IFs is open-source and is free to use online or to download for offline use. The following sections describe key

areas of the model for this work, but extensive model information and documentation is available for further detail [34].

IFs forecasts patterns of long-term economic growth using a recursive dynamic general equilibrium-seeking structure with a Cobb–Douglas production function and an endogenously dynamic Solow residual. Six capital sectors, labor by skill level, and the endogenously driven productivity term are shaped by forces within each of the 188 countries but also by international trade, official development assistance, foreign direct investment flows, and international migration with associated remittance patterns. A social accounting matrix structure accounts for flows across economic sectors and between households, firms, and governments and with the rest of the world. Representation of government finance within the social accounting matrix includes specification of revenues from domestic taxation streams and foreign assistance, while identified expenditures include transfer payments and direct spending in military, health, education, research and development (R&D), infrastructure, and residual categories. Other core features of the IFs model include partial-equilibrium agriculture and energy models physically elaborating those sectors of the total economy, an infrastructure model with access to information and communication technologies, electricity, water and sanitation, and paved roads [32], as well as well as an education model which simulates the grade-level flow of students through the education system and the pattern of educational attainment across adult life spans.

Although the IFs system forecasts variables related to selected targets of all SDG goals, we focus here on three core outcome indicators in IFs: poverty, undernutrition, and the HDI, each described below.

2.1.1. Poverty

Poverty rates in IFs are initialized using data from the World Bank [35], which come originally from household surveys and are driven by the model's economic growth and inequality models [36]. The social accounting matrix structure of the economic model tracks financial flows to and from households resulting from labor earnings and transfers in interaction with firms and governments. Resultant disposable income is allocated to consumption or savings based on long-term country development patterns, demographic structure, and sectoral prices and interest rates. Poverty rates are estimated at per-capita household consumption levels assuming a log-normal distribution of household income, the shape of which is affected by changes to the Gini coefficient.

For this analysis, we focus on extreme poverty, using the recently updated international poverty line of USD 2.15/day in 2017 US dollars at purchasing power parity. For countries lacking data values, the model estimates initial values using a cross-sectional function with GDP per capita.

2.1.2. Malnutrition

Building on variables from and interactions across the demographic, general equilibrium economic, and partial-equilibrium agriculture models, IFs forecasts the prevalence of malnutrition as a function of available calories per capita, a coefficient of variation, and a minimum dietary energy requirement. The partial-equilibrium agriculture sub-model represents crop, meat, and fish production and trade and therefore calorie and protein availability [26], while the economic model generates consumption potential and calorie demand per capita as functions of GDP per capita and food prices. Demographics shape total country demand levels. As with the income that shapes poverty levels, access to calories is assumed to be distributed log-normally. The shape of the distribution is determined by the caloric coefficient of variation, which is driven by income growth, inequality, and social inequality, as represented by female labor participation and the youth dependency ratio. Data from the FAO are used to initialize the prevalence of malnutrition as well as calories per capita, the coefficient of variation, and the minimum daily energy requirement [26].

This analysis is focused on population-wide malnutrition to provide the broadest picture of progress toward eliminating hunger. It does not account for differing levels of hunger by gender or for young children, measures of which are also available in IFs.

2.1.3. Human Development Index

The HDI has been designed and maintained by the United Nations Development Programme (UNDP) to measure general levels of human development in all countries across three basic dimensions—health, education, and living standards. The UNDP replaced an earlier and simpler version of the HDI with a more refined version in 2010 [37]. This index is a geometric mean of three normalized sub-indices, representing (1) life expectancy at birth, (2) an average of mean years of schooling completed at age 25 or older and the expected years of schooling upon entry to education, and (3) a logarithm of gross national income per capita at purchasing power parity (for which IFs substitutes gross domestic product at PPP). Data from the UNDP initialize the HDI values for each country in the 2019 base year of IFs [35].

Forecasts of the HDI in IFs are driven by several sub-models, especially the demographic, health, education, and economic models. The health model produces the life expectancy index. This model, drawing on data and approaches of the Global Burden of Disease project [38], represents 15 causes of age- and sex-specific mortality across communicable, non-communicable, and accident and injury categories, thereby providing the basis for the computation of life expectancy. The education model represents year-specific entry into and flow through primary, lower-secondary, upper-secondary, and tertiary education; the progression through these levels feeds the years of schooling attained by population cohorts at post-educational ages, and the demographic model carries age-specific education through the variable life spans of cohort members. The economic and demographic models determine GDP at PPP.

2.2. Scenarios

We explore three scenarios aimed at evaluating where we are in terms of progress toward the SDGs and how we can collectively begin to narrow the gap between the road we are on and one that achieves the SDG agenda. These scenarios are modified from a set of four scenarios originally produced in 2020 and 2021 [39]. They have since been updated and modified to reflect recent data and the literature and run in an updated version of the IFs model. See Table 1 and following sections for a brief description of the three scenarios. Due to significant volatility in growth projections, Venezuela has been removed from the country set for this study.

Table 1. Description of scenarios used in this analysis.

Scenario Name	Description
No COVID-19	This scenario is a projection of the development path that the world was on prior to the COVID-19 outbreak.
Current Path	The *Current Path* reflects a baseline path of development in the future, including the effect of COVID-19.
SDG Push	This scenario simulates an integrated push toward SDG achievement through ambitious but achievable global interventions.

2.2.1. Current Path

The *Current Path* can be thought of as the baseline development path, with the impacts of COVID-19 but without additional major shocks and without transformative policy change. Using the interconnected sub-models in IFs, this scenario reflects a dynamic unfolding of development patterns within and across countries as well as sectors. The *Current Path* uses exogenously imposed GDP growth rate data and projections from the latest version of the IMF's World Economic Outlook through to 2025 [40]. The *Current Path* in IFs has been

used widely in academic and policy-oriented work to describe the path that the world is currently on [28,30,33].

2.2.2. No COVID-19

The *No COVID-19* scenario serves as a counterfactual, simulating the path we would be on had there been no COVID-19 outbreak, and thus allows us to make a rough assessment of the pandemic impact on the goal path. It leans on the same logic that informs the *Current Path* scenario but uses data and projections made prior to the outbreak of COVID-19. GDP growth rate projections from the IMF World Economic Report released in October 2019 [41] are imposed exogenously through to 2025.

2.2.3. SDG Push

In the wake of the pandemic, UNDP [23] put forth guidance on how the world might not only recover from the pandemic but move beyond recovery to accelerate progress toward the SDGs, defining four key areas of response: governance (building a new social contract), social protection (uprooting inequalities), green economy (rebalancing nature, climate, economy), and digital disruption and innovation (for speed and scale). This *SDG Push* scenario is based on initial work by Hughes et al. [39], oriented around the key areas outlined by UNDP, and further builds on work by Moyer and Hedden [42]. Specific details about the individual scenario interventions and parameter changes within IFs are available in the Supplementary Information.

In this scenario, the world pursues a set of policies that are designed to further sustainable development within planetary boundaries. Beginning with agricultural systems, sustainable development transformations include a shift away from meat-based diets towards plant-based diets, an increase in agricultural yields, and a reduction in loss (including losses in production, transmission, and consumption). In addition to the resulting increase in caloric availability, we also assume an increase in the equity of the distribution of calories, a simulation of cash transfer or food subsidy programs. Governments increasingly focus on programs that are core to human development, boosting spending on infrastructure, education, health (including a focus on family planning), and R&D while also increasing household transfers for welfare and pensions. Households benefit from expanded access to safe water, sanitation, information communication technology, and access to electricity as well as a reduction in traditional cookstoves. While government spending is important, governments in this scenario also improve the efficacy of this spending along with increasingly democratic institutions.

The scenario also simulates a transformation in energy systems by implementing a progressive carbon tax (to USD 200 per ton for OECD countries and USD 50 for non-OECD countries), a progressive reduction in energy demand (greater and more rapid in OECD countries than in non-OECD countries), and improvements in energy efficiency. Future coal production is constrained while renewable energy development and investment is accelerated. Further environmental policies reduce overall water demand relative to the *Current Path*, reduce urban air pollutants, and increase forested land.

The cumulative effect of these interventions is to make development less carbon intensive, more efficient, and less wasteful, while also pointing resources towards areas of investment that are crucial to multidimensional human wellbeing.

3. Results

The following sections include the results of all three scenarios across three key outcome indicators: the population in extreme poverty, the undernourished population, and the Human Development Index.

3.1. Poverty

The elimination of poverty is the first SDG (SDG 1) and highly connected to many of the others. Here, we focus on the international extreme poverty line of USD 2.15/day using

2017 US dollars at purchasing power parity. For this analysis, a country or region is said to have eliminated extreme poverty if the portion of the population living below the extreme poverty line falls below 3 percent. Full global results are available in Table 2.

Table 2. Results by scenario for SDG 1.1, using the percent of the population living on less than USD 2.15/day in 2017 US dollars. Source: IFs 8.10.

	2019	2019	2030	2030	2050	2050
Scenario	**Global Value**	**Countries Meeting Target**	**Global Value**	**Countries Meeting Target**	**Global Value**	**Countries Meeting Target**
No COVID-19	9	102	6.8	113	2.8	140
Current Path	9	102	7.5	107	3.1	139
SDG Push	9	102	6.6	117	1.5	159

Even prior to the outbreak of COVID-19, the world was not on track to meet SDG 1. Globally, an estimated 9 percent of the population (798 million people) lived in extreme poverty. Along the *No COVID-19* trajectory, poverty was expected to decline gradually. In this scenario, 6.6 percent of the population (578 million) would still live in extreme poverty in 2030. By 2050, the world at a global level just meets the target, with 2.8 percent of the world (269 million). At a country level, 102 countries are estimated to have already met the SDG target in 2019. By 2050, they would be joined by an additional 37 countries achieving the goal.

Along the *Current Path* affected by COVID-19, slowed economic growth resulted in an increase in poverty that could continue to affect progress toward SDG 1 for some time. In 2020 alone, we estimate an increase in the extreme poverty rate of 1 percentage point, reflecting nearly 80 million people pushed into extreme poverty by the pandemic in that year. This is a slightly greater effect than seen in previous work estimating the effect of COVID-19 on poverty using the IFs model (an estimated 73.9 million) [43] and the World Bank (estimating over 70 million) [44] and somewhat less than an estimates by Laborde et al. [14] in the most recent work by Mahler et al. [3], which finds a COVID-19-induced increase in extreme poverty of 1.2 percentage points (90 million). As the economy rebounded somewhat, we forecast poverty reductions after the initial year, but these improvements will remain slow and behind the *No COVID-19* counterfactual. By 2030, we project 7.5 percent of the population (635 million) in extreme poverty, still nearly 57 million more than the *No COVID-19* scenario in the same year (Figure 1). By 2050, the world just misses reaching the target, with 3.1 percent of the population (298 million) still in poverty.

In the *SDG Push*, poverty reduction accelerates as a result of interventions which boost growth and sustainable development. The poverty rate in the *SDG Push* scenario falls below that in the *No COVID-19* world by 2029. By 2030, the extreme poverty rate reaches 6.6 percent (499 million people in extreme poverty, which is 81 million fewer than in the *Current Path* headcount). Global extreme poverty falls below 3 percent by 2042, and by 2050, it falls to 1.5 percent (104 million, or 137 million fewer than in the *Current Path*). Along the *Current Path*, the global poverty rate is projected to remain above 3 percent through the horizon chosen for this analysis.

At a regional level, sub-Saharan Africa is home to the most people living in extreme poverty, with an estimated 404 million in 2019. But the effect of COVID-19 in the region was not as severe as in Central and Southern Asia, where 46 million people were pushed into extreme poverty due to COVID-19 in 2020, compared with just under 20 million in SSA (Figure 2). However, in the following years, the poverty difference in the CSA region is expected to fall, while in the SSA region it remains relatively steady, reflecting faster population growth in the sub-Saharan Africa region.

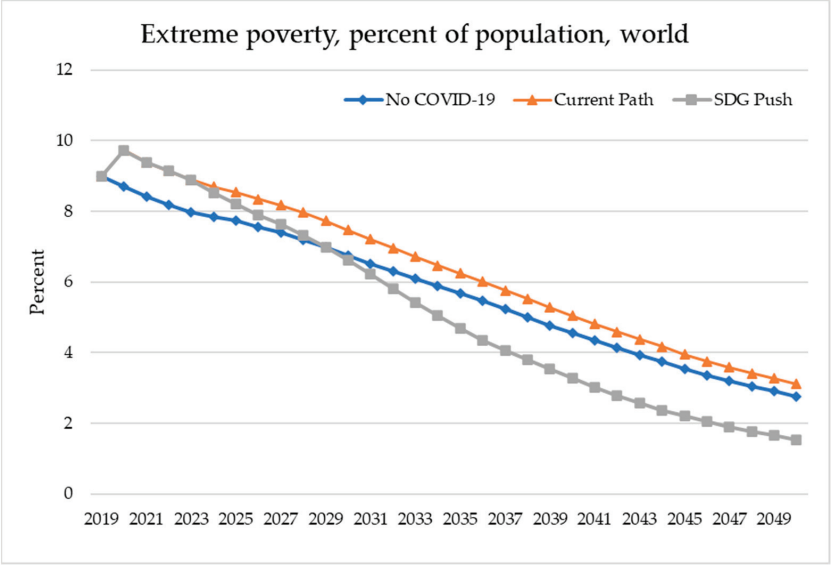


Figure 1. Percent of world population living on less than USD 2.15/day across scenarios. Source: IFs 8.10.

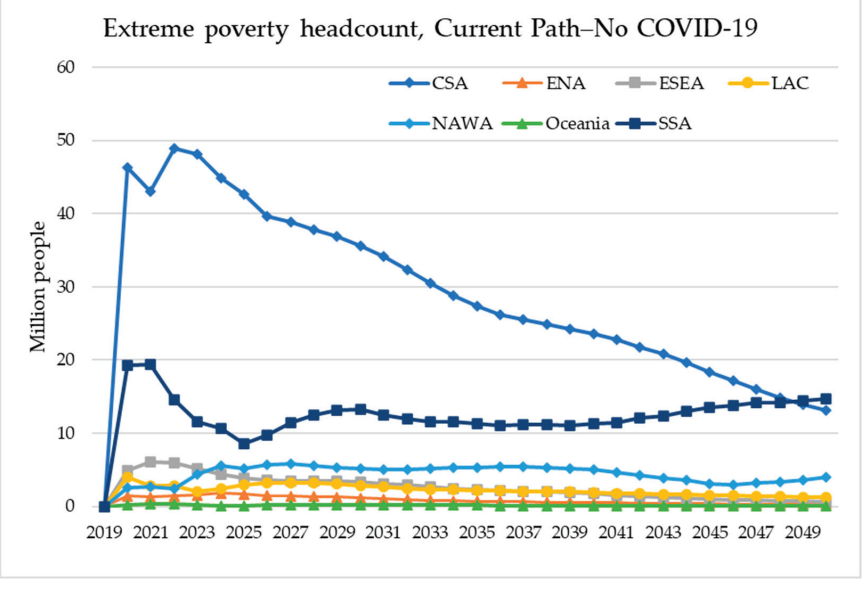
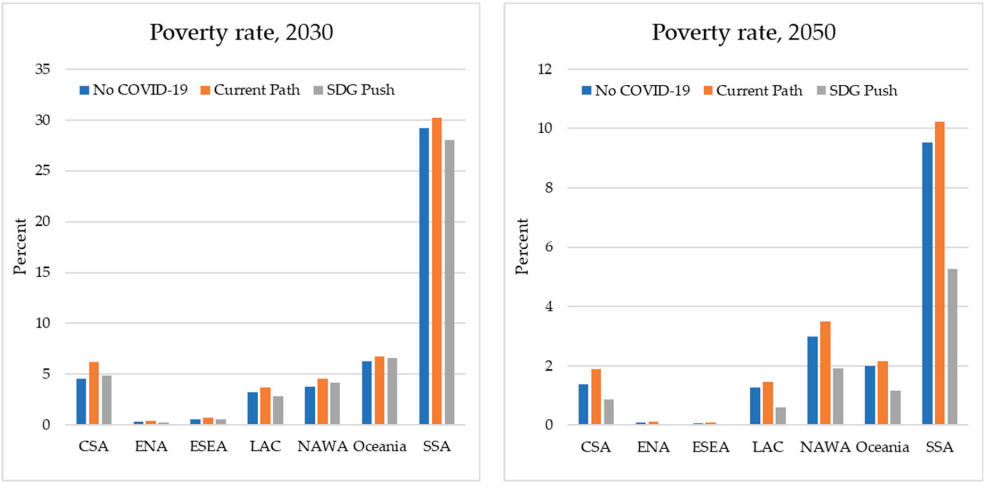


Figure 2. Difference between the number of people in poverty in the *Current Path* scenario and the *No COVID-19* scenario, by region. Source: IFs 8.10.

Figure 3 shows the rate of extreme poverty by region across all three scenarios in 2030 and 2050. The *SDG Push* begins to improve extreme poverty in regions where it is the most prevalent relative to the *Current Path*. In Europe and Northern America (ENA), Latin America and the Caribbean (LAC), and sub-Saharan Africa (SSA), the *SDG Push* makes up for the difference between the *Current Path* and *No COVID-19* scenarios by 2030, while in others—Central and Southern Asia (CSA), Eastern and South-Eastern Asia (ESEA),

Northern Africa and Western Asia (NAWA), and Oceania—the *SDG Push* still lags behind the *No COVID-19* scenario (Figure 3a).



(**a**) (**b**)

Figure 3. (**a**) Percent of population living on less than USD 2.15/day across scenarios by region in 2030. Source: IFs 8.10. (**b**) Percent of population living on less than USD 2.15/day across scenarios by region in 2050. Source: IFs 8.10.

By 2050, the *SDG Push* results in a significant decline in poverty rates across regions (Figure 3b). The SDG 1 goal of eliminating extreme poverty is achieved in all regions except SSA, where the poverty rate is still roughly half that projected along the *Current Path*.

There are various mechanisms in the SDG Push scenario that improve poverty outcomes relative to the Current Path. Government transfer programs boost incomes directly, while a number of interventions also work to alleviate poverty indirectly through improvements to the economy and human development. Family planning programs reduce the future investment required to achieve similar outcomes in areas of education and health, driving up human wellbeing and promoting productivity gains. Government spending is reoriented towards education, health, infrastructure, and R&D sectors, leading to greater long-term gains in multidimensional development. More efficient use of agricultural and energy resources also unlocks economic gains that facilitate reductions in poverty. This combination of direct and indirect interventions leads to a virtuous cycle towards the eradication of poverty.

3.2. Malnutrition

SDG 2 is to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" and targets range from ensuring food access for vulnerable populations to measures addressing agricultural investments and trade. For this analysis, we focus more narrowly on population-wide undernutrition. Full global results are available in Table 3.

Prior to the outbreak of COVID-19, we estimate that just under 8 percent of the global population (612 million people) suffered from malnutrition and that 67 countries had already met the SDG 2.1 goal of Zero Hunger. In a *No COVID-19* world, we project that malnutrition would continue to fall but would not achieve the goal at a global level. By 2030, still more than 5 percent of the population (445 million) would suffer from malnutrition, with 95 countries meeting the target of 3 percent. At a global level, the target would be

achieved by 2044, and by midcentury, the malnourished portion of the population would fall to 2.1 percent (203 million people).

Table 3. Results by scenario for SDG 2.1, using the percent of the population suffering from malnutrition. Source: IFs 8.10.

	2019	2019	2030	2030	2050	2050
Scenario	**Global Value**	**Countries Meeting Target**	**Global Value**	**Countries Meeting Target**	**Global Value**	**Countries Meeting Target**
No COVID-19	7.9	67	5.3	95	2.1	134
Current Path	7.9	67	5.4	89	2.2	133
SDG Push	7.9	67	4.3	106	0.8	164

The COVID-19 outbreak in 2020 reduced economic growth globally and increased both poverty and hunger. We estimate that in 2020, the rate of malnutrition increased by nearly 0.5 percentage points or 37 million people relative to a *No COVID-19* scenario (Figure 4). As the world recovered from that initial shock, hunger began to fall again but remained higher than it would have been otherwise. By 2030, 15 million more people are projected to be malnourished in the *Current Path* scenario compared to a *No COVID-19* world. By 2050, 6.6 million more people are still projected to suffer from malnutrition as a result of the shadow of the pandemic.

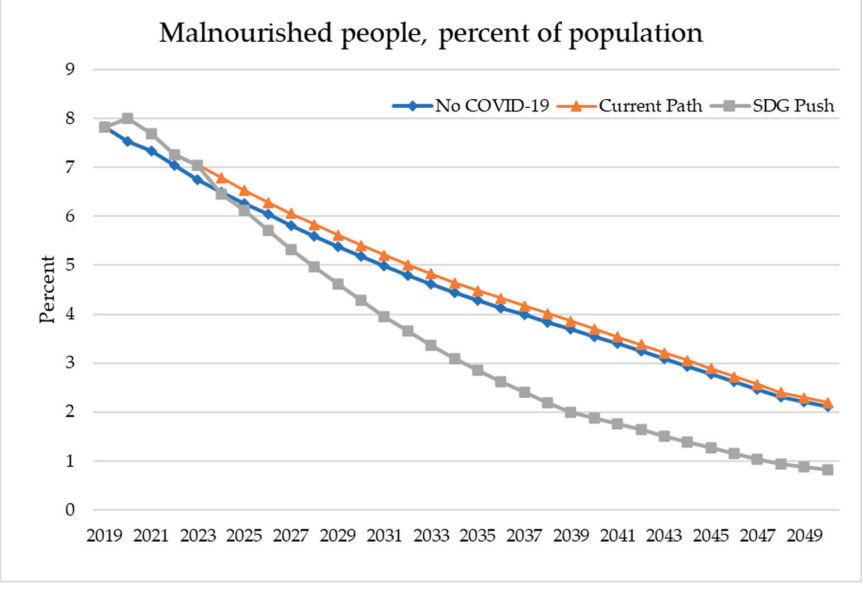


Figure 4. Percent of population malnourished, across the world, across scenarios. Source: IFs 8.10.

However, in an *SDG Push* world, multiple interventions are made to address hunger through both food supply and accessibility. By 2030, global malnutrition is reduced by 1.1 percentage points compared to the *Current Path*, and by 2035 the global malnutrition rate falls below 3 percent, ten years before it is projected to in the *Current Path*. By 2050, the malnourished population falls to 0.8 percent (77 million) and 164 countries have met the SDG 2.1 target—31 more than are projected to do so in the *Current Path*.

As in poverty, CSA is the region that experienced the largest increase in malnourishment due to COVID-19 (Figure 5). In 2020, the *Current Path* reflects an additional 22 million

people in the region pushed into malnutrition compared with a *No COVID-19* scenario (Figure 5), followed by SSA with just over 6 million. By 2050, the COVID-19 effect is not as large but still at nearly 5 million malnourished people, while the effect in SSA falls to meet that of many other regions. However, the effect also remains significant in NAWA, where over 2 million more people remain malnourished in 2050 in the *Current Path*.

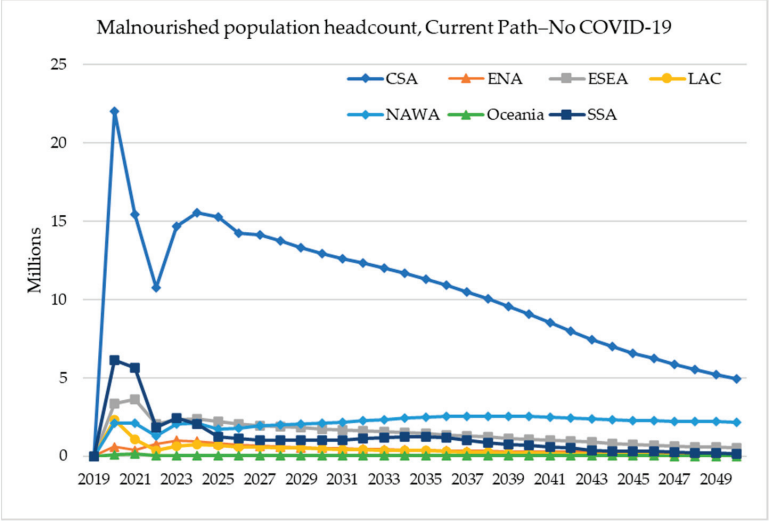
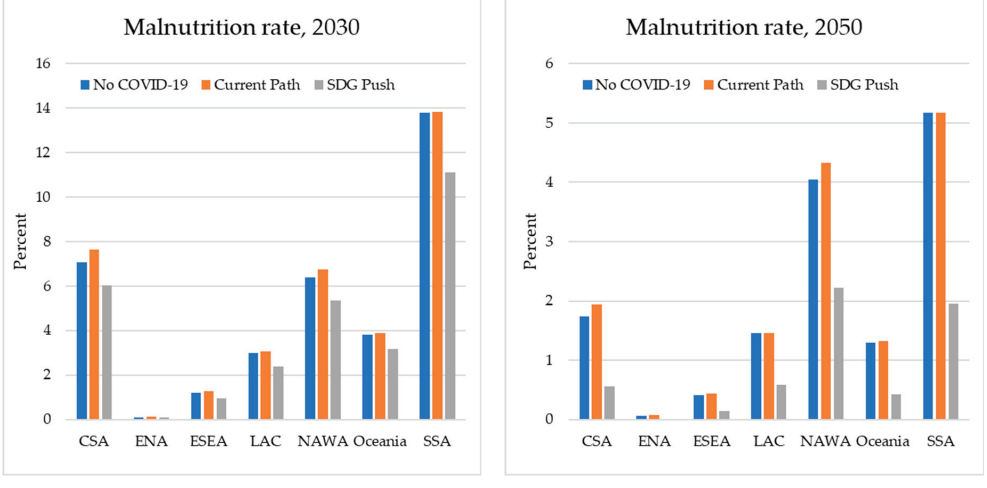


Figure 5. Difference between the number of people with malnutrition in the *Current Path* scenario and the *No COVID-19* scenario, by region. Source: IFs 8.10.

The *SDG Push* scenario simulates a gradual increase in equality of access to calories among other interventions. Even by 2030, the *SDG Push* results in a reduction in the rate of malnutrition below that in the *No COVID-19* scenario in all regions (Figure 6a).



(**a**) (**b**)

Figure 6. (**a**) Percent of population suffering from malnutrition across scenarios by region in 2030. Source: IFs 8.10. (**b**) Percent of population suffering from malnutrition scenarios by region in 2050. Source: IFs 8.10.

Figure 6b shows the same results by region for 2050. Both the NAWA and SSA regions are projected to still fail to achieve the SDG 2 goal of eliminating hunger by the middle of the century in both the *Current Path* and the *No COVID-19* scenario. In the *SDG Push*, the target is met in all regions, and the rate of malnutrition relative to the *Current Path* is cut by between one-half and two-thirds.

The mechanism at play driving this developmental indicator down in the *SDG Push* scenario relative to the *Current Path* is primarily within the agricultural sector, which sees advances in production and yield but also fewer losses from future climate change (as the *SDG Push* scenario reduces carbon emissions relative to the *Current Path*). In addition, a powerful policy strategy to also reduce malnutrition improves the equality in the distribution of caloric resources in a society, a proxy intervention for programs that target food insecurity in the most poor and vulnerable populations.

3.3. HDI

While the HDI itself is not an SDG indicator, it reflects progression toward multiple SDGs directly (including SDG 3: Good Health and Wellbeing, SDG 4: Quality Education, and SDG 8: Decent Work and Economic Growth) and even more indirectly, as improving human development is associated with a myriad of other improvements, from poverty reduction to infrastructure access. Rather than projecting the index itself, IFs constructs the HDI each year from the projection of constituent parts defined by the UNDP: a long and healthy life (life expectancy), being knowledgeable (educational attainment and school life expectancy), and having a decent standard of living (GDP per capita).

In 2019, we estimate the global HDI at 0.710, roughly the level of Jamaica (0.710) or Botswana (0.707) and roughly 20 percent higher than India in the same year. In a *No COVID-19* scenario, this is projected to improve but gradually, reaching 0.739 by 2030 and 0.790 by 2050 (Table 4).

Table 4. Human Development Index (HDI) for the world across scenarios. Source: IFs. 8.10.

Scenario	2019	2030	2050
No COVID-19	0.710	0.739	0.790
Current Path	0.710	0.735	0.786
SDG Push	0.710	0.741	0.814

Driven primarily by the reduction in economic growth, the HDI fell by 0.002 in 2020 before beginning a gradual recovery with a forecast trajectory parallel to that of the *No COVID-19* scenario. By 2030, we project that the HDI in the *Current Path* would rise to 0.735 and by 2050 reach 0.786, nearly half a percent below the counterfactual in both years (Figure 7).

Through addressing barriers to growth, health, and education, the *SDG Push* accelerates improvements in human development and surpasses the *No COVID-19* trajectory by 2029. By 2030, in this scenario, the HDI reaches 0.741 and by 2050 0.814, a 3.5 percent improvement over the *Current Path.* While these improvements are relatively more limited than for poverty and hunger, the HDI is made up of components which change very slowly, such as life expectancy and adult educational attainment.

At a regional level, the CSA region experienced the greatest reduction in the HDI in the COVID-19 scenario relative to the *No COVID-19* scenario (Figure 8). This is not unexpected, as the region also suffered the greatest impact in terms of poverty and undernourishment, shown above. The ESEA region, on the other hand, experienced only a moderate reduction in the HDI in 2020 but is expected to be affected to a greater degree in the long run due to greater impacts on population life expectancy and educational attainment. Even so, the effect of COVID-19 across all regions is not large. Other than GDP per capita, the components of the HDI are measures of long-term stocks reflecting human health and education and should be expected to change very slowly.

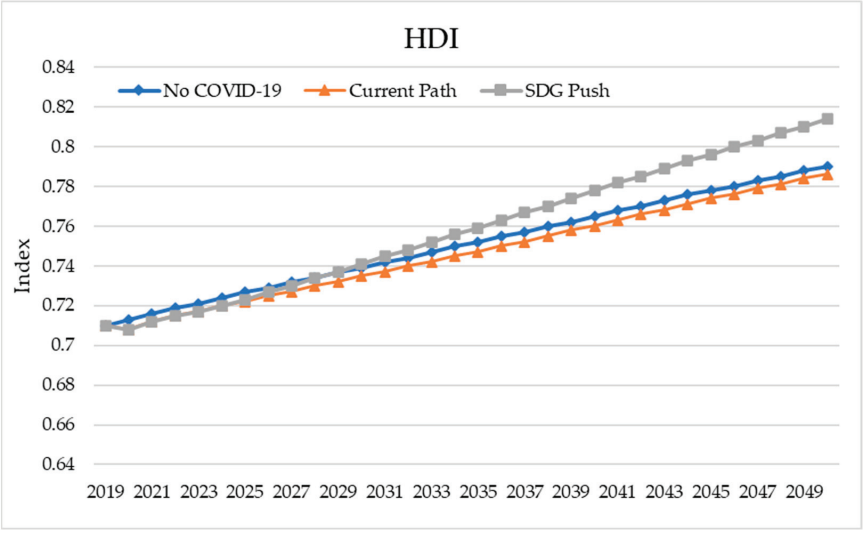


Figure 7. Human Development Index (HDI) across scenarios. Source: IFs. 8.10.

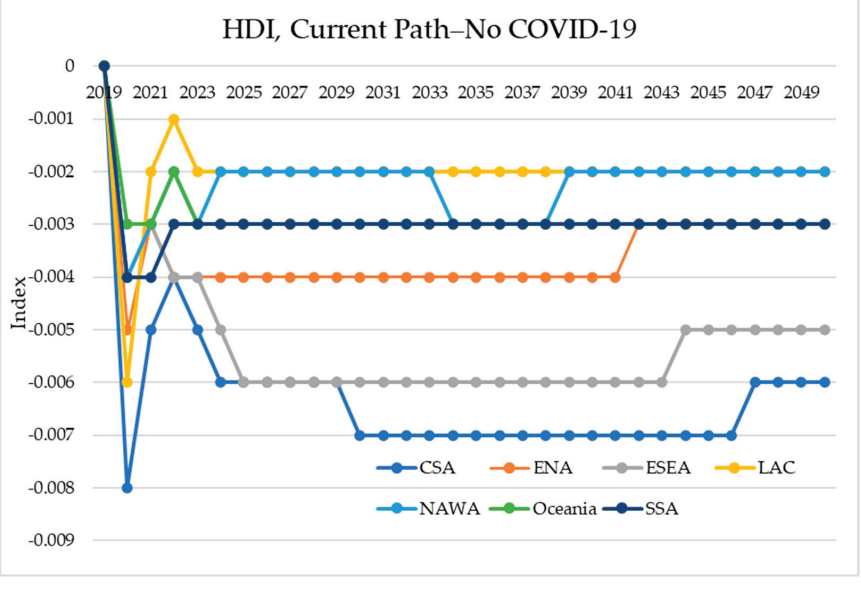


Figure 8. Difference between the HDI in the *Current Path* scenario and the *No COVID-19* scenario, by region. Source: IFs 8.10.

Figure 9 shows the effect of the *SDG Push* scenario on the HDI relative to the *Current Path* scenario by region. Here, the HDI values improve across all scenarios, and the effect of the *SDG Push* is significantly greater than the effect of COVID-19 even in very early years.

The greatest improvements are seen in regions where the HDI values are relatively low to begin with: SSA, CSA, and NAWA. But improvement is still seen in ENA, the region with the highest HDI even prior to COVID-19.

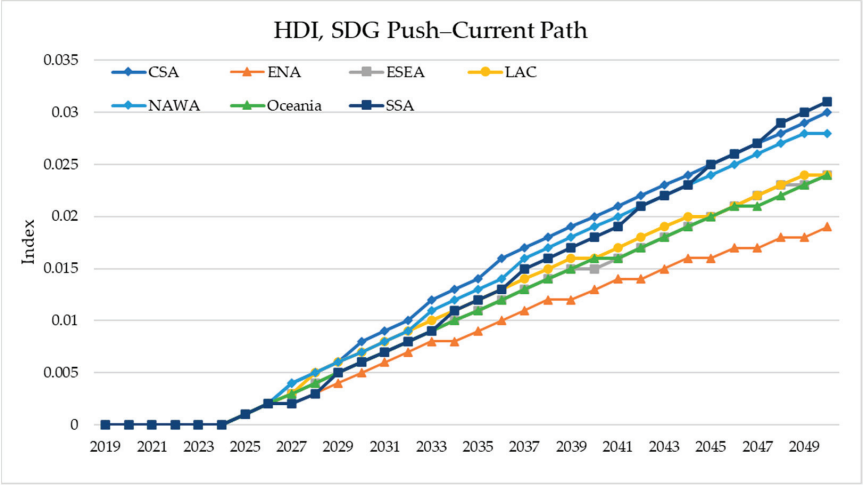


Figure 9. Difference between the HDI in the *Current Path* scenario and the *SDG Push* scenario, by region. Source: IFs 8.10.

Each of the policy strategies simulated in the *SDG Push* scenario leads to improvements in the HDI. Education policies increase attainment and school survival, direct health investments and indirect improvements in the proximate drivers of health outcomes (like improved access to water and sanitation) increase life expectancy, and the broad-based investments in multidimensional development increase productivity and raise GDP per capita.

4. Discussion

Even before the COVID-19 outbreak, we were not on a path to achieve the SDG targets assessed in this report, including eliminating poverty and hunger, as well as improving health and education, by the target date of 2030. This study seeks to (1) better understand how the COVID-19 pandemic has and will continue to set back progress toward the SDGs in the long run and (2) explore how an integrated development push could make up for this lost progress and accelerate development.

We find that the outbreak of COVID-19 and resulting containment measures, such as lockdowns and quarantines, did not have a devastating long-term effect on SDG achievement, though they resulted in further setbacks. The number of countries meeting the 2030 targets reduced from 113 to 107 for poverty and from 95 to 89 for malnutrition due to the COVID-19 shock. COVID-19 increased the global extreme poverty rate by 1 percentage point, and while its effect will soften over time, by 2030 (2050), 57 million (29 million) more people will live in extreme poverty compared with a *No COVID-19* scenario. Some regions have and will continue to recover more rapidly than others. A less severe economic effect and more rapid recovery in SSA in particular led to fewer people in the region pushed into poverty than previous research estimated [14,43,45]. On the other hand, the CSA region bore the brunt of the poverty impact of COVID-19, with more than twice as many people pushed into poverty than in SSA. Still, without additional action, no region is projected to catch up with its *No COVID-19* trajectory.

This research also shows that there is significant room for development improvement using an integrated approach to addressing key human and economic development deficiencies. The *SDG Push* scenario simulates the results of moving beyond recovery from a global crisis, demonstrating how an ambitious global push across issue areas can accelerate progress toward global development goals. This scenario closes the gap between the *Current Path* and the *No COVID-19* world in a matter of years and makes additional

gains toward SDG achievement. By 2050, 20 more countries achieve the SDG 1.1 target and 31 more countries achieve the SDG 2.1 target than expected in the *Current Path.* In this world, the goal of Zero Hunger is projected to be met just a few years behind the target date of 2030 and the goal of ending poverty a little more than a decade behind.

In comparing our results with the results of others, we note that there is general alignment that the COVID-19 pandemic has reduced human development outcomes and our ability to achieve the SDGs without additional policy interventions [5–8,10]. While we are unable to directly quantify what the magnitude of this effect is across SDGs in a composite way (as, say, the work of Li et al. [6]), we see a generally similar magnitude in these results compared with other work. Estimates for the immediate effect on poverty fall within the range provided by previous research [16,43–45]. While we are not aware of other studies which estimate the long-term effect of the pandemic on population-wide undernutrition, our findings are in line with previous work finding that the pandemic increased food unaffordability [17] and child undernutrition [19] in the short run and food insecurity [21] in the long run. These findings are also in line with research emphasizing the benefits of an integrated development push in accelerating progress toward SDG achievement [22].

From a methodological perspective, this work highlights the ongoing importance of representing governmental systems within integrated modeling frameworks to capture patterns of political choice that are crucial for thinking about the future socioeconomic development future on a planet characterized by finite resources. There are ongoing debates about the role of economic growth and technology as a way to balance human development and environmental systems [28,46,47]. More explicitly representing these processes in global modeling efforts will allow us to examine how governmental policies related to education, health, infrastructure, the military, and R&D can inform development in technology while also reducing unnecessary waste.

It is important to note that there are limitations to this work. First, the biggest difference between the *No COVID-19* and *Current Path* scenarios in this analysis comes from the difference in GDP growth rates as projected in 2019, prior to the outbreak, and more recent growth rate data and projections from 2023. In the initial years, COVID-19 can be assumed to have been the primary driver for most changes to growth rates and thus responsible for most of the economic and development effects. In more recent years, additional shocks both local and global have occurred that have also likely changed economic growth trajectories, including but not limited to the onset of wars in Ukraine and more recently in Gaza. This analysis does not seek to isolate the effect of the COVID-19 pandemic from these other shocks but to contrast the *Current Path* we are on today with the trajectory the world was on prior to the outbreak.

Another limitation to the assessment of the effect of the pandemic is the lack of sector-specific effects modeled. COVID-19 had different effects across economic sectors, including hitting some sectors, like tourism and transport, particularly hard. These sectors are not differentiated in IFs and thus may not be fully accounted for here.

Yet another limitation of this work is our inability to effectively treat uncertainty in the analysis. First, the scenarios that are presented here do not include traditional longitudinal "confidence intervals" because the structure of the model and the large number of interconnected systems makes this kind of uncertainty framing implausible. Second, the scenarios themselves are not attempts to account for the actual uncertainty inherent in the global system—as a global pandemic suggests, future human development will be impacted by a wide range of exogenous factors, and it is beyond the scope of this work to extrapolate here. Finally, as all models are representations of reality that make significant simplifying assumptions, the use of tools for planning should be understood to be illustrative and exploratory, not predictive and prescriptive.

This analysis is focused largely on a select few human-development-oriented goals and targets that are most relevant for low- and lower-middle-income countries. This is just one component of the entire SDG agenda and does not address countries that have, for

example, eliminated extreme poverty but still have poverty at higher levels. In focusing on these SDGs and indicators, we focus on populations that are especially vulnerable and addressing core development needs. Moreover, these goals have strong connections with many others—for instance, eradicating poverty has synergies with many other SDGs [48], while failing to meet SDGs 1 and 2 would seriously undermine the ability to meet many others [49,50].

Finally, this analysis also does not address the many sustainability- and environmentally oriented SDGs, like SDGs 13, 14, and 15. Some of the literature indicates that lockdown and quarantine measures, especially reducing road and air travel, had positive effects on reducing emissions and meeting some environmental SDG targets [51,52]. However, much of this was temporary. And the pause in growth and investment could have adverse long-term consequences on environmental progress, outweighing the initial benefits [51].

As the world faces future global shocks and challenges, it is vital to better understand both how those shocks may impact development in the long run and how policy effort can support recovery from and even beyond those impacts. We find that for a shock like that imposed by the COVID-19 pandemic, the consequences to human wellbeing are real, but transformative and integrated policy interventions can lead to much greater benefits.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su16083309/s1, Table S1: Detailed interventions for the SDG Push scenario.

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References

1. Kroll, C.; Warchold, A.; Pradhan, P. Sustainable Development Goals (SDGs): Are We Successful in Turning Trade-Offs into Synergies? *Palgrave Commun.* **2019**, *5*, 140. [CrossRef]
2. WHO. *The True Death Toll of COVID-19: Estimating Global Excess Mortality*; World Health Organization: Geneva, Switzerland, 2021; Data Stories.
3. Mahler, D.G.; Yonzan, N.; Lakner, C. *The Impact of COVID-19 on Global Inequality and Poverty*; World Bank: Washington, DC, USA, 2022.
4. Narayan, A.; Cojocaru, A.; Agrawal, S.; Bundervoet, T.; Davalos, M.; Garcia, N.; Lakner, C.; Mahler, D.G.; Montalva Talledo, V.; Ten, A.; et al. *COVID-19 and Economic Inequality: Short-Term Impacts with Long-Term Consequences*; Policy Research Working Papers; The World Bank: Washington, DC, USA, 2022.

5. Clemente-Suárez, V.J.; Rodriguez-Besteiro, S.; Cabello-Eras, J.J.; Bustamante-Sanchez, A.; Navarro-Jiménez, E.; Donoso-Gonzalez, M.; Beltrán-Velasco, A.I.; Tornero-Aguilera, J.F. Sustainable Development Goals in the COVID-19 Pandemic: A Narrative Review. *Sustainability* **2022**, *14*, 7726. [CrossRef]
6. Li, C.; Deng, Z.; Wang, Z.; Hu, Y.; Wang, L.; Yu, S.; Li, W.; Shi, Z.; Bryan, B.A. Responses to the COVID-19 Pandemic Have Impeded Progress towards the Sustainable Development Goals. *Commun. Earth Environ.* **2023**, *4*, 252. [CrossRef]
7. Ranjbari, M.; Shams Esfandabadi, Z.; Zanetti, M.C.; Scagnelli, S.D.; Siebers, P.-O.; Aghbashlo, M.; Peng, W.; Quatraro, F.; Tabatabaei, M. Three Pillars of Sustainability in the Wake of COVID-19: A Systematic Review and Future Research Agenda for Sustainable Development. *J. Clean. Prod.* **2021**, *297*, 126660. [CrossRef]
8. Qadeer, A.; Anis, M.; Ajmal, Z.; Kirsten, K.L.; Usman, M.; Khosa, R.R.; Liu, M.; Jiang, X.; Zhao, X. Sustainable Development Goals under Threat? Multidimensional Impact of COVID-19 on Our Planet and Society Outweigh Short Term Global Pollution Reduction. *Sustain. Cities Soc.* **2022**, *83*, 103962. [CrossRef]
9. Chopra, M.; Singh, S.K.; Gupta, A.; Aggarwal, K.; Gupta, B.B.; Colace, F. Analysis & Prognosis of Sustainable Development Goals Using Big Data-Based Approach during COVID-19 Pandemic. *Sustain. Technol. Entrep.* **2022**, *1*, 100012. [CrossRef]
10. Wang, Q.; Huang, R. The Impact of COVID-19 Pandemic on Sustainable Development Goals—A Survey. *Environ. Res.* **2021**, *202*, 111637. [CrossRef]
11. Bill & Melinda Gates Foundation; IHME. *COVID-19 A Global Perspective: 2020 Goalkeepers Report*; Bill & Melinda Gates Foundation: Seattle, WA, USA, 2020.
12. Kharas, H. *The Impact of COVID-19 on Global Extreme Poverty*; Brookings: Washington, DC, USA, 2020.
13. Kharas, H.; Dooley, M. *Extreme Poverty in the Time of COVID-19*; Center for Sustainable Development at Brookings: Washington, DC, USA, 2021.
14. Laborde, D.; Martin, W.; Vos, R. Impacts of COVID-19 on Global Poverty, Food Security, and Diets: Insights from Global Model Scenario Analysis. *Agric. Econ. Amst. Neth.* **2021**, *52*, 375–390. [CrossRef]
15. Lakner, C.; Mahler, D.G.; Negre, M.; Prydz, E.B. How Much Does Reducing Inequality Matter for Global Poverty? *J. Econ. Inequal.* **2022**, *20*, 559–585. [CrossRef]
16. Sumner, A.; Hoy, C.; Ortiz-Juarez, E. *Estimates of the Impact of COVID-19 on Global Poverty*; United Nations University: Tokyo, Japan, 2020.
17. Laborde, D.; Herforth, A.; Headey, D.; de Pee, S. COVID-19 Pandemic Leads to Greater Depth of Unaffordability of Healthy and Nutrient-Adequate Diets in Low- and Middle-Income Countries. *Nat. Food* **2021**, *2*, 473–475. [CrossRef]
18. FAO; IFAD; UNICEF; WFP; WHO. *The State of Food Security and Nutrition in the World 2020*; FAO: Rome, Italy, 2020; ISBN 978-92-5-132901-6.
19. Osendarp, S.; Akuoku, J.K.; Black, R.E.; Headey, D.; Ruel, M.; Scott, N.; Shekar, M.; Walker, N.; Flory, A.; Haddad, L.; et al. The COVID-19 Crisis Will Exacerbate Maternal and Child Undernutrition and Child Mortality in Low- and Middle-Income Countries. *Nat. Food* **2021**, *2*, 476–484. [CrossRef]
20. Roberton, T.; Carter, E.D.; Chou, V.B.; Stegmuller, A.R.; Jackson, B.D.; Tam, Y.; Sawadogo-Lewis, T.; Walker, N. Early Estimates of the Indirect Effects of the COVID-19 Pandemic on Maternal and Child Mortality in Low-Income and Middle-Income Countries: A Modelling Study. *Lancet Glob. Health* **2020**, *8*, e901–e908. [CrossRef]
21. Cooper, M.; Müller, B.; Cafiero, C.; Laso Bayas, J.C.; Crespo Cuaresma, J.; Kharas, H. Monitoring and Projecting Global Hunger: Are We on Track? *Glob. Food Secur.* **2021**, *30*, 100568. [CrossRef]
22. Soergel, B.; Kriegler, E.; Weindl, I.; Rauner, S.; Dirnaichner, A.; Ruhe, C.; Hofmann, M.; Bauer, N.; Bertram, C.; Bodirsky, B.L.; et al. A Sustainable Development Pathway for Climate Action within the UN 2030 Agenda. *Nat. Clim. Chang.* **2021**, *11*, 656–664. [CrossRef]
23. UNDP. *Beyond Recovery: Towards 2030*; United Nations Development Programme: New York, NY, USA, 2020.
24. Elavarasan, R.M.; Pugazhendhi, R.; Shafiullah, G.M.; Kumar, N.M.; Arif, M.T.; Jamal, T.; Chopra, S.S.; Dyduch, J. Impacts of COVID-19 on Sustainable Development Goals and Effective Approaches to Maneuver Them in the Post-Pandemic Environment. *Environ. Sci. Pollut. Res.* **2022**, *29*, 33957–33987. [CrossRef]
25. Fenner, R.; Cernev, T. The Implications of the COVID-19 Pandemic for Delivering the Sustainable Development Goals. *Futures* **2021**, *128*, 102726. [CrossRef]
26. Verhagen, W.; Bohl, D.K.; Pulido, A.; Pirzadeh, A.; Solórzano, J.; Hughes, B.B.; Moyer, J.D. Policy Strategies to Achieve Zero Hunger by 2040 at the Country-Level 2023. Available online: https://www.researchsquare.com/article/rs-2495038/v1 (accessed on 22 February 2024).
27. Dickson, J.R.; Hughes, B.B.; Irfan, M.T. *Advancing Global Education: Forecasting the Next 50 Years*; Patterns of Potential Human Progress; Paradigm Publishers: Boulder, CO, USA; Oxford University Press: New Delhi, India, 2011; Volume 2, ISBN 978-1-59451-755-6.
28. Moyer, J.D. Modeling Transformational Policy Pathways on Low Growth and Negative Growth Scenarios to Assess Impacts on Socioeconomic Development and Carbon Emissions. *Sci. Rep.* **2023**, *13*, 15996. [CrossRef]
29. Hughes, B.B.; Joshi, D.K.; Moyer, J.D.; Sisk, T.D.; Solórzano, J.R. *Strengthening Governance Globally: Forecasting the Next 50 Years*; Patterns of Potential Human Progress; Paradigm Publishers: Boulder, CO, USA; Oxford University Press: New Delhi, India, 2014; Volume 5, ISBN 978-1-61205-561-9.

30. Moyer, J.D. Blessed Are the Peacemakers: The Future Burden of Intrastate Conflict on Poverty. *World Dev.* **2023**, *165*, 106188. [CrossRef]
31. Hughes, B.B.; Kuhn, R.; Peterson, C.M.; Rothman, D.S.; Solórzano, J.R. *Improving Global Health: Forecasting the Next 50 Years*; Patterns of Potential Human Progress; Paradigm Publishers: Boulder, CO, USA; Oxford University Press: New Delhi, India, 2011; Volume 3, ISBN 978-1-59451-896-6.
32. Rothman, D.S.; Irfan, M.T.; Margolese-Malin, E.; Hughes, B.B.; Moyer, J.D. *Building Global Infrastructure: Forecasting the Next 50 Years*; Patterns of Potential Human Progress; Paradigm Publishers: Boulder, CO, USA; Oxford University Press: New Delhi, India, 2014; Volume 4, ISBN 978-1-61205-092-8.
33. Moyer, J.D.; Meisel, C.J.; Matthews, A.S. Measuring and Forecasting the Rise of China: Reality over Image. *J. Contemp. China* **2023**, *32*, 191–206. [CrossRef]
34. Hughes, B.B. *International Futures: Building and Using Global Models*; Academic Press: London, UK, 2019; ISBN 978-0-12-804271-7.
35. World Bank Poverty and Inequality Platform. Available online: https://pip.worldbank.org/home (accessed on 8 December 2023).
36. Hughes, B.B.; Irfan, M.T.; Khan, H.; Kumar, K.B.; Rothman, D.S.; Solorzano, J.R. *PPHP 1: Reducing Global Poverty*; Patterns of Potential Human Progress; Pardee Center for International Futures, University of Denver: Denver, CO, USA; Paradigm Publishers: Boulder, CO, USA; Oxford University Press: New Delhi, India, 2009; Volume 1, ISBN 978-1-59451-639-9.
37. UNDP. *Human Development Report 2010. The Real Wealth of Nations: Pathways to Human Development*; United Nations Development Programme: New York, NY, USA, 2010.
38. The Lancet The Global Burden of Disease Study 2019. *Lancet* **2020**, *396*, 1129–1306.
39. Hughes, B.B.; Hanna, T.; McNeil, K.; Bohl, D.; Moyer, J.D. *Foundational Research Report: Pursuing the Sustainable Development Goals in a World Reshaped by COVID-19*; Social Science Research Network: Rochester, NY, USA, 2020.
40. IMF. *World Economic Outlook, October 2023: Navigating Global Divergences*; International Monetary Fund: Washington, DC, USA, 2023.
41. IMF. *World Economic Outlook, October 2019: Global Manufacturing Downturn, Rising Trade Barriers*; International Monetary Fund: Washington, DC, USA, 2019.
42. Moyer, J.D.; Hedden, S. Are We on the Right Path to Achieve the Sustainable Development Goals? *World Dev.* **2020**, *127*, 104749. [CrossRef]
43. Moyer, J.D.; Verhagen, W.; Mapes, B.; Bohl, D.K.; Xiong, Y.; Yang, V.; McNeil, K.; Solórzano, J.; Irfan, M.; Carter, C.; et al. How Many People Is the COVID-19 Pandemic Pushing into Poverty? A Long-Term Forecast to 2050 with Alternative Scenarios. *PLoS ONE* **2022**, *17*, e0270846. [CrossRef]
44. World Bank. *Poverty and Shared Prosperity 2022: Correcting Course*; World Bank: Washington, DC, USA, 2022; ISBN 978-1-4648-1894-3.
45. Mahler, D.G.; Lakner, C.; Aguilar, R.A.C.; Wu, H. The Impact of COVID-19 (Coronavirus) on Global Poverty: Why Sub-Saharan Africa Might Be the Region Hardest Hit. Available online: https://blogs.worldbank.org/opendata/impact-covid-19-coronavirus-global-poverty-why-sub-saharan-africa-might-be-region-hardest (accessed on 8 January 2024).
46. Hickel, J.; Hallegatte, S. Can We Live within Environmental Limits and Still Reduce Poverty? Degrowth or Decoupling? *Dev. Policy Rev.* **2022**, *40*, e12584. [CrossRef]
47. O'Neill, B.C. Envisioning a Future with Climate Change. *Nat. Clim. Chang.* **2023**, *13*, 874–876. [CrossRef]
48. van Soest, H.L.; van Vuuren, D.P.; Hilaire, J.; Minx, J.C.; Harmsen, M.J.H.M.; Krey, V.; Popp, A.; Riahi, K.; Luderer, G. Analysing Interactions among Sustainable Development Goals with Integrated Assessment Models. *Glob. Transit.* **2019**, *1*, 210–225. [CrossRef]
49. Cernev, T.; Fenner, R. The Importance of Achieving Foundational Sustainable Development Goals in Reducing Global Risk. *Futures* **2020**, *115*, 102492. [CrossRef]
50. Wei, Y.; Zhong, F.; Song, X.; Huang, C. Exploring the Impact of Poverty on the Sustainable Development Goals: Inhibiting Synergies and Magnifying Trade-Offs. *Sustain. Cities Soc.* **2023**, *89*, 104367. [CrossRef]
51. Gillingham, K.T.; Knittel, C.R.; Li, J.; Ovaere, M.; Reguant, M. The Short-Run and Long-Run Effects of COVID-19 on Energy and the Environment. *Joule* **2020**, *4*, 1337–1341. [CrossRef]
52. Le Quéré, C.; Jackson, R.B.; Jones, M.W.; Smith, A.J.P.; Abernethy, S.; Andrew, R.M.; De-Gol, A.J.; Willis, D.R.; Shan, Y.; Canadell, J.G.; et al. Temporary Reduction in Daily Global CO2 Emissions during the COVID-19 Forced Confinement. *Nat. Clim. Chang.* **2020**, *10*, 647–653. [CrossRef]

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The Impact of External Shocks on the Sustainable Development Goals (SDGs): Linking the COVID-19 Pandemic to SDG Implementation at the Local Government Level

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Abstract: Using data from a survey we conducted in collaboration with the Association of Flemish Cities and Municipalities (VVSG), this article sought to examine the effects of the COVID-19 pandemic on the implementation of SDGs by Flemish local governments (cities and municipalities). Identifying such effects has usually been conducted on individuals and at a macro level and not at the organization and local government level. By using a counterfactual approach, we were able to disentangle various COVID-19 effects over time and learn how systems at the local level react to external shocks. The approach allowed us to single out the effects of the pandemic at the organizational level while looking into three distinct periods: before the pandemic, during the pandemic, and in its aftermath. Results showed that the COVID-19 pandemic slowed down the Flemish public sector's implementation of SDGs at the local level. At the same time, COVID-19 allowed local public institutions to accelerate the implementation of a few SDGs (e.g., SDG1, SDG3) and to postpone a few SDG-related activities which would be resumed once the pandemic is 'over'. COVID-19 is not only a challenge; it acts as a wake-up call and an opportunity to commit more towards the implementation of (certain) SDGs.

Keywords: UN sustainable development goals (SDGs); COVID-19; SDG implementation; local governments

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1. Introduction

The COVID-19 pandemic has impacted social, economic, and environmental systems worldwide, slowing down and reversing the progress made in achieving the Sustainable Development Goals (SDGs) [1]. While some SDGs have been directly and hugely impacted, others have been indirectly affected by the global pandemic emergency [2,3]. At some point, the pandemic brought the advancement of Agenda 2030 to a standstill and, as a result, has put serious doubt on the achievement of SDGs [4]. Most of the existing research examines the effects of COVID-19 on SDGs at an individual level [5], while other studies focus on a macro level [6]. According to the Crisis in Context Theory (CCT), the way individuals react to external shocks is different from the reactions of the system, as both entities form different layers in a crisis model [7]. While it is important to analyze each layer involved in the crisis, there is little evidence on how the COVID-19 pandemic has stalled the implementation of the SDGs at the organizational level and how organizations reacted to the pandemic. We filled this gap in the literature by examining whether and to what extent COVID-19 has affected local governments' SDG implementation.

A growing body of research has already explored the relationship between COVID-19 and SDGs [8–10]. While some studies suggest that COVID-19 measures have brought a few positive impacts on the environment, for example, by reducing air pollutants and greenhouse gas emissions [11,12], other research gives a harsh judgment on the impact of COVID-19 on SDGs by claiming that COVID-19 has torn to shreds sustained economic growth and globalization, the two big assumptions on which SDGs' success were built [8]. Specifically, following the shrinking of the global economy, different SDGs were negatively

affected [3,5]. However, since most of these studies focused their main attention on how individuals were affected by COVID-19, we based our analysis on organizations. Building on earlier insights, we embraced a novel perspective in our research by investigating how the local public sector was hindered by COVID-19 in its efforts to implement SDGs. This approach allows us to gain a deeper understanding of how local public institutions may not only have been prevented from pursuing their efforts to achieve the Agenda 2030 but are also likely to have shifted their priorities to respond to the challenges presented to them by the pandemic, thereby accelerating on some SDGs. We examined how and to what extent public organizations (institutions) at the local level adjusted their strategies to respond to the crisis. During global shocks, organizations react differently, and hence it makes sense to investigate organizational behaviors when faced with crises.

Furthermore, research has pointed out that COVID-19 delayed the achievement of some SDGs. For instance, it reversed approximately a decade in the world's progress in reducing poverty [13–15]. It also slowed down the progress made in the area of health [5]. This further warrants our focus on the impact of COVID-19 on SDGs and how institutions reacted to the crisis by shifting priorities. A theory suggests that "Only a crisis—actual or perceived—produces real change. When that crisis occurs, the actions that are taken depend on the ideas that are lying around" [16] (p. 7). Faced with the pandemic, local governments were forced to respond within their capacity and were sometimes obliged to shift priorities away from the usual actions. Because of their limited exploration of the efforts of the public sector in achieving SDGs, earlier studies failed to appreciate how public institutions adapted their strategies and how SDG tools helped them to navigate through the pandemic without abandoning their efforts and engagement with SDG implementation. The consequences of COVID-19 on SDGs called organizations into action for prompt measures [3]. Building further on these insights, our study showed that some organizations ceased the 'opportunity' offered by the COVID-19 crisis to accelerate their implementation of a number of SDGs and were building on this momentum in the aftermath of the pandemic. Consequently, we aimed to gain a better understanding of the relationship between the two variables by analyzing how local governments' implementations of SDGs were hindered or encouraged by COVID-19. To understand governmental institutions' SDG implementation efforts and activities, we partly based our analysis on the SDG compass, which is a tool that different organizations utilize to apply SDGs at their levels. Meanwhile, there is little research on public institutions, especially at the local level vis-à-vis COVID-19 and SDGs, despite this being a topical issue in public administration.

Relying on data from a survey we developed and conducted in July 2021 in collaboration with the VVSG (the Association of Flemish Cities and Municipalities), we investigated how Flemish public organizations' SDG implementation activities and efforts were hampered by COVID-19. This provided us a better picture of how much the implementation of some SDGs was put on hold to focus on more urgent SDGs. We obtained insights on how local public institutions in Flanders (region that is part of the federal state of Belgium and has its own assigned powers, which were granted by the federal constitution. Flanders exercises these powers (e.g., cultural matters, welfare, education, economic matters, etc.) autonomously according to the principle of federal loyalty. Flanders has five provinces and 300 cities and municipalities with jurisdiction over a given territory. These local governments are autonomous on the one hand, and on the other hand, they are part of the state (coadministration). These administrations also have an open mandate, which means, among other things, that they can take their own initiative in many matters and levy their own taxes. For these reasons, mandataries are also directly elected at this level. Municipal powers are very broad and include everything related to the "municipal interest," in other words, the collective needs of residents. In theory, a city/municipality in Flanders can do anything as long as it is not prohibited. Jurisdiction includes public works, social assistance, law enforcement, housing, education, etc.) may have shifted priorities to respond better to the crisis and may have come out of the crisis more equipped to pursue efforts to achieve the Agenda 2030.

The remainder of this article is organized as follows. In Section 1, we discuss the literature regarding the impact of the COVID-19 pandemic on SDGs and elaborate on subsequent hypotheses. Building on the literature, we develop our argument on whether and to what degree COVID-19 impacts SDG implementation in the public sector at the local level. In Section 2, we show how data were collected and analyzed, while in Section 3, the results are discussed and analyzed. Finally, Section 4 concludes with a discussion and outlines possibilities for future research on the themes discussed in the paper.

2. Literature Review and Hypotheses

Although SDGs are a recent phenomenon, there is a growing body of research developed on the impact of COVID-19 on SDGs [17]. The pandemic is likely to have threatened SDG achievement scheduled in 2030 [18]. The SDG implementation process is a key step because the Agenda 2030 framework may lead to different sustainability outcomes, depending on how it is implemented by the diverse set of competent agents [19–21]. Mazmanian and Sabatier [22] (p. 20) defined implementation as "the carrying out of a basic policy decision, usually incorporated in a statute but which can also take the form of important executive orders". As a policy decision, SDGs identify the problem(s) to be addressed, stipulate the objective(s) to be pursued, and structure the implementation process. We regarded SDGs as a universal project to end poverty, protect the planet, and improve the lives and livelihoods of everyone everywhere [23].

Since the adoption of SDGs in 2015, private and public institutions at different levels have been encouraged to join hands in implementing SDGs. Evaluating countries' trajectory, macro-level research has classified nations into five categories in light of their SDG implementation process: "decreasing" (country score is moving away from SDG achievement), "stagnating" (country score remains stagnant or is improving at a rate below 50% of what is needed for SDG achievement by 2030), "moderately increasing" (country score is increasing at a rate above 50% but below the rate needed for SDG achievement by 2030), "on track" (score is improving at the rate needed for SDG achievement by 2030), "maintaining goal achievement" (country score is on the level and remains at or above SDG achievement) [24]. We built on these insights to check the trajectory of the SDG implementation process among public organizations at the local level that form an important part of the national effort. We believe that local governments are the key implementers of policy decisions and produce the outcomes of those decisions in the governance process. It is at this level that all actions take place [25], and hence we find it important to study the local level.

3. Determining the Effects of the COVID-19 Pandemic on SDG Implementation

3.1. The Slowdown Effect: COVID-19 Slowed down Organizations' SDG Implementation in General

Since their adoption in 2015, many SDGs (e.g., economic growth, education for all, and poverty reduction) have experienced relative progress. The spread of COVID-19 seems to have changed the scenario. Based on the United Nations report [26], Fallah Shayan et al. [5] demonstrated how COVID-19 had dramatically disrupted the decreasing number of poor people. Due to the worldwide disruption of the economy and food supply chain, more people have suffered from malnutrition. Similarly, following school closures during lockdowns, so many students did not have basic equipment or access to attend online schools and may have fallen behind [5]. In a particular way, the COVID-19 pandemic is a major economic shock that has already increased economic insecurity, particularly for less educated people [27,28]. The economic insecurity was translated into job-related disruptions, including losing a job, a reduction in working hours, or a fall in income for millions of people [29].

While some studies investigate the pandemic's social, economic, and environmental impacts separately or only focus on a few SDGs [30–34], other studies focus on all 17 goals, thereby giving a holistic picture [5,35]. In addition, most of these studies focus their studies

on how COVID-19 has an effect on individuals. These studies maintain that the economic crisis that followed the pandemic is estimated to have flung 400 million people below the $1.90 poverty line [14,15], while the number of people who are likely to face acute food shortages highly increased during the pandemic [36].

Although there is a lot of research on how COVID-19 affects the individual in relation to SDGs, comprehensive studies on the pandemic's impacts (both negative and positive) are still lacking in the context of impacts on organizations. Theories show that there is more than a surface layer of impact to every crisis. Besides individuals being affected, systems, subsystems, and stakeholders get affected [7]. Accordingly, our analysis concentrated on the organizational level rather than the individual level. Although we acknowledged that SDGs are generally meant to serve the well-being of individuals, organizations play a key role in SDG achievement through their investment in SDGs and in policy implementation that is specific to SDGs [37]. The success or the failure of SDGs, for that matter, is mainly dependent on the way different institutions manage to invest time, energy, and money in the SDG project bearing in mind the effects of external environmental factors (i.e., economic crisis, COVID-19). Moreover, the concrete realization of SDGs is impeded by how they are implemented by a diverse set of competent agents [23]. Our intention was not to address the reciprocal effects of crises on individuals and organizations but specifically on how local public organizations are affected. Organizations also play a key role in the realization of Agenda 2030 through various SDG implementation activities [38]. For example, the city of Antwerp has taken different initiatives to contribute to protecting the environment. One of the initiatives is called "Climate Streets" and has seen the city residents work hand in hand with local teams to green up the streets with more plants and natural features. This initiative that began in 2017 is about using permeable materials and rainwater recovery to cope with flooding and greenery to cope with heat stress during hot summers that have become more of a reality in recent years [39]. Literature shows that the public sector is specifically called upon to implement different policy instruments so as to ensure wide access to public services, adopt policies and strategies to achieve certain SDGs such as gender equality (SDG5) and job creation and entrepreneurship (SDG8), and invest resources in different instrumental areas, such as in research and innovation (SDG9) and multisector partnerships (SDG17) [40]. Hörisch [18] maintains that the pandemic has been found to severely threaten the achievement of the SDGs by shifting attention away from the many prior challenges of sustainable development.

Prior research shows that the pandemic has had different degrees or types of impact on SDG implementation. It has negatively impacted most SDGs in the short term. Particularly, the targets of SDG1, 4, 5, 8, 9, 10, 11, and 13 have and will continue to have weakly to moderately negative impacts or what some scholars term restricting impacts. Although most of these impacts are likely to be short-term, these impacts add new challenges in achieving those SDGs by 2030 [34]. According to the organizational resilience theory [41] and organizational improvisation theory [42], organizations are naturally endowed with resilience to external shocks and can adapt to a fast-changing environment, but organizations adapt differently depending on various factors (i.e., the strength of employees, the strength of adaptive models already in place, substantial investment during normal times). COVID-19 appeared to be too strong for a number of organizations because they did not have mechanisms in place to adapt and to be resilient to external shocks and hence saw their implementation activities slow down. Simultaneously, COVID-19 has exposed the fragility of the 2030 Agenda, especially where organizations have a role to play. If COVID-19 has slowed the SDG project further, we expect that the pandemic will have some negative impacts on the SDGs at the organizational level by slowing down local government's SDG implementation. Therefore, we hypothesized that:

Hypothesis 1 (H1). *Local governments' implementation of the SDGs significantly slowed down due to the COVID-19 crisis.*

3.2. The Prioritization and Acceleration Effect: COVID-19 Led Organizations to Prioritize Some SDGs and to Accelerate Their Organizational Implementation

Sunny et al. [34] contended that a few targets of SDG2, 3, 6, and 11 could have benefited from the positive impacts of the pandemic. These mini-impacts are called weakly promoting impacts. Others call these rare effect opportunities [8]. Even though the pandemic has had devastating impacts on some SDGs, surprisingly, other SDGs have benefitted from the crisis. For instance, COVID-19 provided hope in opportunities for facilitating the achievement of SDG13 (climate action). COVID-19 measures taken by governments in the fight against COVID-19 (i.e., lockdowns) have also brought a few positive impacts on the environment by, for example, reducing air pollutants and greenhouse gas emissions [11,12].

The pandemic has also opened a short-lived and narrow window of opportunities for sustainable transformation. The transformative opportunities consist of lessons learned for planning and actions, socio-economic recovery plans, the use of information and communication technologies and the digital economy, reverse migration and "brain gain," and local governments' exercising authorities [34]. Furthermore, although the pandemic will have restricting impacts on most SDGs in the short term, these restricting impacts may subside in the medium and long term and may even result in some promoting impacts. These promoting impacts are expected first of all because some countries would catch up with the ongoing progress in achieving the SDGs and utilize the generated transformative opportunities once the pandemic is under control [34]. Secondly, transformative opportunities are expected because SDGs are interconnected and interlinked. This means that "implementing the 2030 Agenda will bring about synergies—i.e., situations in which achievements on one goal contribute towards progress on other goals" [43] (p. 6).

Organization theories and crisis theories show that institutions and humanity learn from the crisis and adopt more effective measures. The financial crisis of 2007–2008 has increased awareness about the repercussions that weak corporate governance and risk management practices can have on financial markets and the world's economy. The challenges entailed in the climate change process and the depletion of natural resources (as well as air and water pollution and biodiversity loss) have increased demand for more responsible behavior and coordination at the global level from both public and private economic organizations [3]. As a consequence, many organizations have put efforts into socially responsible investment (SRI). Adopting SRI is one way to reduce the negative impact on society as a whole, thereby making changes and contributing to the ills that have been affecting human lives for many years and accelerating on SDG project [37]. For organizations, prioritization is recognized in academic and practitioner literature as a crucial initial step, as it enables focusing on a reduced set of priorities, thus making SDG implementation more effective and manageable [40]. The pandemic and its consequences resulted in an increased focus on healthcare systems, information and communication technologies (ICTs), and the digital economy [34]. At the local level, the increased focus is likely to be in line with the indicators for European cities to assess and monitor the UN SDGs. For instance, many cities in Flanders sensitized residents on the benefits of COVID-19 vaccination and provided their halls to facilitate vaccinations, and invested more money to help in the vaccination campaign. If a number of SDGs benefited from global shocks and crises and got prioritized, we expected that in their response to the pandemic and its consequences, the public sector would witness a certain degree of acceleration in its implementation in certain SDG areas. Therefore, our next hypothesis is:

Hypothesis 2 (H2). *Due to COVID-19, some SDGs were prioritized, and consequently, local governments' implementation of these SDGs got accelerated.*

3.3. The Postponement Effect: During COVID-19, Organizations Postponed Some SDG Implementation-Related Activities

Following the devastating impacts of the COVID-19 pandemic on SDGs and the apparent impossibility of reaching the Agenda 2030, various researchers, as well as practitioners,

have called on the UN to rethink the world's sustainable development strategy. For instance, following the slowdown of progress on the SDGs due to COVID-19, Naidoo and Fisher [8] argued that the world needs to define priorities better and probably focus on a few broad strategic goals rather than all 17 SDGs. A Nature editorial went further to proclaim that it is time to revise SDGs in order to make the goals more achievable [44]. Those who called for revision were aware that it is not just the COVID-19 crisis that made SDGs beyond our reach. The SDG project was all along slow and impossible to achieve. Reports on the first phase of the SDG agenda (2015–2020) showed unequivocally that progress toward achieving the SDGs had been slow in all parts of the world prior to the COVID-19 crisis [24,26,45]. However, this did not remove the fact that the advent of COVID-19 worsened the situation.

Since the COVID-19 pandemic affected the planet, the United Nations raised the stakes for SDGs by viewing it as vital for COVID-19 recovery, which leads to greener, more inclusive economies and stronger, more resilient societies [45]. There is a strong conviction that achieving the SDGs would bring about a safer, more stable world with fewer natural and manmade hazards, thus lowering the likelihood of future crises occurring [10]. Backsliding on the progress already made on the SDGs not only imperils prospects for eradicating basic deprivations but also reduces resilience to other shocks in the future, especially for those least able to cope. Maintaining the progress already made must continue to be a priority during the crisis response and beyond—supporting those at immediate risk of poverty, hunger, or disease while facilitating their safe return to work and education and their access to healthcare [46].

According to the second step of the SDG compass [47], organizations are encouraged to determine their priorities, relying on an assessment of their positive-and-negative, current-and-potential impacts on SDGs across their value chains. Due to the impact that COVID-19 had on the organization, the latter may have had to postpone some activities. It is expected that while institutions put more focus on maintaining some SDG activities, they willingly or unwillingly make a choice to postpone other activities, hoping to resume them once the crisis is behind them. We, therefore, hypothesized that:

Hypothesis 3 (H3). *Due to the COVID-19 crisis, local governments postponed certain SDG implementation activities.*

4. Materials and Methods

4.1. Sample and Procedures

The population for this study consisted of all 300 Flemish cities and municipalities. All of them were given the opportunity to participate voluntarily in an online Qualtrics survey, drafted in Dutch and held in July 2021, to fully grasp the potential COVID-19 pandemic effects. Through the Association of Flemish Cities and Municipalities (VVSG), respondents were mailed the link to this self-administered questionnaire with an accompanying cover letter, and this mail was directed primarily to sustainability or environmental staff. The surveys were thus completed by a civil servant on behalf of each municipality/city. One of the cover letter's key messages was that for one city/municipality, only one response was demanded, and this was verified using some control variables (type of city/municipality, province, number of citizens). To counteract possible common method bias, participants were further informed that their responses would remain anonymous and confidential [48]. In total, 220 participants completed the survey, but 90 were excluded from further analysis since it concerned partial (missing values) and some double participation. The final sample of complete responses thus comprised 130 unique cities and municipalities, resulting in a response rate of 43.3%. We also noted that cities and municipalities of all categories and all regions are included in the 130 unique ones, resulting in a representative sample.

The data retrieved from the survey were subsequently used to describe the status of the variable SDG implementation of Flemish cities and municipalities and to attempt to determine the relationship between the COVID-19 pandemic and the SDG implementation

of cities/municipalities based on the hypotheses drawn up above. In order to do so, some of these data were statistically tested using SPSS 28.0.

4.2. Survey Design

This study was intended to provide some empirical evidence on the relationship between the COVID-19 pandemic and SDG implementation of individual organizations, more specifically, cities and municipalities. To investigate, the survey sections of interest for this article were: (1) an assessment of the status of the organizations' SDG implementation (currently [the time the survey was completed], counterfactually [given the non-existence of COVID-19], and future), (2) an overview of SDG implementation activities (currently [the time the survey was completed], counterfactually [given the non-existence of COVID-19], and future), (3) an assessment of the direct impact of COVID-19 on the organizations' SDG implementation (currently [the time the survey was completed], and in the future), and (4) an assessment of the direct impact of COVID-19 on the organization's implementation of the individual SDGs. Participants were thus asked both directly and indirectly about the relationship between the variables COVID-19 and SDG implementation. To measure the variables, the following survey questions were used: "What do you consider to be the impact of the COVID-19 crisis on the SDG Implementation of your city/municipality so far(1)/within a year(2)?" (answers: no, slowdown, acceleration), and "In your assessment, how far along is your city/municipality in implementing the SDGs currently(1)/had there been no COVID-19(2)/within a year(3)?" (answers: no SDG implementation, early stage, somewhat advanced, advanced, far advanced, complete SDG implementation). The survey acted thus also as a way to help cities and municipalities evaluate their past and present achievement of the SDGs in light of COVID-19 and to project themselves into the future.

To gain insights into SDG implementation activities of cities and municipalities, this paper made use of a model consisting of several steps, which appeared in both academic literature and practitioner guides for all types of organizations. This five-step model is also known as the SDG compass [47]. The SDG compass is a tool that was created to help institutions to implement SDGs in different states of their programs and strategies. The SDG compass guide is addressed to all governmental and non-governmental development actors who are looking for practical guidance on how to further mold their organization and programs to Agenda 2030 and the underlying principles [49]. Although there are many tools, we found the SDG compass to be easier to understand and apply by all local governments. The five steps are: understanding the SDGs, defining SDG priorities, setting SDG goals, integrating the SDGs, and reporting and communicating on the SDGs. These five steps of SDG implementation are well-known to practitioners and hence very recognizable to the participants of this survey. Unfortunately, we did not know exactly how many of the surveyed cities and municipalities actually used or even knew the SDG compass. However, we were confident that they were all familiar with the five-step model, especially since the Flemish government's SDG manual for governmental organizations is inspired by the SDG compass and thus relies on the same five-step model [50]. Hence, to measure the variable, the following survey questions were used: "In your assessment, to what extent is your city/municipality implementing the SDGs? Please indicate the activities that your city/municipality is doing currently(1)/had there been no COVID-19(2)/within a year(3)?" (answers: no, understanding the SDGs, defining priorities, setting goals, integrating, reporting and communicating).

Since the SDG compass guide aims to provide practical and operational support to organizations in their efforts to design, implement, monitor, and evaluate their interventions in a way that respects and contributes to Agenda 2030 [49], we used it to evaluate how local governments were able to implement SDGs during COVID-19 and analyze how the very implementation could have been hindered. A few other studies used SDG tools to evaluate the organization's engagement with SDGs or to provide new insights. Grainger-Brown and Malekpour [51] used different SDG tools (SDG compass, global reporting initiative, and the 'SDG industry matrix') in their review research of different strategic SDG tools. Muff,

Kapalka, and Dyllick [52], in turn, enriched the SDG compass by introducing process know-how and content expertise in order to facilitate its application in the strategic processes of businesses. Such tools and frameworks are a way of aligning global goals to "micro" strategies [3].

5. Results

5.1. The Slowdown Effect

The respondents' assessment of the status of the organizations' SDG implementation (Figure 1) clearly indicated that at the moment of questioning, more than 90% of the Flemish cities and municipalities (90% of the sample) were already actively engaged in SDG implementation, with more than half being at an early stage of SDG implementation. Looking at the counterfactual numbers (given the non-existence of the COVID-19 crisis), the results cautiously showed that if COVID-19 had not existed, Flemish cities and municipalities would have been further ahead with their SDG implementation. In this hypothetical situation, more than half would already be at a somewhat advanced stage of SDG implementation or further. Looking at the future situation (within 1 year), the results showed a commitment of Flemish cities and municipalities to keep on engaging in SDG implementation. Most organizations indicated they would be at an advanced or even far advanced stage of SDG implementation one year later. To conclude, Figure 1 cautiously shows that COVID-19 has had a slowdown effect on the SDG implementation of Flemish cities and municipalities.

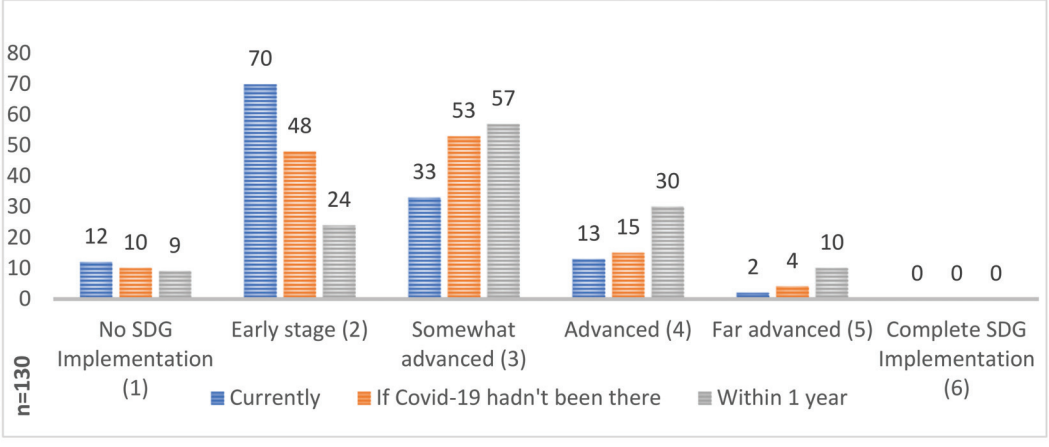

Figure 1. SDG Implementation of Flemish cities/municipalities.

Table 1 shows the basic statistics of the SDG implementation of Flemish cities and municipalities in all three situations. The basic statistics also tentatively indicated that had it not been for COVID-19, Flemish cities and municipalities would have been further advanced in their SDG implementation (mean 2.65) than the current situation (mean 2.41). The numbers also showed the previously mentioned commitment of the organizations to keep on engaging in SDG implementation in the future (mean 3.06). The paired-sample *t*-test results showed that if COVID-19 had not been there, SDG implementation of Flemish cities and municipalities would have been 0.246 higher than the current situation. It was found that, since the significance value for change in SDG implementation is less than 0.05, the average hypothetical rise of 0.246 was not due to chance variation and could be attributed to the COVID-19 crisis. This indicated again that COVID-19 slowed down SDG implementation in Flemish cities and municipalities. Hence, H1 is supported, and there is a statistically significant difference between SDG implementation in the COVID-19 situation and in the hypothetical counterfactual situation (with no COVID-19).

Table 1. Paired-Sample Statistics 'SDG Implementation of Flemish cities/municipalities'.

	Mean	Standard Deviation	Standard Error Mean
SDG Implementation Currently (A)	2.41	0.851	0.075
SDG Implementation if COVID-19 had not been there (B)	2.65	0.895	0.079
SDG Implementation within 1 year (C)	3.06	1.002	0.088
Paired-sample correlations			
		Correlation	Significance.
A & B		0.828	<0.001
Paired-samples test			
	Paired differences Mean difference	t	Significance. (2-tailed)
A & B	−0.246	−5.457	<0.001
n = 130			

Supplementary, the participants were also asked directly about the impact of COVID-19 on the SDG implementation of their organizations. Figure 2 shows that almost 50% of them (64 in total) indicated that in the current situation, COVID-19 caused a slowdown in the SDG implementation of their organizations. The main reasons given for this are: changing priorities, lack of manpower, and less interest. This reinforced the acceptance of H1: local governments' implementation of SDGs significantly slowed down due to the COVID-19 crisis. It is worth noting that in addition, a few cities and municipalities (five in total) also indicated that the COVID-19 crisis had had just the opposite effect on the SDG implementation and that they have shifted up a gear (seemed to have accelerated). Although this concerned an absolute minority (less than 4%), we might note that for these cities and municipalities, COVID-19 could also have created an opportunity for them to accelerate the implementation of SDGs.

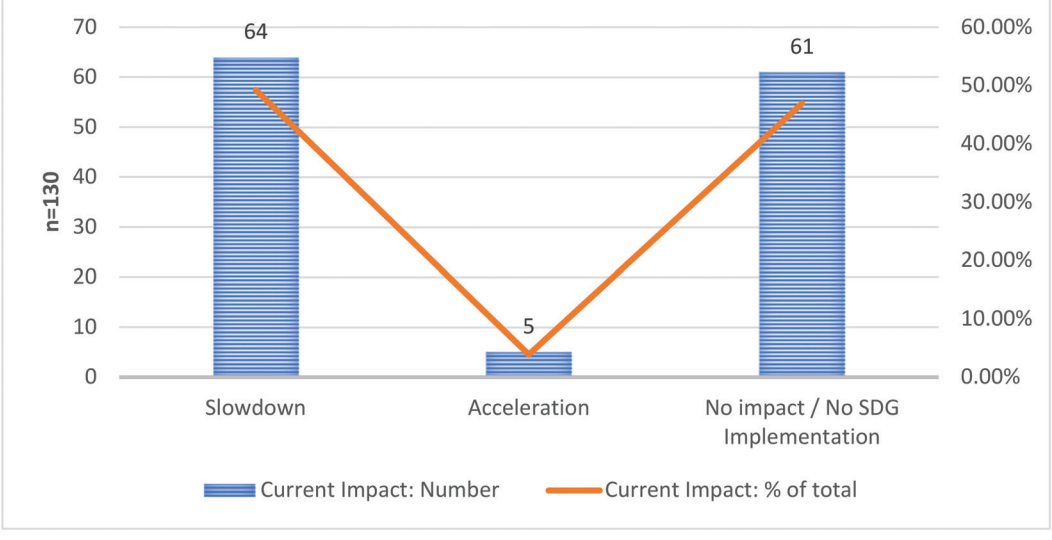

Figure 2. Direct impact of COVID-19 on SDG Implementation of cities/municipalities.

Our study revealed that almost 50% of cities and municipalities indicated that COVID-19 slowed down organizations' SDG implementation and that this slowdown was significant. Our findings are in line with earlier studies. Shula et al. [4] concluded that the

unusual situation created by COVID-19 negatively influenced the commitment to SDGs and undermined the general approach toward suitability by slowing down the process toward achieving the 17 SDGs and changing the trajectory of development. In particular, those SDGs that depend on globalization and economic growth are mostly affected. Specifically, the COVID-19 pandemic poses a severe threat to socio-economic SDGs, such as SDG1 (no poverty) or SDG8 (decent work and economic growth) [18]. There is a lot of probability that what happens at an organizational level spills over and has consequences on individuals, as system theories suggest. Earlier studies found that COVID-19 reversed years of worldwide health progress. There has been a decline in human life expectancy. The coronavirus has also disrupted ongoing health improvements, such as newborn and child death prevention, non-communicable disease treatments, communicable disease detection, mental health, and equal healthcare. Furthermore, infected people are at risk of death, long-term disabilities, lung and heart damage, and antibacterial resistance as a result of the virus [5]. Other studies showed that even before the pandemic, progress toward achieving the SDGs had been too slow [10].

We also found that more than half of the cities and municipalities that experienced a slowdown in the SDG process due to the COVID-19 crisis indicated that they were planning to evolve toward acceleration and foresaw no impact on their SDG implementation once COVID-19 was over (Figure 3). In fact, local governments hoped to further strengthen the commitment toward SDGs even after COVID-19. However, we found that the SDG implementation, in general, did not seem to accelerate during the crisis (only for a small minority). The crisis mainly acted as a wake-up call that led some organizations to accelerate their commitment once the crisis was over. COVID-19 can thus act as a threat to SDG implementation but also as an opportunity. This is in line with other research, which states that the crisis can be used as an opportunity to strengthen the commitment to the Agenda 2030 [4]. Pan and Zhang [53] (p. 1), in turn, concluded that the "pandemic presents an excellent opportunity for the human family to act in solidarity and turn this crisis into an impetus to achieve the UN SDGs".

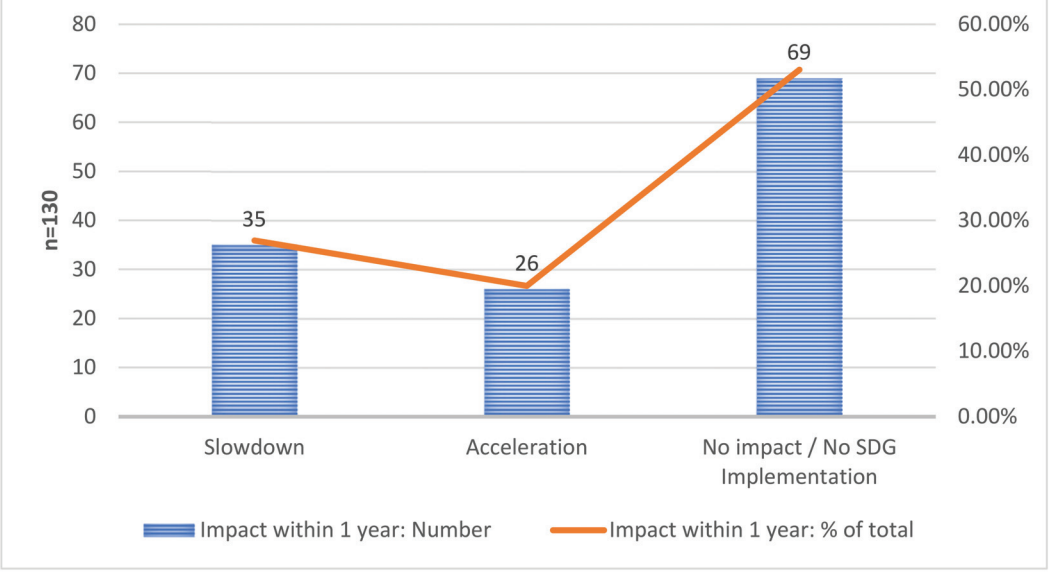

Figure 3. Direct impact of COVID-19 on SDG Implementation of cities/municipalities within 1 year.

5.2. The Prioritization and Acceleration Effect

Zooming in on the separate SDGs for a moment, it appeared that SDG3 (good health and well-being), SDG1 (no poverty), SDG11 (sustainable cities and communities), and SDG4 (quality education) were already high on the agenda of Flemish cities and municipalities in July 2021. At the time of the survey, the cities and municipalities indicated a particular engagement with the above-mentioned SDGs in respective order. We also asked the question of which of the SDGs the engagement of the city or municipality changed due to the COVID-19 crisis (Table 2). SDG3 (good health and well-being) again scored very high. Just under 60% of the cities and municipalities indicated an increased engagement with this SDG because of the COVID-19 crisis. SDG1 (no poverty) again scored high and was also an outlier. Just under 55% of the cities and municipalities indicated that the engagement with this SDG had increased due to COVID-19. Finally, we asked which SDGs the cities and municipalities expect to engage in within a year. The results from this were almost identical to the results of the current situation mentioned above. SDG11 (sustainable cities and communities) and SDG1 (no poverty) again scored particularly high. SDG3 (good health and well-being) also scored high here. However, suddenly, SDG7 (affordable and sustainable energy) and SDG13 (climate action) moved up in the score, so these SDGs appeared to be becoming increasingly important for cities and municipalities.

Table 2. COVID-19 impact on individual SDG engagement.

	Reduced Engagement		**No Change**		**Increased Engagement**	
	Number	**% of Total**	**Number**	**% of Total**	**Number**	**% of Total**
SDG1	2	1.79%	50	44.64%	60	53.57%
SDG2	3	2.70%	74	66.67%	34	30.63%
SDG3	3	2.68%	43	38.39%	66	58.93%
SDG4	7	6.36%	77	70.00%	26	23.64%
SDG5	4	3.67%	99	90.83%	6	5.50%
SDG6	4	3.67%	95	87.16%	10	9.17%
SDG7	9	8.11%	88	79.28%	14	12.61%
SDG8	5	4.50%	82	73.87%	24	21.62%
SDG9	7	6.48%	87	80.56%	14	12.96%
SDG10	1	0.90%	83	74.77%	27	24.32%
SDG11	6	5.36%	84	75.00%	22	19.64%
SDG12	8	7.14%	85	75.89%	19	16.96%
SDG13	7	6.25%	86	76.79%	19	16.96%
SDG14	6	5.45%	98	89.09%	6	5.45%
SDG15	4	3.64%	93	84.55%	13	11.82%
SDG16	6	5.50%	84	77.06%	19	17.43%
SDG17	9	8.18%	80	72.73%	21	19.09%

In part, these specific results are within a pattern of expectation. COVID-19 has created new societal challenges and changed priorities for a lot of societal actors. For instance, the primary impact the virus had was obviously on the health of humans and consequently on the health system, resulting in overcrowded hospitals and not fully sufficient medical treatments [3]. With the COVID-19 pandemic hitting in early 2020, cities and municipalities worldwide were faced with new challenges. Hospitals and residential care centers had to be given extra support, local vaccination centers had to be quickly set up, etc. These circumstances led Flemish local authorities to shift their priorities in order to provide local services that were needed to meet the health challenges caused by the COVID-19 crisis. In this sense, SDG3 became a priority for many organizations due to COVID-19, especially for cities and municipalities (Table 2). One of the other main consequences is the fact that SDG1 (no poverty) has been severely hit by the economic crisis following the COVID-19 crisis, as roughly half a billion people are likely to have been driven into poverty [18]. This has engaged the public sector more in the fight against poverty. During the pandemic, the UN projected that this increase in poverty could represent a reversal of approximately a decade

in the world's progress in reducing poverty [13,14]. No wonder SDG1 became another main priority behind health following the COVID-19 outbreak. As mentioned above, this is reflected in the results, since at the time of the survey (mid-COVID-19 crisis), SDG3 and SDG1 were the SDGs on which Flemish cities and municipalities were engaged the most. We thus argued that SDG priorities had been shifted by the crisis. Although there were priorities before COVID-19, the pandemic ensured that cities and municipalities shifted their priorities or reworked them to respond to the crisis. At the same time, the cities and municipalities were able to protect themselves by setting priorities once the pandemic was over.

If we compare the above findings, we can conclude that cities and municipalities mainly focused on SDG3 (good health and well-being), SDG1 (no poverty), SDG11 (sustainable cities and communities), and SDG4 (quality education). Due to the COVID-19 crisis, some of these SDGs got even more prioritized (SDG3/SDG1). As a consequence, the engagement with these SDGs has also increased, and the cities and municipalities plan to continue this into subsequent years. In fact, the engagement of cities and municipalities has increased sharply during the COVID-19 crisis regarding specifically these SDGs. As a result, H2 is also accepted: local governments' implementation of some SDGs that got prioritized due to COVID-19 got accelerated. This sudden shift in priority could also mean that they had to postpone other SDG-related activities until COVID-19 was under control, which in turn also explained the overall slowdown of SDG implementation in general (H1).

5.3. The Postponement Effect

Figure 4 and Table 3 show the results of the SDG implementation activities in the current situation, in the hypothetical counterfactual situation (given the non-existence of COVID-19), and in the future. To gain insights into SDG implementation activities, we made use of the SDG compass and its five proposed steps (activities). We noticed that, for example, at the moment of the survey, 88 cities and municipalities indicated that they had been engaging with 'understanding the SDGs', which corresponds to almost 70% of all the participants. This means that about two-thirds of the Flemish cities and municipalities were actively engaged with 'Understanding the SDGs' at the moment of the survey. Keep in mind that this constitutes a snapshot. It could be the case that of the 30% who are not doing this, a number of them might have already taken this step in the past.

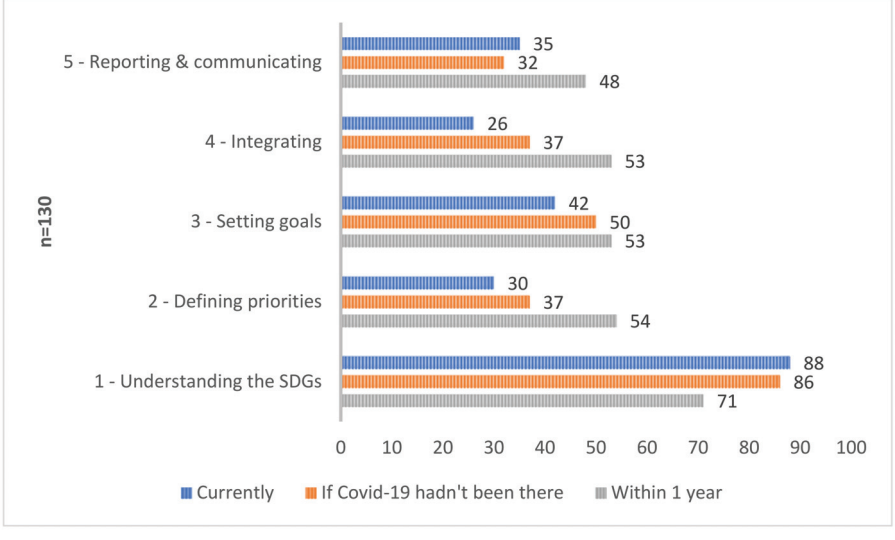

Figure 4. SDG Implementation of Flemish cities/municipalities—SDG Compass.

Table 3. SDG Implementation of Flemish cities/municipalities—SDG Compass.

	Currently		If COVID-19 Had not Been There		Within 1 Year	
	Number	**%**	**Number**	**%**	**Number**	**%**
Understanding the SDGs	88	67.69%	86	66.15%	71	54.62%
Defining priorities	30	23.08%	37	28.46%	54	41.54%
Setting goals	42	32.31%	50	38.46%	53	40.77%
Integrating	26	20.00%	37	28.46%	53	40.77%
Reporting & communicating	35	26.92%	32	24.62%	48	36.92%
Total responses	221	n = 130	242	n = 130	279	n = 130

The results indicated that if there had not been a COVID-19 crisis, cities and municipalities would have achieved a little more with regard to the application of the SDGs in their policies, especially in terms of defining priorities, setting goals, and integrating. We also noticed that had COVID-19 not been there, a total of 242 activities would have been undertaken by the 130 participants. At the time of the survey, a total of 221 activities were being undertaken by the 130 participants. Hence, had it not been for COVID-19, nearly 10% more SDG implementation activities in total would have taken place. This showed again that, to a limited extent, there was some postponement of SDG activities. When we then looked at the future numbers (within a year), we saw that some of these activities are clearly increasing, sometimes even doubling. Additionally, the 130 participants indicated that they would undertake 279 SDG implementation activities in total within a year, meaning an increase of more than 25%. This again demonstrated both the commitment referred to earlier but also gave a limited indication of a deferral of various SDG activities.

Therefore, we found that if COVID-19 have not been there, Flemish cities and municipalities would have achieved somewhat more regarding SDG implementation activities. On top, we found that during COVID-19, some SDG implementation activities were not coming up, although a lot of cities and municipalities were actually planning them. This gave us an indication that, during the COVID-19 crisis, local governments indeed postponed certain SDG implementation activities. We thus accepted H3: due to the COVID-19 crisis, local governments postponed certain SDG implementation activities.

Again, these results are within a pattern of expectation. Due to COVID-19, organizations around the world were forced to suspend several activities and/or to even shut down (Leal Filho et al., 2020). The former also applied to state and local governments as COVID-19 shocked cities and revealed some of their vulnerabilities [54]. Virtually overnight, cities were forced to organize, implement, and financially respond to both public health and economic crisis [55]. Hence, COVID-19 created a lot of policy challenges for them, but also some financial challenges. Given significant losses in revenues and increased expenditures, cities had thus to face severe problems on both the revenue and expenditure sides of their budgets [56]. As a consequence of these financial and policy challenges, a lot of cities and municipalities postponed, paused, or even stopped some activities. A recent study, for example, showed that due to COVID-19, almost all of the researched cities and municipalities stopped the preparation and implementation of new investments and also stopped providing financial support to, for example, sports and culture [56]. As a result, non-priority expenditures and planned investments were canceled or postponed. The same went for planned activities and projects. Many non-priority activities and projects of cities and municipalities were also postponed or canceled because of COVID-19 and had to give way to what at that time really counted. Essentially, one could expect this since literature tells us that when organizations are facing harsh times; voluntary and non-priority activities and expenses are the first things to be axed [57]. One could argue that at the time of COVID-19, when cities were forced to organize and implement massive responses to an unseen crisis, conducting activities for SDG implementation was neither

a priority nor mandatory. Therefore, one could expect that many of these activities were indeed axed or postponed.

It is noticeable that at the time of the survey, less than one-third of all the cities and municipalities were involved in what we considered the more intensive and complex steps in the SDG compass (defining priorities, setting goals, integrating, and reporting and communicating). This seems to be a general tendency in many organizations as other research pointed to a superficial engagement with the SDGs for the vast majority of organizations, which, according to some, could suggest a process of 'SDG-washing' [58]. Embracing but not fully implementing SDGs could create a particular danger: that of unintended 'SDG washing'. Organizations should guard against what scholars have termed SDG cherry-picking. Prioritizing within the SDGs is sound when it is established through coherent and structured approaches [59,60], as otherwise, there is a risk of "cherry picking" the goals that the organization was already working on and not dealing with those that were left out but were still important for the organization or its stakeholders [61], which can lead to reinforcing "business as usual" and stopping the transformational character of the 2030 Agenda [40].

6. Discussion and Conclusions

The main ambition of this study was to examine the effect of the COVID-19 pandemic on the local public sector's SDG implementation. Practitioners and scholars of the public sector have recently begun to realize that the pandemic and its aftermath offer an opportunity to rethink our (economic) policy foundations and align them with the needs of the people and the planet. This study built on a growing body of work that has pointed at the impact of COVID-19 on macro and micro levels, especially on public organizations, using an innovative methodological approach to single out the effects of the pandemic at the organizational level while looking into the past, the period of the pandemic, and after the pandemic and to evaluate public organizations' efforts to implement the UN 2030 Agenda.

Our findings offered support to the expectations that COVID-19 has slowed down the public sector's SDG implementation at the local level. At the same time, COVID-19 has allowed local public institutions to accelerate the implementation of a number of key SDGs that got prioritized due to COVID-19, such as SDG3 (health) and SDG1 (poverty). COVID-19 has also allowed local governments to set new priorities in this way, some of which will be accomplished once the pandemic is 'over'. In that sense, COVID-19 has acted as a sort of accelerant. Finally, due to COVID-19, local governments postponed a few SDG-related activities, which would be resumed once the pandemic is 'over'. Our study contributed to other studies by demonstrating that the findings hold when using a counterfactual approach of not just 'how did COVID-19 prevent organizations from implementing SDGs?' but also 'what stage would the organization be at if COVID-19 had not been there?' and 'how does the organization plan implementing SDGs once the pandemic is over?' As such, this study is the first to offer rigorous empirical evidence on the impact of COVID-19 on public organizations at the local level contributing to existing findings that have studied the impact of COVID-19 at a macro level and on individuals.

The findings of this study suggested two main contributions for scholars and practitioners dealing with SDGs. At the theory level, the contribution of this paper lies in its support that while individuals are part of systems, both entities are separate and react to the crisis differently. As such, reactions to a crisis, either by individuals or systems, are a vital element to be considered in understanding the impact of a crisis within the context of layers. To our knowledge, this study is the first to rigorously separate organizations (systems) and individuals and show how organizations, with the example of local public institutions, reacted to and were affected by the COVID-19 crisis. SDG achievement is important not just to individuals but also to organizations and hence the importance of our research. Future studies could focus on how organizations in the private sector react and get affected by the crisis.

The second contribution of our study is at the level of the methodological approach. Although different scholars analyzed the effects of COVID-19 on SDGs [4,9,18], it was unclear whether the effects on SDG implementation are only attributable to the COVID-19 crisis or had been there before. Using data from the survey we conducted together with VVSG, we were able to disentangle various effects over time. Besides knowing what the effects of COVID-19 are on the implementation of SDGs, our methodological approach allowed us to estimate corresponding counterfactual situations in the past and in the future. This strategy allowed us to distinguish effects caused by pre-existing problems predating the crisis from the effects of the crisis and also allowed us to estimate what reactions would be taken to counter both types of effects. This allowed us to support the proposed hypotheses and to make empirical claims regarding diverse effects on public organizations' quest to implement SDGs.

There are a number of limitations and research implications associated with this study. We are aware that there could be some other hidden factors, mechanisms, and processes (such as funding, size, expertise, SDG maturity, etc.) of which we currently have no data that make local governments' SDG implementation positively and negatively affected by COVID-19 (either concurrently or separately). We are also aware that specific state and institutional structures in which local governments operate could have a significant influence on the explored relationship. We are also aware of the fact that these structures differ amongst nations (e.g., developed vs. developing states), limiting the generalization of the findings. Future studies could adopt other methodological approaches, such as process tracing in qualitative analysis, to complement our correlation approach in the analysis of causation.

In line with the research implication for practice, the results call for a focus on all SDGs instead of falling into cherry-picking and SDG washing. Given that COVID-19 has reversed the progress made on achieving the Agenda 2030, renewed effort in the implementation of SDGs by public organizations and private ones alike is crucial. There is a need for different organizations and levels to adjust their priorities in line with COVID-19 effects but also bearing in mind that there is an interaction between individual SDGs. This argument becomes more important when taking into account the long-term effects of COVID-19. Bearing this in mind will lead organizations both at local and other levels to adopt new strategies that may accelerate the implementation of SDGs so that no one can be left behind. This study joins various earlier studies on the effects of crises on SDG implementation. It is good to always consider both negative effects and positive effects. COVID-19 is a wake-up call and an opportunity to commit more toward the implementation of SDGs. During the crisis, it became apparent that the focus turned on solving the crisis, and this involved setting new priorities and postponing some activities. Once the crisis is over, the public sector falls back to its initial priorities. Some institutions even propose to strengthen some of the pre-crisis priorities mainly because of the lessons they have learned from the crisis. Whether it is strengthening existing priorities or taking on new or initially neglected elements as priorities, COVID-19 has led the public sector to adopt a temporary shift in priorities in certain SDGs and other unrelated activities.

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References

1. Pradhan, P.; Subedi, D.R.; Khatiwada, D.; Joshi, K.K.; Kafle, S.; Chhetri, R.P.; Dhakal, S.; Gautam, A.P.; Khatiwada, P.P.; Mainaly, J. The COVID-19 pandemic not only poses challenges, but also opens opportunities for sustainable transformation. *Earth's Future* **2021**, *9*, e2021EF001996. [CrossRef]
2. Farzad, F.S.; Salamzadeh, Y.; Amran, A.B.; Hafezalkotob, A. Social Innovation: Towards a better life after COVID-19 crisis: What to concentrate on. *J. Entrep. Bus. Econ.* **2020**, *8*, 89–120.
3. Martinoli, S. *2030 Agenda and Business Strategies: The Sustainable Development Goals as a Compass towards a Common Direction*; FrancoAngeli: Milan, Italy, 2021; pp. 129–152. [CrossRef]
4. Shulla, K.; Voigt, B.-F.; Cibian, S.; Scandone, G.; Martinez, E.; Nelkovski, F.; Salehi, P. Effects of COVID-19 on the sustainable development goals (SDGs). *Discov. Sustain.* **2021**, *2*, 15. [CrossRef]
5. Fallah Shayan, N.; Mohabbati-Kalejahi, N.; Alavi, S.; Zahed, M.A. Sustainable Development Goals (SDGs) as a Framework for Corporate Social Responsibility (CSR). *Sustainability* **2022**, *14*, 1222. [CrossRef]
6. Meuleman, L. Public Administration and Governance for the SDGs: Navigating between Change and Stability. *Sustainability* **2021**, *13*, 5914. [CrossRef]
7. Myer, R.A.; Moore, H.B. Crisis in context theory: An ecological model. *J. Couns. Dev.* **2006**, *84*, 139–147. [CrossRef]
8. Naidoo, R.; Fisher, B. Reset sustainable development goals for a pandemic world. *Nature* **2020**, *583*, 198–201. [CrossRef]
9. Ottersen, O.P.; Engebretsen, E. COVID-19 puts the sustainable development goals center stage. *Nat. Med.* **2020**, *26*, 1672–1673. [CrossRef]
10. Van Zanten, J.A.; Van Tulder, R. Beyond COVID-19: Applying "SDG logics" for resilient transformations. *J. Int. Bus. Policy* **2020**, *3*, 451–464. [CrossRef]
11. Chen, J.; Gao, M.; Cheng, S.; Hou, W.; Song, M.; Liu, X.; Liu, Y.; Shan, Y. County-level CO_2 emissions and sequestration in China during 1997–2017. *Sci. Data* **2020**, *7*, 391.
12. Le Quéré, C.; Jackson, R.B.; Jones, M.W.; Smith, A.J.; Abernethy, S.; Andrew, R.M.; De-Gol, A.J.; Willis, D.R.; Shan, Y.; Canadell, J.G. Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement. *Nat. Clim. Change* **2020**, *10*, 647–653. [CrossRef]
13. Lu, J. What Will COVID-19 Do to the Sustainable Development Goals? 2020. Available online: https://www.undispatch.com/what-will-COVID-19-do-to-the-sustainable-development-goals/ (accessed on 9 February 2023).
14. Sumner, A.; Hoy, C.; Ortiz-Juarez, E. *Estimates of the Impact of COVID-19 on Global Poverty*; WIDER Working Paper; The United Nations University World Institute for Development Economics Research (UNU-WIDER): Helsinki, Finland, 2020.
15. Sumner, A.; Ortiz-Juarez, E.; Hoy, C. Precarity and the Pandemic: COVID-19 and Poverty Incidence, Intensity, and Severity in Developing Countries. WIDER Working Paper; The United Nations University World Institute for Development Economics Research (UNU-WIDER): Helsinki, Finland, 2020.
16. Friedman, M. *Capitalism and Freedom*; University of Chicago Press: Chicago, IL, USA, 2020.
17. Alibegovic, M.; Cavalli, L.; Lizzi, G.; Romani, I.G.; Vergalli, S. COVID-19 & SDGs: Does the current pandemic have an impact on the 17 Sustainable Development Goals? A qualitative analysis. A Qualitative Analysis (June 8, 2020). FEEM Policy Brief. 2020. Available online: https://www.feem.it/publications/covid-19-sdgs-does-the-current-pandemic-have-an-impact-on-the-17-sustainable-development-goals-a-qualitative-analysis/ (accessed on 9 February 2023).
18. Hörisch, J. The relation of COVID-19 to the UN sustainable development goals: Implications for sustainability accounting, management and policy research. *Sustain. Account. Manag. Policy J.* **2021**, *5*, 877–888. [CrossRef]
19. Hajer, M.; Nilsson, M.; Raworth, K.; Bakker, P.; Berkhout, F.; De Boer, Y.; Rockström, J.; Ludwig, K.; Kok, M. Beyond cockpit-ism: Four insights to enhance the transformative potential of the sustainable development goals. *Sustainability* **2015**, *7*, 1651–1660. [CrossRef]
20. Pogge, T.; Sengupta, M. The Sustainable Development Goals: A plan for building a better world? *J. Glob. Ethics* **2015**, *11*, 56–64. [CrossRef]
21. Stevens, C.; Kanie, N. The transformative potential of the sustainable development goals (SDGs). *Int. Environ. Agreem. Politics Law Econ.* **2016**, *16*, 393–396. [CrossRef]
22. Mazmanian, D.A.; Sabatier, P.A. *Implementation and Public Policy*; Scott Foresman: Northbrook, IL, USA, 1983.
23. Fiandrino, S.; Scarpa, F.; Torelli, R. Fostering Social Impact Through Corporate Implementation of the SDGs: Transformative Mechanisms Towards Interconnectedness and Inclusiveness. *J. Bus. Ethics* **2022**, *180*, 959–973. [CrossRef]
24. Sachs, J.; Schmidt-Traub, G.; Kroll, C.; Lafortune, G.; Fuller, G. *Sustainable Development Report 2019*; Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN): New York, NY, USA, 2019.

25. Beshi, T.D.; Kaur, R. Public trust in local government: Explaining the role of good governance practices. *Public Organ. Rev.* **2020**, *20*, 337–350. [CrossRef]
26. United Nations. *The Sustainable Development Goals Report 2021*; United Nations: New York, NY, USA, 2021.
27. Adams-Prassl, A.; Boneva, T.; Golin, M.; Rauh, C. Inequality in the impact of the coronavirus shock: Evidence from real time surveys. *J. Public Econ.* **2020**, *189*, 104245. [CrossRef]
28. Eurofound. *Living and Working in Europe 2021*; Publications Office of the European Union: Luxembourg, 2022.
29. Brezzi, M.; González, S.; Nguyen, D.; Prats, M. *An Updated OECD Framework on Drivers of Trust in Public Institutions to Meet Current and Future Challenges*; OECD Working Papers on Public Governance; OECD: Paris, France, 2021; Volume 48. [CrossRef]
30. Adhikari, S.P.; Meng, S.; Wu, Y.-J.; Mao, Y.-P.; Ye, R.-X.; Wang, Q.-Z.; Sun, C.; Sylvia, S.; Rozelle, S.; Raat, H.; et al. Epidemiology, causes, clinical manifestation and diagnosis, prevention and control of coronavirus disease (COVID-19) during the early outbreak period: A scoping review. *Infect. Dis. Poverty* **2020**, *9*, 29. [CrossRef]
31. Fleetwood, J. Social justice, food loss, and the sustainable development goals in the era of COVID-19. *Sustainability* **2020**, *12*, 5027. [CrossRef]
32. Khetrapal, S.; Bhatia, R. Impact of COVID-19 pandemic on health system & Sustainable Development Goal 3. *Indian J. Med. Res.* **2020**, *151*, 395. [PubMed]
33. Kumar, A.; Luthra, S.; Mangla, S.K.; Kazançoğlu, Y. COVID-19 impact on sustainable production and operations management. *Sustain. Oper. Comput.* **2020**, *1*, 1–7. [CrossRef]
34. Sunny, A.R.; Sazzad, S.A.; Prodhan, S.H.; Ashrafuzzaman, M.; Datta, G.C.; Sarker, A.K.; Rahman, M.; Mithun, M.H. Assessing impacts of COVID-19 on aquatic food system and small-scale fisheries in Bangladesh. *Mar. Policy* **2021**, *126*, 104422. [CrossRef] [PubMed]
35. Leal Filho, W.; Brandli, L.L.; Lange Salvia, A.; Rayman-Bacchus, L.; Platje, J. COVID-19 and the UN sustainable development goals: Threat to solidarity or an opportunity? *Sustainability* **2020**, *12*, 5343. [CrossRef]
36. FAO & WFP. *FAO-WFP Early Warning Analysis of Acute Food Insecurity Hotspots: July 2020*; Food and Agriculture Organization of the United Nations/World Food Programme: Rome, Italy, 2020.
37. Sempiga, O. Investing in Sustainable Development Goals: Opportunities for private and public institutions to solve wicked problems that characterize a VUCA world. In *Investment Strategies—New Advances and Challenges*; Prelipcean, G., Ed.; IntechOpen: London, UK, 2023; ISBN 978-1-83768-199-0.
38. Forestier, O.; Kim, R.E. Cherry-picking the Sustainable Development Goals: Goal prioritization by national governments and implications for global governance. *Sustain. Dev.* **2020**, *28*, 1269–1278. [CrossRef]
39. CIVITAS. The 'Climate Streets' of Antwerp. 2022. Available online: https://sump-plus.eu/news?c=search&uid=F08FBTRh (accessed on 9 February 2023).
40. Soberón, M.; Sánchez-Chaparro, T.; Urquijo, J.; Pereira, D. Introducing an Organizational Perspective in SDG Implementation in the Public Sector in Spain: The Case of the Former Ministry of Agriculture, Fisheries, Food and Environment. *Sustainability* **2020**, *12*, 9959. [CrossRef]
41. Linnenluecke, M.K. Resilience in business and management research: A review of influential publications and a research agenda. *Int. J. Manag. Rev.* **2017**, *19*, 4–30. [CrossRef]
42. Hadida, A.L.; Tarvainen, W.; Rose, J. Organizational improvisation: A consolidating review and framework. *Int. J. Manag. Rev.* **2015**, *17*, 437–459. [CrossRef]
43. Breuer, A.; Janetschek, H.; Malerba, D. Translating sustainable development goal (SDG) interdependencies into policy advice. *Sustainability* **2019**, *11*, 2092. [CrossRef]
44. Nature Editoral. Time to revise the Sustainable Development Goals. *Nature* **2020**, *583*, 331–332. [CrossRef]
45. United Nations. *Progress Towards the Sustainable Development Goals*; Report of the Secretary-General; High-level political forum on sustainable development, convened under the auspices of the Economic and Social Council: New York, NY, USA, 2020.
46. United Nations. *World Social Report 2020. Inequality in a Rapidly Changing World*; Department of Economic and Social Affairs, Ed.; United Nations: New York, NY, USA, 2020.
47. GRI; UN Global Compact; WBCSD. SDG Compass. 2015. Available online: https://sdgcompass.org/ (accessed on 9 February 2023).
48. Podsakoff, P.M.; MacKenzie, S.B.; Lee, J.-Y.; Podsakoff, N.P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *J. Appl. Psychol.* **2003**, *88*, 879. [CrossRef]
49. Briones Alonso, E.; Van Ongevalle, J.; Molenaers, N.; Vandenbroucke, S. *SDG Compass Guide: Practical Frameworks and Tools to Operationalise Agenda 2030*; HIVA-KU Leuven Working Paper; HIVA-KU Leuven: Leuven, Belgium, 2021.
50. Vlaamse Overheid. *SDG Handleiding Voor Overheidsorganisaties*; Departement Kanselarij & Bestuur, Ed.; Vlaamse Overheid: Brussel, Belgium, 2018.
51. Grainger-Brown, J.; Malekpour, S. Implementing the sustainable development goals: A review of strategic tools and frameworks available to organisations. *Sustainability* **2019**, *11*, 1381. [CrossRef]
52. Muff, K.; Kapalka, A.; Dyllick, T. The Gap Frame—Translating the SDGs into relevant national grand challenges for strategic business opportunities. *Int. J. Manag. Educ.* **2017**, *15*, 363–383. [CrossRef]
53. Pan, S.L.; Zhang, S. From fighting COVID-19 pandemic to tackling sustainable development goals: An opportunity for responsible information systems research. *Int. J. Inf. Manag.* **2020**, *55*, 102196. [CrossRef]

54. Hassankhani, M.; Alidadi, M.; Sharifi, A.; Azhdari, A. Smart City and Crisis Management: Lessons for the COVID-19 Pandemic. *Int. J. Environ. Res. Public Health* **2021**, *18*, 7736. [CrossRef]
55. Green, D.; Loualiche, E. State and local government employment in the COVID-19 crisis. *J. Public Econ.* **2021**, *193*, 104321. [CrossRef]
56. Nemec, J.; Špaček, D. The COVID-19 pandemic and local government finance: Czechia and Slovakia. *J. Public Budg. Account. Financ. Manag.* **2020**, *32*, 837–846. [CrossRef]
57. Harwood, I.; Humby, S.; Harwood, A. On the resilience of corporate social responsibility. *Eur. Manag. J.* **2011**, *29*, 283–290. [CrossRef]
58. Heras-Saizarbitoria, I.; Urbieta, L.; Boiral, O. Organizations' engagement with sustainable development goals: From cherry-picking to SDG-washing? *Corp. Soc. Responsib. Environ. Manag.* **2022**, *29*, 316–328. [CrossRef]
59. Allen, C.; Metternicht, G.; Wiedmann, T. Initial progress in implementing the Sustainable Development Goals (SDGs): A review of evidence from countries. *Sustain. Sci.* **2018**, *13*, 1453–1467. [CrossRef]
60. Allen, C.; Metternicht, G.; Wiedmann, T. Prioritising SDG targets: Assessing baselines, gaps and interlinkages. *Sustain. Sci.* **2019**, *14*, 421–438. [CrossRef]
61. Ranängen, H.; Cöster, M.; Isaksson, R.; Garvare, R. From global goals and planetary boundaries to public governance—A framework for prioritizing organizational sustainability activities. *Sustainability* **2018**, *10*, 2741. [CrossRef]

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The Impact of the COVID-19 Pandemic on Financial Condition and Mortality in Polish Regions

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Abstract: The study aimed to assess the impact of the COVID-19 pandemic on the financial condition and mortality in Polish voivodeships. To achieve this objective, the relationship between the number of deaths before and during the pandemic and the financial condition of the provinces in Poland was studied. The study covered the years 2017–2020, for which a one-way ANOVA was used to verify whether there was a relationship between the level of a province's financial condition and the number of deaths. The results of the study are surprising and show that before the COVID-19 pandemic, there was a higher number of deaths in provinces that were better off financially, but the relationship was not statistically significant. In contrast, during the pandemic, a statistically significant strong negative correlation between these values was proven, which, in practice, shows that regions with better financial conditions had a higher number of deaths during COVID-19.

Keywords: self-government finances; financial condition of local administrative units; number of deaths; COVID-19

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1. Introduction

The pandemic brought about by the SARS-CoV-2 virus changed the way the world functioned, the economy, and citizens' lives. It also affected the condition of public finances, including self-government finances. The research completed by the key financial institutions has shown that the COVID-19 pandemic had an impact on reducing the income of local administrative units—LAUs (municipalities, poviats, and voivodships), mainly as a result of decreasing the tax proceeds, and also on increasing the expenses, which finally resulted in decreased possibilities of contracting debt. Taking a look from a financial perspective makes it possible to comprehensively evaluate LAU functioning and its development capabilities [1]. Finance management in LAU should foster rational expenditure of public financial resources and make correct decisions regarding the management of monetary funds [2]. An important issue in LAU evaluation is its financial condition understood as the self-government's ability to balance the recurring expenses with recurring sources of income while fulfilling the statutory tasks stipulated by the legal regulations. Other definitions of financial conditions take into account the possibility of financing the services on a continuous basis, the complexity of healthy finance, the ability to pay liabilities, and keeping the current level of services while maintaining the resistance to changes taking place over time [3]. The terms 'financial condition' and 'financial situation' are used interchangeably and defined in different ways [1,4–10]. In view of the research studies presented in this paper, it was decided that the most pertinent definition of financial condition will be the entity's ability to timely meet its financial liabilities and the ability to sustain the services provided to the public [11].

Researchers all over the world have taken up numerous studies regarding the impact of COVID-19 on the activity of business entities. The research studies covered the influence of COVID-19 on the labor market and its inequalities [12], also taking into consideration people with disabilities [13], the school education process in Germany [14], and also on employment in LAUs in the USA, in particular, the situation of decreased income and increased expenses [15]. Other research studies also addressed the relationship between the COVID-19 pandemic and the mortality rate [16], the economic development rate [17], and the population size, which has an impact on burdening the healthcare system [18]. An analysis of the average life expectancy has shown an increased mortality risk during the pandemic, globally as well as in Poland [19], and more lost years of life expectancy than before the pandemic [20]. Additionally, the analysis covered the impact of COVID-19 nationally [21], in local sectors [22], and the federal budgets in the USA [23] on the subject of small and medium enterprises [24,25], their creditworthiness, and the system of guarantees and suretyships for SMEs [26]. Rama Iyer and Simkins [27] analyzed 81 articles regarding COVID-19 and the economy, according to citation counts in Google Scholar. They divided the selected articles into five thematic areas: investments and assets valuation, macroeconomics and banking, resources, business finance, and others. The studies regarded the capital market, labor market, education market, and condition of enterprises and economies on the macro scale.

Despite such extensive research available in the literature, the authors of this paper identified a shortage of studies regarding the financial condition of local administrative units (LAUs), such as cities and municipalities, second-tier administrative units (poviats), or self-governments of provinces (voivodeships). This is particularly important because, in a COVID-19 pandemic, regional economies were vulnerable to measures taken by central governments and instruments used in mitigating the pandemic's effects. At the same time, measures taken on a national scale had an impact on regions and their economic situation, however, with diverse effects [28]. In this context, the financial situation of LAUs in that period should be considered in two aspects. On one side, from the point of view of the need to increase expenses to counteract the COVID-19 pandemic and to eliminate its effects, and parallel to that in terms of decreased current proceeds (i.a. from lease and rental fees, due to releasing entrepreneurs from the duty to pay such charges as a result of temporary suspension of their activity). The study aimed to assess the impact of the COVID-19 pandemic on the financial condition and mortality in Polish regions. To achieve the goal, the relationship between the number of deaths and the financial condition of voivodeships in Poland in the period before the COVID-19 pandemic and during the course of it.

This research study was based on the statistical and financial data found in budget implementation reports submitted by LAUs in Poland for the years 2017–2020 (latest available data). For each region, financial condition indicators (in relative terms) were computed, which made it possible to draw conclusions regarding the impact of COVID-19 on their financial standing, and its influence on the mortality rate.

The research scope covered 16 self-governing voivodeships in Poland [29,30]. Voivodeships in Poland are interchangeably referred to as regions (NUTS2), In the same breadth and they constitute one of the three levels of LAUs, along with municipalities and poviats.

The paper consists of several sections put in a logical sequence. Section one includes theoretical aspects connected with the discussed issues, prepared on the basis of the literature review. Additionally, it contains the analyses of the concept and factors of LAU's financial condition as well as metrics of its evaluation. The next section discusses the scale and effects of the COVID-19 pandemic and its impact on public finances and mortality rates in the regions. Section three presents the research study concept along with a description of the applied research methods. Section four shows the research results, and the last one contains conclusions.

2. The Concept of the Financial Condition of Regions

Each self-governing voivodeship functions and operates on the basis of the same regulatory framework. This includes not only the systemic and administrative norms but first and foremost the aspects of the functional affiliation, in accordance with which the relevant legal acts (Act on municipality self-government, poviat self-government, and voivodeship government) contain a catalog of statutory tasks, which imposes on each voivodeship the duty to carry out the same tasks (where one of the major tasks is fostering the development of a given voivodeship and creation of mechanisms and instruments to stimulate its development). In order that the enumerated tasks may be implemented, the legislator (i.a. in the Act on public finance or in the Constitution) indicated concrete sources of income, which are identical for every voivodeship. This means that in the legal and financial aspects the situation of all voivodeships at the starting point is the same.

Financial condition is in most cases treated as a synonym for the terms financial situation or financial standing. Dylewski et al. [7] pointed out that the concepts of financial condition and financial situation are almost identical and they added that the financial situation of a LAU is the state of finances that makes it possible to finance the implementation of statutory tasks, meeting the quantitative and qualitative requirements at a given time and in the future, which is specified by the time frame of the measurement, whereas, the financial condition is a result of decisions taken by local administrative units. Kopyściański and Rólczyński [6] supplemented this view saying that on the one hand the financial situation goal of an entity's activity, and on the other hand an outcome of decisions taken earlier. Zawora [1], in turn, underlined that the financial condition is not only a derivative of implemented public tasks and projects, but it itself constitutes a source of pro-effective activities. According to Natrini and Ritonga [11], the financial condition describes a LAU's ability to meet its financial liabilities, and based on the evaluation the self-government is able to specify how to meet the public needs, and how to make use of the resources in a more productive manner. A LAU in a good financial condition usually maintains an appropriate level of services despite a decrease in the fiscal income, it identifies long-term economic or demographic changes and adapts to them, and prepares resources to meet future needs. However, when under fiscal stress, a LAU usually faces problems with balancing the budget, experiences decreased levels of services, encounters difficulties with adapting to the socio-economic conditions, and has limited resources for financing future needs [31]. Proper assessment of a LAU's financial condition is not an easy process due to the complexity of the phenomenon, and in order to make the assessment objective financial ratios are most often used in practice [10].

According to Ritonga et al. [5], only a few researchers attempted to explain the factors influencing the financial condition, quoting papers that enumerate the main determinants of the financial condition of LAUs in various countries. The most frequently indicated determinants include: population size/density, environmental conditions, the state of the local economic base, governmental policies and financial practices (tax levels) having an impact on local resources, labor costs, costs of capital and other production resources. It is possible to state that in general terms the factors that are the most frequently identified are broadly defined socio-economic ones. Due to the complexity of factors influencing the financial condition of self-government, there are not any easy or immediate ways to understand the diversification of the financial situations of self-government.

Taking into account the factors mentioned above, it is possible to distinguish six metrics that illustrate the financial condition of a LAU [4]:

- ability to meet short-term liabilities (short-term solvency);
- ability to meet operating liabilities (budget liquidity);
- ability to meet long-term liabilities (long-term solvency);
- ability to overcome unexpected events in the future (financial flexibility);
- ability to effectively execute property rights (financial independence);
- ability to provide services for the community (solvency in terms of services provision).

The issue of assessing a LAU's financial condition is extremely important from the point of view of the informative value for decision-making and information purposes, as well as in view of the ability or inability to contract debt. Such an assessment provides information that facilitates decision-making with regard to implementing new tasks, and at the same time, it enables evaluation of the activities completed so far by the self-government within a specific scope [32]. The Polish literature on the subject presents the results of LAU's financial condition evaluation obtained via various methods, including those based on empirical metrics or synthetic indicators. Researchers most often rely on, for example, the indicators proposed by the Ministry of Finance. In view of the differentiation between the concepts of financial condition and financial situation, they supplement the indicators proposed by the Ministry with additional metrics [3,10,33–36]. The most frequently applied indicators to assess LAU's financial condition include the growth rate of income and expenses of LAUs in connection with the evaluation of the budget balances and with the operating result and the result of assets-related activities. The prevailing opinion is that any given unit's condition is best reflected by the level of income and expenses per capita [33]. In self-governmental practice, indicators of this kind are applied in order to make comparisons in terms of time and space in relation to other LAUs (particularly the neighboring ones) which in some aspects may be competitors e.g., when potential investors choose a location for investment or when residents want to start their business activity. Among the concepts, the one that deserves attention is the approach taken by the Regional Accounting Chamber which in its analysis of threats to LAU's financial management applies 9 criteria selected on the basis of indicators related to debt and financial results (total liabilities to income ratio, accumulated debt to income ratio, presence of payables due, individual debt repayment ratio, current expenses and debt to current income ratio, share of operating surplus/deficit in total income, lack of funds to cover an operating deficit, funds to be carried forward to next year's budget based on LAU's budget implementation balance sheet for the previous year, budget result to income ratio) [34]. Based on the outcome of LAU's credibility evaluation carried out by means of discriminant analysis methods, Adamczyk & Dawidowicz [3] pointed out that indicators of the greatest importance are those which in their structure comprise categories such as total income value, level of own income, operating surplus value, debt level, and debt service cost. Additionally, their research has shown that more diverse sets of indicators should be applied when analyzing the financial condition of bigger LAUs, e.g., cities with poviat (second-tier of local government administration in Poland) rights: or voivodeships (regions).

3. The Impact of the COVID-19 Pandemic on the Economy

The first cases of infections with the SARC-CoV-2 virus were identified in the city of Wuhan (province of Hubei, China) in December 2019. In March 2020 the World Health Organisation (WHO) announced "a global pandemic" [37]. Initially, the virus spread in China and Europe, but in the second quarter of 2020, it was present all over the world [24,38]. The COVID-19 pandemic quickly sprawled out, resulting in human tragedies and economic losses, affecting both developed and developing countries. By the end of 2020, more than 79 million SARC-CoV-2 infections were detected, resulting in more than 1.7 million deaths all over the world [39]. In Poland, the first case of a SARC-CoV-2 infection was identified on 4 March 2020 in Lubuskie voivodeship [40]. From the beginning of the pandemic till the end of 2020, over 1.25 million SARC-CoV-2 infections were detected in Poland, and there were more than 27 thousand deaths caused by COVID-19 [39].

The SARS-CoV-2 pandemic changed the way the world was functioning, affecting the economy and the citizens' lives, it also left its mark on the condition of public finances [21]. No country escaped the negative consequences [41,42]. The financial outcomes of the pandemic include on the one hand decreased public revenues (mainly from taxes), which was caused i.a. by restricted business activity, lower income, and decreased activity of households [43,44]. On the other hand, there was a rise in COVID-related expenses to compensate for the losses experienced by enterprises [45]. Most surveyees (63%) of

the OECD-European Committee of the Regions expected that the socio-economic crisis caused by the COVID-19 pandemic would have a significantly negative effect on local self-governments [46]. The findings of the initial studies and analyses were pessimistic with regard to the condition of local administrative units of each level [47,48]. In general, however, in many countries, the shock was partially cushioned by measures taken by central governments in the area of financial transfers [35]. In 2020 most countries introduced measures to support local and regional finances, to partially mitigate the effects of the economic shock. Cities and regions faced new challenges connected with the condition of local and regional economies, caused by the unpredictability of income levels and their reallocation in response to unpredicted events. Many self-governments had to cope with 'the scissors effect', i.e., increased levels of self-government expenses accompanied by decreased levels of income [46,49,50].

The research done by the World Bank has shown that the COVID-19 pandemic led to a decrease in the income of local administrative units, mainly as a result of decreased proceeds from taxes, increased expenses caused by extraordinary items, decreased creditworthiness and reduced ability to contract debt [51,52]. The research on the impact of COVID-19 on regional finances in Europe, Asia, and Africa have shown an average decrease in income of 10% and an average increase in expenses of 5%. The main reason for that decrease was a reduction in proceeds from taxes and charges, lease or sale of assets, and smaller transfers from central governments. This entailed the need to borrow money in order to cope with crisis situations, and suspending or abandoning of key investments [49]. Authorities all over the world took steps to prevent the virus from spreading and to mitigate its effects, the result of which was a total or partial closure of the whole economy sectors [53], which in turn reduced the activity of business entities [43,44] triggering long-term effects [54], in particular for tourism and aviation industry [55]. They ranged widely from travel restrictions to national and regional lockdowns, keeping social distance, and other measures fostering the formation of unconventional geopolitical and socio-spatial movements [28]. In response to the virus propagation, authorities imposed restrictions on transport, economic and industrial activity in many countries.

The scope and scale of the COVID-19 impact were unprecedented and heterogeneous, with major implications for crisis management and political reactions [56], on the one hand being an object of scientific research, and on the other generating effects which will be experienced for many years. COVID-19 had an impact on everyday life, causing far-reaching consequences in the area of healthcare and economy, and also in the social dimension [57,58]. According to the analysts, the effects of those measures were dramatic, and business activity slumped on a global scale [38]. According to P. Brinca et al. [53], the pandemic was unique in terms of its nature and size, the uncertainty of its duration, and demand and supply shocks as well as various unforeseeable effects.

Economists compare the pandemic time with the Great Depression of the 1930s and the Great Recession of 2008. Even though the financial crisis of 2008 and the COVID-19 pandemic were different in terms of scope and time of impact [28], both of them influenced economies in many countries [59]. Still, according to economists, the COVID-19 pandemic has had the greatest impact on the economy since the Great Depression, at least in the short run. The preventive measures taken will influence the duration of the recession and the recovery time needed by the economy to return to the state from before the pandemic [23].

Nevertheless, the actual negative impact of COVID-19 turned out to be smaller than initially estimated. This was mainly due to the financial support received from the central government to strengthen the financial condition of local administrative units, maintaining fairly stable proceeds from taxes (mainly from the property tax) coming to the local budgets, and also savings in expenses, resulting from limiting or abandoning the local investments [50]. The financial situation of local administrative units in Poland was not found to be dramatically deteriorated, however, this may not justify the optimism of the central government in that regard [60]. Compared to central governments, self-governments have less effective instruments to respond to economic shocks, even though their proceeds are

less sensitive to deterioration of the economic situation than those of central governments. The effectiveness of the tools being at the disposal of local or regional self-governments is smaller, the tools also have a moderate impact on the short-term situation of the budget and on the economic situation in the region [35,47]. The impact of COVID-19 on regional and local finances is not unambiguous due to the possibility of the continuation of the pandemic and its effects [61]. Undoubtedly, the negative impacts did not spread evenly. Due to the territorial aspect of the COVID-19 crisis [52], regions were not affected in the same way and its medium- and long-term effects are diverse [35,62]. The differentiating factors for this impact include e.g., the sensitivity of a region to the operation of global value chains [63], the share of vulnerable sectors (tourism, accommodation, catering) in the local economy [64], kinds of income and budget expenses in the particular types of LAUs. The development of the pandemic also affected the number of deaths and mortality rates, which reached levels not seen for a long time. This also drew the attention of scientists, who began to study the problem [58,65].

Even though over the last several decades the number of deaths all over the world decreased, the last years showed a slight rise in the number, and in 2020 the rise was considerable. Additionally in Poland, the year 2020 saw a significantly higher mortality rate compared to the previous years, which was directly and indirectly caused by the COVID-19 pandemic (Figure 1).

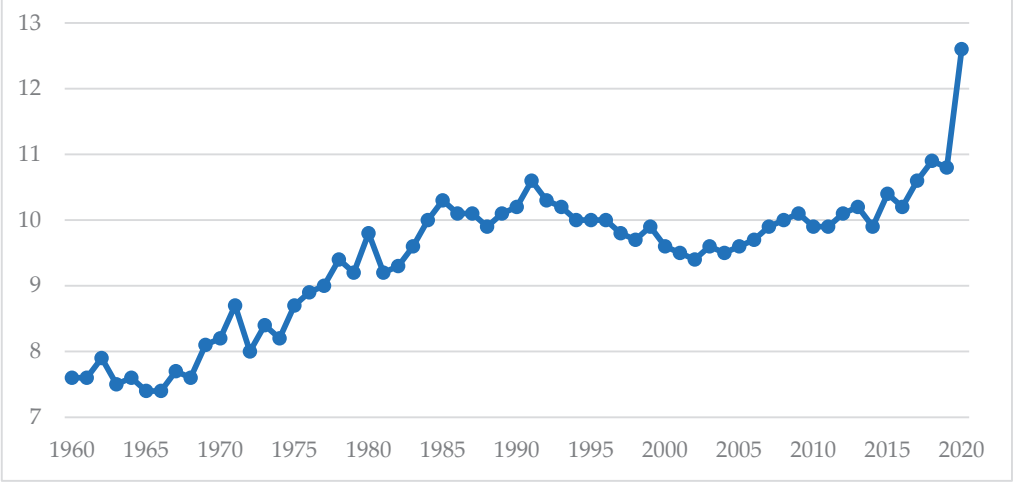

Figure 1. Mortality rate per 1000 population in Poland over the years 1960–2020. Source: own study based on Data from World Bank [62].

4. Materials and Methods

The object of the research was local government units at the voivodeship level. In Poland are 16 LAUs, all of which were covered by the research (total sample). Based on the review of the literature regarding the financial condition of self-governments, legal regulations concerning their operation, and the range of suggested study indicators, and also based on the conclusions derived from the literature review and indicators used by the Central Statistical Office in Poland, a set of variables was selected to describe an LAU's financial condition. To maintain the logic of the research process and the comparability of data, the input data used in the calculations come from the Local Data Bank of the Central Statistical Office, Regional Accounting Chambers, and from financial data derived from the budget reports of all the voivodeships for the years 2017–2020. The research period was divided into two parts, before and during the pandemic [66,67], enabling on the one side, to analyze of data from the years preceding the pandemic, which provides a baseline,

and on the other side, the cyclical nature of the publication of data by the Polish Central Statistical Office (many months after the end of the year) makes 2020, the last complete data, covering the pandemic period. To ensure comparability of the analyzed data, they were expressed in relative terms (the source data which were expressed on the 'per capita' basis were left unchanged, whereas the remaining data were recalculated per 10,000 population, which was determined by the volume and clarity of received results). The study covered all the regional self-governments in Poland, i.e., 16 voivodeships (Table 1). Financial data of the analyzed LAUs used in the evaluation of the financial condition were presented in Appendix A (Table A1).

Table 1. Features describing the financial situation of Polish regions.

Feature	LTB/STB
property income per capita in PLN	LTB
property expenses per capita in PLN	LTB
operating surplus as % of total income per 10,000 population	LTB
ratio of financing capital expenditure with operating surplus	LTB
planned debt amount in PLN per capita (for a given year)	STB
investment volume indicator per 10,000 population in PLN	LTB
annual debt to total income percentage ratio	STB

Source: own work.

Due to the short data presentation period connected with the COVID-19 pandemic by voivodeship (since 23 November 2020), the number of deaths in the particular voivodeships was assumed to specify the impact of the COVID-19 pandemic on the financial condition of the regions in Poland. For that purpose, the mortality rate per 10,000 population was applied. A study of the relationship between mortality rates and socio-economic status was conducted by Aykaç and Etiler [65]. On the other hand, Yavuz and Etiler [58] looked for a relationship between urban health indicators and the third wave of COVID-19 on a regional basis. Their results indicate COVID-19 cases are higher in more developed cities with higher manufacturing sector activity.

The calculation of the financial condition was based on the financial data from all voivodeships and the synthetic indicator method which required standardization of the data. The study of the relationships required the previous specifications of the socioeconomic development level and the financial standing of the whole sample. The evaluation of the analyzed phenomenon applied the synthetic indicator method [68], the application of which involved several stages [69]. In the first stage, variables describing the phenomenon were selected [70–72] and used in constructing a matrix. The next stage consisted in converting the metrics in order to normalize them to basic features [73]. It was assumed that when a high value of the diagnostic variable for a given phenomenon is associated with beneficial growth, the feature is considered Larger-the-better (LTB), whereas, in a situation where a low value of the variable is beneficial for the phenomenon in question, it is deemed smaller-the-better (STB) [74,75]. The following formulas were applied in the calculations [69,71]:

$$\text{for LTB factors (S) } Z_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})}$$

$$\text{for STB factors (D) } Z_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})}$$

where: Z_{ij}—diagnostic variable, falling within the range from 0 to 1;
x_{ij} —the feature value for a given region;
min x_{ij}—the lowest value of the feature among the examined regions;
max x_{ij}—the highest value of the feature among the examined regions.

Another step was the calculation of the synthetic indicator [71,76]:

$$q_i = \frac{\sum_{j=1}^{m} z_{ij}}{m} \propto_j, (i = 1, 2, 3, \ldots, n)$$

where: q_i—the calculated value of the synthetic indicator, z_{ij}—the standardized value of the *j-th* feature of the *i-th* unit, m—number of features included, α_j—the weight of the *j-th* value variable.

The indicator values always fall within the (0, 1) range. When the indicator equals one, this means the maximum level of the analyzed phenomenon in relation to the other units in the sample. The last step in the analysis was to put in order the computed values of the synthetic indicator.

To estimate the financial situation of self-governing voivodeships, the analysis applied the following indicators meeting the factual and statistical criteria (i.e., it was assumed that the indicator differentiation level must exceed 10%) (Table 1).

Based on the obtained results, 3 classes of the financial situation of voivodeships were distinguished (good—I, average—II, weak—III), and the voivodeships were classified as per the following algorithm:

$$\text{Class I: } q_i \geq \bar{q} + \frac{S_q}{2}$$

$$\text{Class II: } \bar{q} + \frac{S_q}{2} > q_i \geq \bar{q} - \frac{S_q}{2}$$

$$\text{Class III: } q_i < \bar{q} - \frac{S_q}{2}$$

where: q_i—the calculated value of the synthetic meter, $\bar{q}$—the mean value of the synthetic indicator, S_q—the standard deviation of the synthetic indicator.

The classification made it possible to obtain relatively equinumerous groups. In the pre-COVID-19 period, there were 4 voivodeships in Class I, 6 in Class II, and 6 in Class III. During the COVID-19 pandemic, there were 4 voivodeships in Class I, 7 in Class II, and 5 in Class III. Due to the specific nature of the data—the object of the study is the impact of the financial situation on the number of deaths, therefore, the dependent variable is a quantitative variable, whereas the independent variable is a factor variable (with 3 levels of variability), the voivodeships were studied in the 3 listed classes in terms of the numbers of deaths found there. The study applied the analysis of variance (i.e., comparison of intergroup variation with the intragroup variation) comparing the said groups in relation to the number of deaths in each voivodeship. For this purpose, a 'one-way ANOVA' was applied, which is a parametric test used to verify that there are statistically significant differences in the means between at least three groups. [77], which helped to obtain an answer to the question: was there a relationship between the financial situation of a given voivodeship and the number of deaths? The application of ANOVA made it possible to find an answer to the question of whether or not there was an actual difference between the classes, and if so, between which of them. In accordance with the ANOVA assumptions, its application is not possible for the whole population, but only for a sample. Therefore, it was decided to draw by lot 3 voivodeships from each class and include them in the analysis. Thus, a sample of 9 voivodeships was obtained for the pre-COVID-19 period (2017–2019) and a sample of 9 voivodeships for the COVID-19 period (2020). Thanks to that, the experimental form of the study was maintained. An important aspect in the context of the tools applied in the study was also the fact that it was carried out in equinumerous groups (3 voivodeships from each class).

5. Research Results

Before the onset of the COVID-19 pandemic, the mortality rate in Poland ranged from 9.4 to 10.6 per 1000 population; the average rate in the last five years before the pandemic

was 10.6, whereas in 2020 it reached the record level of 12.6, which means a double-digit rise of 16.7% compared to the previous year. Figure 2 presents the comparison of the number of deaths per 1000 population in the individual regions in 2017 (before the pandemic) and in 2020 (during the pandemic).

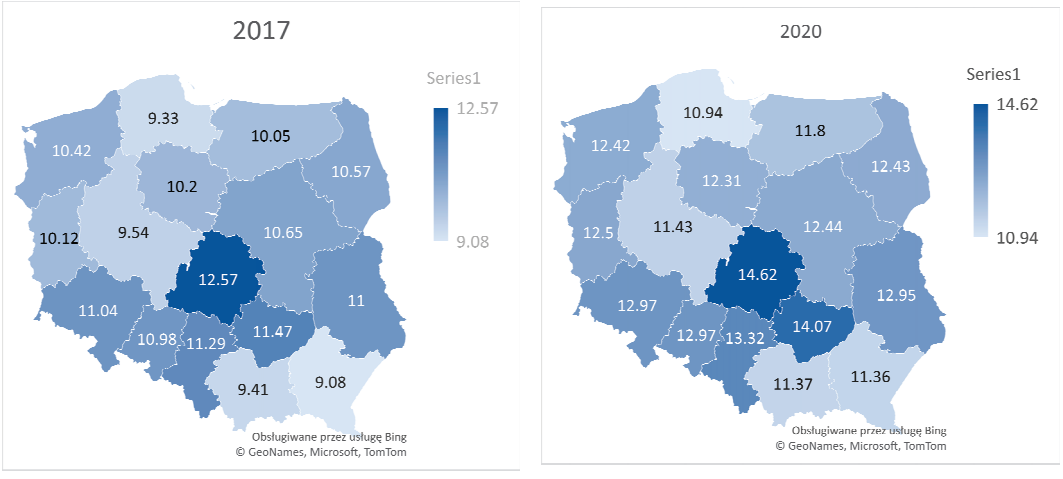

Figure 2. Number of deaths per 1000 population in Poland. Source: own study based on Local Data Bank [58].

The Polish voivodeships where the number of deaths per 1000 population was the highest both in 2017 (12.57), and in 2020 were Łódzkie, Świętokrzyskie, Śląskie, Lubelskie, Dolnośląskie, and Opolskie. The death rate in those regions has for years been higher than in the other ones.

The lowest numbers of deaths in 2017 and in 2020 were seen in voivodeships: Pomorskie, Małopolskie, Podkarpackie, and Wielkopolskie. These regions have for years been characterized by a lower mortality rate than the national average. In the years analyzed, the number of deaths increased in each voivodship, with the highest number in the Podkarpackie (25.11%), Lubuskie (23.51%), and Świętokrzyskie (22.67%) voivodships.

In accordance with the previous assumptions and to ensure the logic of the research, the study period was divided into two stages, taking into account the two different situations, i.e., before and during the pandemic.

Stage 1—the pre-COVID-19 period.

In the first place, it was decided to optically verify the mortality rate depending on the financial situation of each of the analyzed classes. No outliers were found, and the differences between the groups seemed to be too small to enable drawing a conclusion on their significant differentiation. Additionally, it was not possible to conclude the impact of a voivodeship's financial situation on the mortality rate within each of them (Figure 3).

The subsequent step was the verification of the ANOVA assumptions about the parametric and homoscedasticity of the classes. To that end, the Shapiro–Wilk test was applied, and its result showed there was no basis for stating a lack of normality in the groups. Bartlett's test, in turn, showed there were no grounds to identify heterogeneity of variances (Table 2).

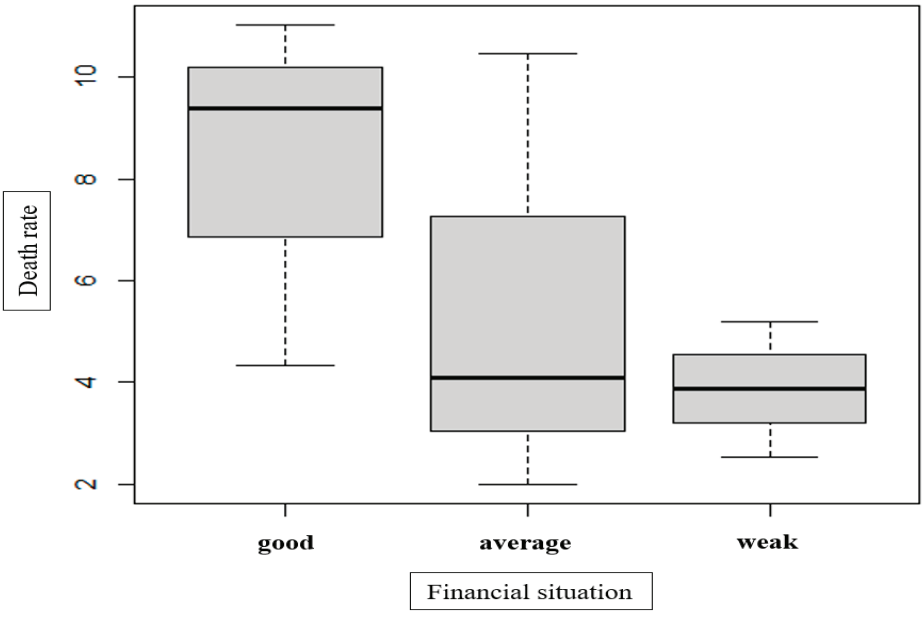

Figure 3. Dependency between the financial situation and the number of deaths in the individual analysed groups in the years 2017–2020 (before COVID-19). Source: own elaboration.

Table 2. Results of Shapiro–Wilk and Bartlett's tests in the pre-COVID-19 period.

Financial Situation (Groups)	Shapiro-Wilk Normality Test	Bartlett Homogeneity of Variance Test
Good	$p = 0.4589$	
Average	$p = 0.4562$	$p = 0.3816$
Weak	$p = 0.9913$	

Source: own elaboration.

Meeting the ANOVA assumptions (quantitative variable measured on a quantitative scale, sample randomness, independence, normal distribution, no heteroscedasticity) made it possible to estimate the ONE-WAY ANOVA model ($p = 0.335$). The analysis has shown that in the pre-COVID-19 study period, there was no statistically significant correlation between the financial situation of a voivodeship and the mortality rate level.

Stage 2—the COVID-19 period.

The study covering the COVID-19 period showed a bigger difference between the voivodeships with a good financial situation and particularly those with a weak one, in relation to the number of deaths. This difference is not visible between the other classes (Figure 4). However, without further analyses, it is not possible to state whether the difference was significant. Additionally, there were no outliers.

The next step in the study was a verification of the ANOVA assumptions about the parametric and homoscedasticity of the groups. The Shapiro-Wilk test was applied to check the distribution, and its result showed there was no basis for stating a lack of normality in the groups. Bartlett's test in turn showed there were no grounds to identify heterogeneity of variances (Table 3).

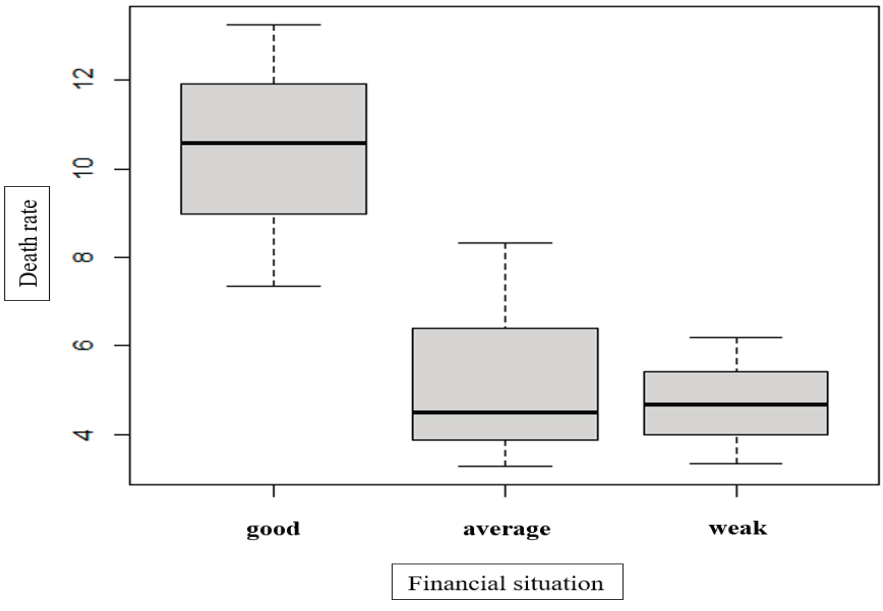

Figure 4. Dependency between the financial situation and number of deaths in the individual analyzed groups in the COVID-19 period. Source: own elaboration.

Table 3. Results of Shapiro-Wilk and Bartlett's tests in the pre-COVID-19 period.

Financial Situation (Groups)	Shapiro-Wilk Normality Test	Bartlett Homogeneity of Variance Test
Good	$p = 0.8971$	
Average	$p = 0.4435$	$p = 0.6562$
Weak	$p = 0.9947$	

Source: own elaboration.

Additionally, in this case, all the ANOVA assumptions were met; therefore, the ONE-WAY ANOVA model was estimated ($p = 0.0545$). Due to the ANOVA assumption that a quantitative variable is measured on a quantitative scale, it was found that at the significance level of 10%, there was a statistically significant correlation between a voivodeship's financial situation and the level of the mortality rate in the regions in the COVID-19 period. Therefore, it may be concluded that the level of the financial situation had a significant impact on the number of deaths. The data shown in the ONE-WAY ANOVA model made it possible to run subsequent studies in that respect. The next step was verifying the correlation strength by means of the experimental effect—the strength of the general effect, indicating the strength of the phenomenon, allowing the true significance of the outcome to be assessed, in this case (eta squared) indicating what proportion of the total variance in the dependent variable is explained by the effect. Based on the eta squared parameter (62%) it was found that the impact of the financial situation level on the number of deaths was strong (above 14%).

The last step was the post hoc analysis, making it possible to verify whether the voivodeships with various levels of financial situation significantly differed from each other in terms of the numbers of deaths. As a result of the analysis, a significant difference was found between voivodeships showing good and average financial situations ($p = 0.044$) as well as good and weak financial situations ($p = 0.029$). However, there was no relationship between voivodeships with average and weak financial situations ($p = 0.760$).

6. Discussion and Conclusions

In the legal and financial aspect, the situation of all voivodeships at the starting point is the same. However, due to different kinds of budget proceeds (diverse income structures), the analysis of the financial condition of the individual LAUs can be interesting, especially during a crisis or pandemic. According to Auerbach et al. [23], the pandemic has had a very atypical impact on the state budget and local budget incomes. In Poland, the budgets of cities and municipalities rely on the personal income tax (PIT) and their own income, whereas budgets of voivodeship self-governments depend mainly on the corporate income tax (CIT). Amounts of the income proceeds may be different in times of crisis. Therefore, depending on the kind of local administrative unit and the budget proceeds structure, the impact of a crisis (including the one caused by the COVID-19 pandemic) may vary. Moreover, self-governments applied instruments to mitigate the influence of the COVID-19 pandemic (e.g., exemption, tax relief, deferred payments) to different extents, depending on the availability of such measures and the administrative unit's wealth; consequently, their impacts varied during the first wave of infections [78].

This study contributes to the growing field of research on the economic impact of the COVID-19 pandemic. Focusing on the sub-national level allows for territorial differences within a single country to be taken into account, while at the same time providing a seed and a kind of pilot for the next level of analysis, covering all EU regions.

Using a one-way ANOVA model, we provide evidence that despite the fact that before the pandemic (as of 2017) there was no statistically significant relationship, between the level of the financial health of a region and the level of mortality in its area, it is evident during the pandemic. Interestingly, the correlation between the financial situation and the number of deaths was negative. For the pre-COVID-19 period, the box plot (Figure 3) also shows that the financially better-off voivodeships featured higher numbers of deaths, however, the correlation was not statistically significant. This regularity was, however, found for the COVID-19 period (Figure 4). Hence, it is possible to state that administrative units with better finances experienced higher numbers of deaths in the COVID-19 period, and this phenomenon was not totally random, as the analysis of variance showed an impact of the financial situation on that phenomenon. Our findings are consistent with the results obtained by Aykac, Etiler [65] and Yavuz, Etiler [58].

Our study at this point has several limitations: the financial health of regions is influenced by their potential: the entrepreneurial resources of local and regional policymakers and subordinate officials, as well as the entrepreneurial forces and potential of local companies. These factors translate into the level of socio-economic development of the regions, which is to some extent conditioned by and at the same time determines the distribution of the population in a given area.

Due to the limitations of the study, the populations of individual voivodeships were not analyzed in terms of age structure, addictions, susceptibility to diseases, or population size, which has an influence on burdening the healthcare service and lower effectiveness of treatment in countries/regions characterized by large populations [17,18]. Voivodeships in a better financial condition (Class I) showed higher mortality rates than those with a worse financial standing (Class II and III). Theoretically, the richer regions should spend more on healthcare, which in turn should translate into lower mortality. The results show the need for appropriate management of health care and accessibility to medical services. The better financial health of the voivodeship does not guarantee better access to medical services, including specialized ones. However, this requires further research, including into the efficiency of healthcare financing and medical services in the regions not only during the crisis [79]. However, without a more in-depth analysis of the social structure in each of the voivodeships and an analysis of the expense structure (including the amounts of spending on healthcare in the individual regions), it is not possible to know the reason why this correlation occurred.

In this context, it makes sense to continue the research, expanding it to include aspects related to demographic factors and other determinants of socioeconomic development.

Policymakers from regions with higher mortality rates and/or lower levels of financial health should analyze initiatives and implement solutions in other regions where this works better (taking into account the potential differentiating characteristics of these regions). It also seems to be an interesting step to analyze the data with a distinction of metropolitan areas—analyses of regions where metropolises operate can lead to a situation where the financial aspects of the operation and level of development of the metropolis raise the indicators of the financial health of the region, while at the same time municipalities outside the range of strong influence of the metropolis can be low developed but functioning within some correct framework. Extraordinary situations, such as a crisis caused by a pandemic, are a verifier of the effectiveness and efficiency of such entities. At the same time, more difficult-to-measure sociological aspects remain important, such as beliefs about the meaning of medical treatment, vaccination uptake, etc. These considerations show the vast possibilities for further analysis of this phenomenon.

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Appendix A

Table A1. Financial data of the analyzed LAUs used in evaluation of the financial condition.

Voivodeship	Year	Property Income Per Capita (PLN)	Total Expenses Per Capita (PLN)	Operating Surplus as % of Total Income Per 10,000 Population (%)	Ratio of Financing Capital Expenditure with Operating Surplus (%)	Planned Amount of Debt Per Capita (for a Given Year) (%)	Investment Volume Indicator Per 10,000 Population (PLN)	Ratio of Annual Debt to Total Income (%)
Dolnośląskie	2017	73.75	385.95	0.0474	0.4716	237.76	1,162,886	59.70
Kujawsko-pomorskie		23.84	330.65	0.0685	0.6727	130.82	703,457	39.47
Lubelskie		100.29	401.41	0.0601	0.3536	305.89	1,476,307	75.29
Lubuskie		78.44	471.64	0.0986	0.2752	169.90	1,579,370	39.00
Łódzkie		32.02	259.96	0.0582	0.8073	110.77	506,010	39.25
Małopolskie		117.79	381.79	0.0411	0.3436	128.38	1,601,728	32.55
Mazowieckie		13.65	426.96	0.0498	1.3508	221.87	940,106	46.85
Opolskie		145.16	451.79	0.1284	0.3540	137.67	1,739,733	28.41
Podkarpackie		111.75	430.80	0.0608	0.3656	107.86	1,568,676	24.34
Podlaskie		158.00	439.93	0.1101	0.3448	34.13	1,813,484	7.12
Pomorskie		46.62	359.26	0.0607	0.4794	114.02	1,036,237	32.40

Table A1. *Cont.*

Voivodeship	Year	Property Income Per Capita (PLN)	Total Expenses Per Capita (PLN)	Operating Surplus as % of Total Income Per 10,000 Population (%)	Ratio of Financing Capital Expenditure with Operating Surplus (%)	Planned Amount of Debt Per Capita (for a Given Year) (%)	Investment Volume Indicator Per 10,000 Population (PLN)	Ratio of Annual Debt to Total Income (%)
Śląskie		22.15	268.47	0.0353	0.7206	150.59	612,495	55.06
Świętokrzyskie		113.11	386.00	0.1043	0.3745	132.64	1,430,997	32.38
Warmińsko-mazurskie		44.93	363.88	0.0500	0.3279	209.80	779,372	58.86
Wielkopolskie		28.21	336.23	0.0531	0.6101	95.58	989,017	29.33
Zachodniopomorskie		131.81	472.55	0.0646	0.2828	138.55	1,841,225	29.33
Dolnośląskie		80.92	396.63	0.0545	0.6025	210.21	1,134,539	48.61
Kujawsko-pomorskie		50.38	392.36	0.0681	0.4679	131.44	1,154,862	34.47
Lubelskie		77.51	437.30	0.0621	0.3284	335.83	1,638,904	82.97
Lubuskie		73.22	445.81	0.1100	0.3260	173.63	1,445,360	41.18
Łódzkie		43.86	324.46	0.0743	0.6496	125.31	948,820	37.40
Małopolskie		87.81	386.66	0.0469	0.4711	122.21	1,361,976	30.37
Mazowieckie		26.12	489.37	0.0568	1.2562	185.81	1,340,993	33.79
Opolskie	2018	174.74	504.68	0.1160	0.2828	119.31	2,130,931	22.66
Podkarpackie		176.97	537.23	0.0917	0.4202	92.08	2,612,734	16.36
Podlaskie		249.23	671.03	0.0885	0.1622	107.43	3,858,776	18.00
Pomorskie		113.08	449.74	0.0632	0.3640	93.97	1,808,170	20.98
Śląskie		50.18	318.73	0.0474	0.7743	132.94	967,667	38.30
Świętokrzyskie		195.50	564.67	0.1181	0.2499	121.01	3,102,732	22.94
Warmińsko-mazurskie		64.50	428.76	0.0900	0.3529	254.22	1,455,065	63.70
Wielkopolskie		27.93	363.97	0.0506	0.6231	115.79	1,003,941	32.70
Zachodniopomorskie		198.39	559.71	0.0531	0.1962	172.37	2,547,042	31.15
Dolnośląskie		58.71	384.33	0.0614	0.6678	182.80	1,085,665	44.92
Kujawsko-pomorskie		45.81	431.88	0.1112	0.6907	130.31	1,444,978	30.09
Lubelskie		190.03	576.78	0.0707	0.2977	329.60	2,872,741	58.33
Lubuskie		108.97	517.12	0.1071	0.2662	210.40	1,967,707	43.68
Łódzkie		72.16	387.98	0.0641	0.4970	251.78	1,261,237	63.47
Małopolskie		63.02	390.55	0.0565	0.6752	108.99	1,184,400	26.26
Mazowieckie		40.87	597.31	0.0504	0.8752	148.38	1,912,433	24.15
Opolskie		165.29	519.24	0.1483	0.3971	100.60	2,056,248	17.95
Podkarpackie	2019	151.17	496.82	0.0959	0.5179	99.83	2,146,005	18.33
Podlaskie		368.60	835.10	0.0869	0.1444	183.75	5,321,012	24.55
Pomorskie		155.75	563.64	0.0773	0.3706	114.64	2,683,275	20.82
Śląskie		38.76	328.39	0.0522	0.9840	107.31	881,677	29.34
Świętokrzyskie		179.66	551.18	0.1579	0.3966	108.20	2,787,006	19.23
Warmińsko-mazurskie		91.90	473.45	0.0878	0.3930	254.60	1,506,189	53.72
Wielkopolskie		91.59	450.83	0.0548	0.4598	126.19	1,846,122	28.50
Zachodniopomorskie		83.45	463.86	0.0998	0.5052	146.67	1,574,015	31.24

Table A1. *Cont.*

Voivodeship	Year	Property Income Per Capita (PLN)	Total Expenses Per Capita (PLN)	Operating Surplus as % of Total Income Per 10,000 Population (%)	Ratio of Financing Capital Expenditure with Operating Surplus (%)	Planned Amount of Debt Per Capita (for a Given Year) (%)	Investment Volume Indicator Per 10,000 Population (PLN)	Ratio of Annual Debt to Total Income (%)
Dolnośląskie	2020	69.65	381.86	0.0930	1.2270	141.81	1,044,769	29.84
Kujawsko-pomorskie		67.38	510.33	0.1223	0.7856	129.51	1,747,413	23.97
Lubelskie		95.78	474.97	0.0461	0.3877	326.64	1,244,255	66.04
Lubuskie		150.71	613.78	0.1585	0.3832	227.17	2,548,829	37.41
Łódzkie		84.01	419.42	0.0851	0.6019	230.67	1,541,501	52.18
Małopolskie		151.79	591.41	0.0360	0.3422	142.89	2,150,655	23.75
Mazowieckie		29.37	614.11	0.0422	1.0638	174.94	1,398,053	26.82
Opolskie		125.31	554.43	0.1959	0.7580	81.09	1,632,610	12.67
Podkarpackie		173.44	565.19	0.0884	0.4552	127.19	2,492,443	21.10
Podlaskie		269.82	728.75	0.0961	0.2196	244.34	3,679,158	34.34
Pomorskie		72.66	455.41	0.0790	0.6100	104.53	1,428,247	22.13
Śląskie		93.96	426.40	0.0347	0.3696	101.16	1,745,141	24.65
Świętokrzyskie		110.18	478.39	0.2279	0.8256	95.66	1,903,624	17.22
Warmińsko-mazurskie		198.59	588.08	0.1168	0.3681	242.27	2,773,166	39.62
Wielkopolskie		108.33	469.58	0.0739	0.6963	116.78	1,926,712	22.48
Zachodniopomorskie		140.38	566.76	0.1179	0.5512	173.38	2,212,195	28.52

Source: own study based on resolutions on adopting budgets and long-term financial forecasts for voivodeships, resolutions on amending budgets and long-term financial forecasts for voivodeships for the years 2017–2020, and budget implementation reports.

References

1. Zawora, J. Analiza wskaźnikowa w procesie zarządzania finansami samorządowymi. *Zarządzanie Finansami i Rachunkowość* **2015**, *3*, 33–45.
2. Mrówczyńska-Kamińska, A.; Kucharczyk, A.; Średzińska, J.; Analiza finansowa w jednostkach samorządu terytorialnego na przykładzie Miasta i Gminy Środa Wlkp. In Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego. In *Ekonomika i Organizacja Gospodarki Żywnościowej*; 2011; p. 89. Available online: http://yadda.icm.edu.pl/yadda/element/bwmeta1.element.agro-b7ee59fd-e724-4c90-be30-d5983b8215b3 (accessed on 22 September 2022).
3. Adamczyk, A.; Dawidowicz, D. Wartość informacyjna wskaźników oceny kondycji finansowej jednostek samorządu terytorialnego. *Ekon. Probl. Usług* **2016**, *125*, 25–36. [CrossRef]
4. Ritonga, I.T.; Clark, C.; Wickremasinghe, G. Assessing financial condition of local government in Indonesia: An exploration. *Public Munic. Financ.* **2012**, *1*, 15.
5. Ritonga, I.; Clark, C.; Wickremasinghe, G. Factors Affecting Financial Condition of Local Government in Indonesia. *J. Account. Investig.* **2019**, *20*, 1–25. [CrossRef]
6. Kopyściański, T.; Rólczyński, T. Analiza wskaźników opisujących sytuację finansową powiatów w województwie dolnośląskim w latach 2006–2012. *Stud. Ekon.* **2014**, *206*, 61–73.
7. Dylewski, M.; Filipiak, B.; Gorzałczyńska-Koczkodaj, M. *Analiza Finansowa Budżetów Jednostek Samorządu Terytorialnego*; Municipium: Warszawa, Poland, 2011.
8. Filipiak, B. (Ed.) *Metodyka Kompleksowej Oceny Gospodarki Finansowej Jednostki Samorządu Terytorialnego*; Difin: Warszawa, Poland, 2009.
9. Kotowska, E. Przesłanki racjonalnej polityki budżetowej w jednostkach samorządu terytorialnego. In *Funkcjonowanie Samorządu Terytorialnego—Uwarunkowania Prawne i Społeczne*; Gołębiowska, W.A., Zientarski, P.B., Eds.; Kancelaria Senatu RP: Warszawa, Poland, 2016.
10. Wiśniewski, M. Wyznaczniki sytuacji finansowej gminy—Ocena istotności za pomocą analizy skupień. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu. Nauki o Finansach* **2011**, *9*, 110–119.
11. Natrini, N.D.; Taufiq Ritonga, I. Design and Analysis of Financial Condition Local Government Java and Bali (2013–2014). *SHS Web Conf.* **2017**, *34*, 03003. [CrossRef]

12. Danieli, A.; Olmstead-Rumsey, J. Sector-Specific Shocks and the Expenditure Elasticity Channel During the COVID-19 Crisis. 2020. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3593514 (accessed on 15 May 2022).
13. Jones, M. COVID-19 and the labour market outcomes of disabled people in the UK. *Soc. Sci. Med.* **2022**, *292*, 114637. [CrossRef]
14. Grewenig, E.; Lergetporer, P.; Werner, K.; Woessmann, L.; Zierow, L. COVID-19 and educational inequality: How school closures affect low- and high-achieving students. *Eur. Econ. Rev.* **2021**, *140*, 103920. [CrossRef]
15. Green, D.; Loualiche, E. State and local government employment in the COVID-19 crisis. *J. Public Econ.* **2020**, *193*, 104321. [CrossRef]
16. COVID-19 Excess Mortality Collaborators. Estimating excess mortality due to the COVID-19 pandemic: A systematic analysis of COVID-19-related mortality, 2020–2021. *Lancet* **2022**, *399*, 1513–1536. [CrossRef]
17. El Mouhayyar, C.; Jaber, L.T.; Bergmann, M.; Tighiouart, H.; Jaber, B.L. Country-level determinants of COVID-19 case rates and death rates: An ecological study. *Transbound. Emerg. Dis.* **2021**, *69*, 14360. [CrossRef]
18. Cao, Y.; Hiyoshi, A.; Montgomery, S. COVID-19 case-fatality rate and demographic and socioeconomic influencers: Worldwide spatial regression analysis based on country-level data. *BMJ Open* **2020**, *10*, e043560. [CrossRef] [PubMed]
19. Schöley, J.; Aburto, J.M.; Kashnitsky, I.; Kniffka, M.S.; Zhang, L.; Jaadla, H.; Dowd, J.B.; Kashyap, R. Life expectancy changes since COVID-19. *Nat. Hum. Behav.* **2022**, *6*, 1649–1659. [CrossRef] [PubMed]
20. Arolas, H.P.; Acosta, E.; López-Casasnovas, G.; Lo, A.; Nicodemo, C.; Riffe, T.; Myrskylä, M. Years of life lost to COVID-19 in 81 countries. *Sci. Rep.* **2021**, *11*, 3504. [CrossRef]
21. Grittayaphong, P.; Restrepo-Echavarria, P. *COVID-19: Fiscal Implications and Financial Stability in Developing Countries*; Federal Reserve Bank of St. Louis: St. Louis, MO, USA, 2023.
22. Padovani, E.; Iacuzzi, S.; Jorge, S.; Pimentel, L. Municipal financial vulnerability in pandemic crises: A framework for analysis. *J. Public Budg. Account. Financ. Manag.* **2021**, *33*, 87–408. [CrossRef]
23. Auerbach, A.; Gale, B.; Lutz, B.; Sheiner, L. Fiscal Effects of COVID-19; For Presentation at Brookings Papers on Economic Activity; 2020. Available online: https://www.brookings.edu/bpea-articles/fiscal-effects-of-covid-19/ (accessed on 12 March 2023).
24. Hossain, M.R.; Akhter, F.; Sultana, M.M. SMEs in COVID-19 Crisis and Combating Strategies: A Systematic Literature Review (SLR) and A Case from Emerging Economy. *Oper. Res. Perspect.* **2022**, *9*, 100222. [CrossRef]
25. Siuta-Tokarska, B. SMEs during the COVID-19 Pandemic Crisis. The Sources of Problems, the Effects of Changes, Applied Tools and Management Strategies—The Example of Poland. *Sustainability* **2021**, *13*, 10185. [CrossRef]
26. Taghizadeh-Hesary, F.; Phoumin, H.; Rasoulinezhad, E. COVID-19 and regional solutions for mitigating the risk of SME finance in selected ASEAN member states. *Econ. Anal. Policy* **2022**, *74*, 506–525. [CrossRef]
27. Iyer, S.R.; Simkins, B.J. COVID-19 and the Economy: Summary of research and future directions. *Finance Res. Lett.* **2022**, *47*, 102801. [CrossRef]
28. Hu, X.; Li, L.; Dong, K. What matters for regional economic resilience amid COVID-19? Evidence from cities in Northeast China. *Cities* **2021**, *120*, 103440.
29. *Konstytucja Rzeczypospolitej Polskiej z Dnia 2 Kwietnia 1997 r.; Dz. U. 1997, nr 78, poz. 483*; 1997. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu19970780483 (accessed on 12 March 2023).
30. Ustawa z Dnia 24 Lipca 1998 r. o Wprowadzeniu Zasadniczego Trójstopniowego Podziału Terytorialnego Państwa; Dz.U. 1998 nr 96 poz. 603. Available online: https://isap.sejm.gov.pl/isap.nsf/DocDetails.xsp?id=wdu19980960603 (accessed on 12 March 2023).
31. Di Napoli, T.P. Local Government Management Guide—Financial Condition Analysis. Division of Local Government and School Accountability. 2019, p. 2. Available online: https://www.osc.state.ny.us/files/local-government/publications/pdf/financialconditionanalysis.pdf (accessed on 12 March 2023).
32. Osiński, J.; Zawiślińska, I. Financial Condition of Local Government in Poland vs StructuralReforms of Municipal Government in Scandinavian States. *Przegląd Politol.* **2020**, *4*, 5–22. [CrossRef]
33. Kwaśny, J. Kondycja finansowa wybranych jednostek samorządu terytorialnego województwa małopolskiego w nowej perspektywie finansowej Unii Europejskiej. *Nierówności Społeczne A Wzrost Gospod.* **2017**, *49*, 228–250. [CrossRef]
34. Regionalna Izba Obrachunkowa. *Analiza Ryzyka Wystąpienia Zagrożeń w Gospodarce Finansowej Jednostek Samorządu Terytorialnego Województwa Opolskiego za 2019 r. Z Uwzględnieniem Art. 243 Ustawy O Finansach Publicznych*; RIO Opole: Opole, Poland, 2020.
35. Swianiewicz, P.; Łukomska, J. *Ewolucja sytuacji finansowej samorządów terytorialnych w Polsce po 2014 roku*; Fundacja im. Stefana Batorego: Warszawa, Poland, 2020.
36. Ślebocka, M. Wykorzystanie Analizy Finansowej w Jednostkach Samorządu Terytorialnego Dla Potrzeb Przedsięwzięć Rewitalizacyjnych na Przykładzie Miasta Łodzi. *Ekonomiczne Problemy Usług* **2018**, *129*, 257–268. [CrossRef]
37. WHO. *Coronavirus Disease 2019 Situation Report-67*; World Health Organ: Geneva, Switzerland, 2020; Available online: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situationreports (accessed on 12 March 2023).
38. Brodeur, A.; Gray, D.; Islam, A.; Bhuiyan, S. A literature review of the economics of COVID-19. *J. Econ. Surv.* **2021**, *35*, 1007–1044. [CrossRef] [PubMed]
39. WHO. *COVID-19 Weekly Epidemiological Update*; WHO: Geneva, Switzerland, 2023.
40. Ministerstwo Zdrowia. Available online: https://www.gov.pl/web/zdrowie/pierwszy-przypadek-koronawirusa-w-polsce (accessed on 12 March 2023).

41. Chudik, A.; Mohaddes, K.; Pesaran, H.; Raissi, M.; Rebucci, A. Economic Consequences of COVID-19: A Counterfactual Multi-Country Analysis, 19 October 2020. Available online: https://voxeu.org/article/economic-consequences-covid-19-multi-country-analysis (accessed on 12 March 2023).
42. Goldbach, S.; Nitsch, V. COVID-19 and Capital Flows: The Responses of Investors to the Responses of Governments. *Open Econ. Rev.* **2022**, *33*, 751–774. [CrossRef]
43. Del Rio-Chanona, R.M.; Mealy, P.; Pichler, A.; Lafond, F.; Farmer, J.D. Supply and demand shocks in the COVID-19 pandemic: An industry and occupation perspective. *Oxf. Rev. Econ. Policy* **2020**, *36* (Suppl. S1), 95. [CrossRef]
44. Addas, A.; Maghrabi, A. The Impact of COVID-19 Lockdowns on Air Quality—A Global Review. *Sustainability* **2021**, *13*, 10212. [CrossRef]
45. Misiąg, W. Wpływ pandemii COVID-19 na polskie finanse publiczne—Źródła finansowania, wydatki, procedury. *Kwart. Prawno-Finans.* **2020**, 7–25. [CrossRef]
46. *The Impact of the COVID-19 Crisis on Regional and Local Governments: Main Findings from the Joint CoR-OECD Survey*; OECD Regional Development Papers; OECD: Paris, France, 2020; p. 9.
47. *Raport Samorząd: Pomiędzy Nadzwyczajnymi Zadaniami a Ograniczonymi Możliwościami—Samorząd Terytorialny w Czasie Pandemii*; Fundacja GAP, Open Eyes Economy: Kraków, Poland, 2020.
48. Gołaszewski, M. Samorządy z Nadwyżką Czy Ukrytym Deficytem. 2021. Available online: https://www.miasta.pl/aktualnosci/samorzady-z-nadwyzka-czy-ukrytym-deficytem (accessed on 20 December 2021).
49. Legrand, J.-B. The Impact of the COVID-19 Pandemic on Subnational Finances, Emergency Governance for Cities and Regions, Analitysc Note #03; 2021. Available online: https://www.lse.ac.uk/Cities/publications/Policy-Briefs-and-Analytics-Notes/Analytics-Note-03-The-Impact-of-the-Covid-19-pandemic-on-Subnational-Finances (accessed on 20 December 2021).
50. Dougherty, S.; de Biase, P. State and Local Government Finances in the Time of COVID-19, Research-Based Policy Analysis and Commentary from Leading Economists. Available online: https://voxeu.org/article/state-and-local-government-finances-time-covid-19 (accessed on 12 March 2023).
51. Kochanov, P.; Hong, Y.; Mutambatsere, E. *COVID-19's Impact on Sub-National Governments*; International Finance Corporation World Bank Group: Washington, DC, USA, 2020.
52. ARAL, N.; Bakir, H. Spatiotemporal Analysis of COVID-19 in Turkey. *Sustain. Cities Soc.* **2021**, *76*, 103421. [CrossRef]
53. Brinca, P.; Duarte, J.B.; Faria-E-Castro, M. Measuring labor supply and demand shocks during COVID-19. *Eur. Econ. Rev.* **2021**, *139*, 103901. [CrossRef] [PubMed]
54. Demirgüç-Kunt, A.; Pedraza, A.; Ruiz-Ortega, C. Banking sector performance during the COVID-19 crisis. *J. Bank. Finance* **2021**, *133*, 106305. [CrossRef] [PubMed]
55. Zhanga, D.; Hua, M.; Ji, Q. Financial markets under the global pandemic of COVID-19. *Financ. Res. Lett.* **2020**, *36*, 101528. [CrossRef] [PubMed]
56. Organisation for Economic Co-operation and Development. The territorial impact of COVID-19: Managing the crisis and recovery across levels of government. In *Tackling Coronavirus (COVID-19): Contributong to a Global Effort*; OECD: Paris, France, 2021.
57. Haleem, A.; Javaid, M.; Vaishya, R. Effects of COVID-19 pandemic in daily life. *Curr. Med. Res. Pract* **2020**, *10*, 78–79. [CrossRef]
58. Yavuz, M.; Etiler, N. The correlation between attack rates and urban health indicators during the third wave of the COVID-19 outbreak in Turkey. *Front. Public Health* **2022**, *10*, 986273. [CrossRef]
59. Tan, B.; Igan, D.; Martinez Peria, M.S.; Pierri, N.; Presbitero, A.F. Government intervention and bank markups: Lessons from the global financial crisis for the COVID-19 crisis. *J. Bank. Financ.* **2021**, *133*, 106320. [CrossRef]
60. Kostyk-Siekierska, K. Wpływ pandemii COVID-19 na sytuację finansową i funkcjonowanie jednostek samorządu terytorialnego. *Zesz. Nauk. Małopolskiej Wyższej Szkoły Ekon. W Tarn.* **2021**, *51*, 29–45. [CrossRef]
61. Malinowska-Misiąg, E. Finanse jednostek samorządu terytorialnego w Polsce w pierwszym roku pandemii, Finanse jednostek samorządu terytorialnego w Polsce w pierwszym roku pandemii. *Optimum. Econ. Stud.* **2022**, *107*, 48–63. [CrossRef]
62. World Bank. *Impact of the COVID-19 Pandemic on Municipal Finance©*; World Bank: Washington, DC, USA, 2021; Available online: http://hdl.handle.net/10986/37205 (accessed on 12 March 2023).
63. Delardas, O.; Kechagias, K.S.; Pontikos, P.N.; Giannos, P. Socio-Economic Impacts and Challenges of the Coronavirus Pandemic (COVID-19): An Updated Review. *Sustainability* **2022**, *14*, 9699. [CrossRef]
64. Pan, K.; Yueb, X.-G. Multidimensional effect of COVID-19 on the economy: Evidence from survey data. *Econ. Res. Ekon. Istraživanja* **2022**, *35*, 1658–1685. [CrossRef]
65. Aykaç, N.; Etiler, N. COVID-19 mortality in Istanbul in association with air pollution and socioeconomic status: An ecological study. *Environ. Sci. Pollut. Res.* **2022**, *29*, 13700–13708. [CrossRef] [PubMed]
66. Mestdagh, B.; Sempiga, O.; Van Liedekerke, L. The Impact of External Shocks on the Sustainable Development Goals (SDGs): Linking the COVID-19 Pandemic to SDG Implementation at the Local Government Level. *Sustainability* **2023**, *15*, 6234. [CrossRef]
67. Bieszk-Stolorz, B.; Dmytrów, K. Assessment of the Similarity of the Situation in the EU Labour Markets and Their Changes in the Face of the COVID-19 Pandemic. *Sustainability* **2022**, *14*, 3646. [CrossRef]
68. Stanny, M.; Strzelczyk, W. Pomiar kondycji finansowej jednostek samorządu lokalnego—Kwerenda międzynarodowa. *Nierówności Społeczne A Wzrost Gospod.* **2017**, *49*, 372–383. [CrossRef]
69. Kamińska, A.; Janulewicz, P. Klasyfikacja gmin wiejskich województwa lubelskiego na podstawie rozwoju społeczno-gospodarczego. *Folia Pomeranae Univ. Technol. Stetin. Folia Pomer. Univ. Technol. Stetin.* **2009**, *275*, 31–42.

70. Suchecki, B.; Lewandowska-Gwarda, K. Klasyfikacja, wizualizacja i grupowanie danych przestrzennych, w: Ekonometria przestrzenna. In *Metody i Modele Analizy Danych Przestrzennych*; Wydawnictwo CH Beck: Warszawa, Poland, 2010.
71. Wysocki, F.; Lira, J. *Statystyka Opisowa*; Wydawnictwo Akademii Rolniczej: Poznań, Poland, 2003.
72. Parysek, J.J.; Wojtasiewicz, L. *Metody Analizy Regionalnej i Metody Planowania Regionalnego*; Studia PWN, LXIX: Warszawa, Poland, 1978; pp. 25–26.
73. Feltynowski, M. *Planowanie przestrzenne a rozwój społeczno-gospodarczy w gminach wiejskich województwa łódzkiego*; Foila Pomeranae Universitatis Technologiae Stetinensis, Oeconomica: Szczecin, Poland, 2009; Volume 268, pp. 35–44.
74. Kogut-Jaworska, M.; Ociepa-Kicińska, E. Smart Specialisation as a Strategy for Implementing the Regional Innovation Development Policy—Poland Case Study. *Sustainability* **2020**, *12*, 7986. [CrossRef]
75. Sobko, R.; Janiszewska, D.; Ossowska, L.; Oklevik, O. The Role of the Financial Condition in the Development of Coastal Municipalities in Poland. *Eur. Res. Stud. J.* **2021**, *XXIV*, 688–703. [CrossRef]
76. Klóska, R. *Statystyczna Analiza Poziomu Rozwoju Społeczno-Gospodarczego w Polsce—W Ujęciu Regionalnym, Zeszyty Naukowe Wyższej Szkoły Bankowej w Poznaniu 2012, nr 42, Przestrzeń w Nowych Realiach Gospodarczych*; Space in New Economic Reality; Wyższa Szkoła Bankowa: Poznań, Poland, 2012; pp. 127–135.
77. Moder, K. Alternatives to F-Test in One Way ANOVA in case of heterogeneity of variances (a simulation study). *Psychol. Test Assess. Model.* **2010**, *52*, 343–353.
78. Kańduła, S.; Przybylska, S. Financial instruments used by Polish municipalities in response to the first wave of COVID-19. *Public Organ. Rev.* **2021**, *21*, 665–686. [CrossRef]
79. Markowicz, I.; Rudawska, I. Struggling with COVID-19—A Framework for Assessing Health System Performance. *Sustainability* **2021**, *13*, 11146. [CrossRef]

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Digitalization as a Factor in Reducing Poverty and Its Implications in the Context of the COVID-19 Pandemic

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Abstract: In the present economic context, one of the most important topics of discussion is that regarding sustainable development. According to the agenda developed by the United Nations, one of the most important objectives for the present decade is represented by the list of the Sustainable Development Goals. The Sustainable Development Goals can be divided into five pillars: people, planet, prosperity, partnership and peace. One of the first stipulated goals of the UN agenda is the eradication of poverty and famine. We consider that a significant influence on the eradication of poverty is represented by the development of technology. In this paper, the authors aim to establish a connection between the rate of technological development and the poverty headcount rate. To measure the digital development of the analyzed countries, we decided to compose an index of digital development by taking into account indicators made available by the International Telecommunication Union and the poverty headcount ratio, as was calculated by the World Bank database. This empirical study is of interest for the implications that it has in shaping governmental policies regarding easing the access to digital technology. The method used to quantify the influence of digital development on poverty was the panel data GMM vector autoregressive model for a dataset composed of 35 countries for the period between 2005 and 2018. The results indicate that an increase in digital development will lead to a reduction in the poverty headcount rate. These results imply that by increasing access to technology, countries could help reduce their level of poverty. In this paper, we will also analyze the way in which adopting digital development leads to better economic performance when faced with the COVID-19 pandemic. The results of the present study are of great interest to the scientific community and the public due to the implications of digital development in the field of economics and the combined effect of this phenomenon and the COVID-19 pandemic. We thus conclude that by encouraging digital development and through adopting new technologies, the government can lead to the eradication of poverty. This seems counterintuitive due to the fact that investment in shelter and primary goods can be seen as one of the primary ways of developing the economy. We conclude that better and more consistent results regarding the reduction of poverty can be obtained by increasing the digital development of a country.

Keywords: poverty; panel data; digitalization index; economic development; COVID-19 pandemic; digital development; Sustainable Development Goals (SDGs)

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1. Introduction

One of the most discussed problems of the present is sustainability. The problem of sustainable development was defined for the first time in its present form in the Brundtland Report [1] published in October 1987, where the concept gained additional focus regarding

the building of a socially inclusive and environmentally sustainable form of economic development (at first, the concept had a bigger and greater focus on the environment, such as in the definition offered by the International Union for the Conservation of Nature [2] in 1980).

Taking into account the importance of the concept, the present paper proposes a model for analyzing the influence of digital development on the poverty headcount ratio as calculated by the World Bank. We considered the poverty headcount ratio to be a determinant factor of sustainable development due to its priority on the agenda of the United Nations in the 2030 Sustainable Development Goals [3]. In the following sections, we will review the articles that we considered to be of the highest importance in the development of the present paper, and we will develop a digitalization index and quantify its influence by using the methodology of the vector autoregressive model for the panel data. The scope of this paper is to answer the following research question:

RQ: How does the increase in technological development influence the rate of poverty at a national level, and how does digital development relate to the response to the COVID-19 pandemic?

The present article was developed as a result of studying the literature, with the scope of assessing the way in which sustainable development and poverty relate to digital development and presenting the main topics of research in the field of the Sustainable Development Goals and their implementation. From this extensive study, the authors discovered a research gap represented by the way in which the relation between digital development, expressed as an indicator measured by precise metrics, has an influence on the poverty headcount rate. We decided to analyze the way in which the real impact of technology adoption can be quantified. In order to measure this, the authors decided to implement a vector autoregressive model with panel data, with this being, in our opinion, an original contribution to this field of study (i.e., the application of quantitative methods with calculable results). Another interesting approach that we developed in the present paper is the building of a digital development index. This allowed us to compare the level of development of the analyzed countries and also gain a better understanding of their evolution in the given time frame. The article also allows for a worldwide view of digital development and technology adoption by ranking 175 countries for the year 2019. In order to present the results of the research, the authors decided to first present a brief discussion regarding the main topics of research in the field of the Sustainable Development Goals and their implementation. In this article, we also investigate the relation between digital development and resilience to external shocks. One of the more significant shocks of the last decades was the COVID-19 pandemic, and in this paper, we will try to show that the more developed countries from a digital standpoint were less impacted by the pandemic.

This literature review is continued by a quantitative research study that consists of using a panel data vector autoregressive model to better understand the relation between the rate of poverty and the digital development of a country. At the end of the paper, we present a set of discussions regarding the relation of the findings to the relevant scientific literature and the research limitations, along with further study directions, and a section of conclusions in which the authors present the theoretical implications of the present study, the possibility of the model to be used by international organizations for promoting the application of technology affordability programs and the perspectives of this field of knowledge in light of the present article. This study takes into consideration only the correlation between the digital development and poverty, with this being due to the fact that the authors wanted to have an isolated view of how digital development and poverty are related. The authors recognize the fact that poverty is a very complex subject with many underlying connections including but not limited to societal institutions, education, democracy, rule of law and other factors. Even if the present study offers a small insight into the way in which poverty is related to digitalization, due to the mentioned limitations, we consider it to be of interest because of its global scale and for generalizing the relation between poverty and digital development. The originality of the current paper

is represented by the fact that we present a worldwide view of the digitalization process and the relation between digital development and the reduction of the poverty headcount as a significant influence on this phenomenon. Additionally, the present paper also aims to make sense of the patterns regarding digital development at a worldwide level by presenting the results of a vector autoregressive model with dynamic panel data for the period between 2005 and 2018. These developments and the overview of the scientific literature lead to the conclusion that an increase in digital development at a country level will lead to a decrease in the poverty headcount ratio, thus making an impact in the context of the Sustainable Development Goals promoted by the United Nations.

2. Literature Review

In the following section, the authors develop, in a brief manner, the three main points of interest of the scientific literature that were considered when developing our paper in order to study the relation between digital development and the poverty headcount rate. This review presents in an organized structure the methodologies used and the main influences that the authors had in developing this paper. In accordance with this, the authors decided to present the main papers in each of the three main identified ideas relating to our research question.

2.1. Sustainable Development Goals and Their Implementation at a Worldwide Scale

One of the most cited papers that analyzed the concept of the Sustainable Development Goals is the one written by Griggs et al. [4] with the title "Policy: Sustainable development goals for people and planet". The conclusions of this paper indicate that global stability depends on integration of the goals, such as combating poverty and securing human well-being in the plans of the United Nations. Another interesting article is the one written by French and Koze [5]. This article analyzes the ways in which statistics regarding poverty are calculated and their accuracy for the indicators that measure the level of poverty. This paper estimates that in 2013, approximately 385 million children were living on less than USD 1.90 per day. These data are, however, stated as being an approximation due to the fact that 63% of countries do not publish data regarding child poverty, with this being in the context of the UN Sustainable Development Goals agenda for 2030, in which the eradication of poverty is the first priority.

An interesting overview of the subject is described in "A Systematic Study of Sustainable Development Goal (SDG) Interactions" by Pradhan [6]. We decided to analyze the Sustainable Development Goals set by the UN Agenda for 2030 for potential synergies between them. It is stated that the first goal of the agenda (the eradication of poverty) has a synergistic relation with most of the other goals, and the twelfth goal (responsible consumption and production) is described by the authors as being the most likely to suffer trade-offs. This is due to the implications of reducing the use of coal and oil use in industry which, if carried out in an unprepared economy, will lead to unemployment and poverty. The article concludes that in order for the goals to become obtainable by the 227 analyzed economies, they must be adopted in a non-obstructive way, and the current strategies of implementation should take into account the level of development of the analyzed countries. Another interesting paper is the one written by Filho et al. [7], which presents a series of three case studies to show how the Sustainable Development Goals are an opportunity to advance equal opportunities and foster the economic development of countries by promoting sustainable development. The topic of sustainable development has been linked in the literature with the resilience of the economy. One such paper is the one written by Folke et al. [8]. In this article, the authors describe two fundamental errors in the design of environmental policies: the implicit assumption that the ecosystem's responses to the influence generated by humans are defined by linearity and predictability and that the environment and human society can be treated separately when designing a policy. The authors used the concept of resilience, defined as the capacity to change, learn

and develop, to analyze the best strategies to increase the economy's capacity and adapt in the present climate.

Another interesting view on the subject is presented in the article written by Hickel [9]. According to the author, there in is an inherent contradiction in the two sides of the sustainable development concept, as stated in the Sustainable Development Goals in of the United Nations between the goal of yearly global economic growth of 3% and the protection of the environment (as stated in goals 6, 12, 13, 14, and 15). The paper states that the by accepting the global economic growth rate at 3%, it is almost impossible to achieve any reductions in the aggregate global resource use. In our opinion, this offers an interesting view, due to the alternative of downscaling resource use in order to reach the target of climate change rate reduction in high-income nations by introducing quantified objectives for resource use.

In the scientific literature, there are views [10–12] that state that the evolution of sustainable development is difficult to quantify, and its influence on macroeconomic indicators is challenging to analyze. In this paper, we aim to present the means of measuring the impact of digital development on an essential part of sustainable development: the reduction of the poverty headcount (this being part of the first two Sustainable Development Goals (reducing poverty and eradicating famine) stated by the United Nations).

In other articles [13,14], we can see that the relevant scientific literature considers using indicators for assessing the evolution of the Sustainable Development Goals agenda. These attempts deal with studying the progress for a short period of time and for various regions. Due to the fact that, in the present paper, we seek to analyze the progress toward the reduction of poverty which has been manifesting in the last two decades, we decided to use the poverty headcount rate as a proxy for sustainable development, and we aimed to determine its correlations and relations with a technology development index.

In addition to the mentioned scientific papers, a major contribution in the advancement of the measurement of poverty is the 2030 Agenda itself [3]. This represents a holistic approach to the problems that the United Nations consider to be fundamental to solve until 2030. In the case of the first goal, which is the eradication of poverty in all its forms, the agenda offers several targets: eradicate extreme poverty, reduce poverty by at least 50%, implement nationally appropriate social protection systems, equal rights to ownership, basic services, technology and economic resources, build resilience to environmental economic and social disasters, the mobilization of resources to end poverty and the establishment of poverty eradication frameworks at all levels. As stated, we are interested in the eradication of extreme poverty. The indicator that the UN considers to be the most important is the proportion of the population living below the international poverty line, aggregated by sex, age, employment status and geographical location. The UN considers the poverty line to be USD 1.90 per day, and in this paper, we used the USD 5.50 poverty line indicator due to its availability for more countries and because we considered that for developed countries, the USD 5.50 per day threshold was closer to the national poverty line (which is linked to an indicator of the second target—reduce poverty by at least 50%—with the indicator of the proportion of the population living below the national poverty line). For example, the USA poverty line was USD 35 per day in 2020 [15], and India's was USD 12 per day in urban areas and USD 7.50 in rural areas in 2005 [16].

By analyzing the literature regarding the Sustainable Development Goals and their relation to the economic development of a country, we can state that they represent more than a list of goals. They represent a development program for bettering the future of the world and a blueprint for sustainable development. With that being said, in the present paper, we attempt to analyze the relation between digital development and the poverty rate. This is due to the attempt to obtain a focused view on the relation between these two variables in order to observe if encouraging digital development (e.g., by subsidizing the acquisition of computers) could lead to advancement in the Sustainable Development Goals. In addition, the adoption of technology could also lead to an increase in equity due to more access to information and opportunities.

2.2. Measuring the Impact of Digital Development on Poverty

In the scientific literature, there has been a number of articles that focus on analyzing the effect of digital development on the poverty level. One such paper is the one written by Kwilinski et al. [17], where the digital economy and society index were used to evaluate the digitalization of the countries of the European Union and were analyzed along with the AROPE indicator (people at risk of poverty and social exclusion). As the main research methods, the paper implements a correlation analysis and uses the Monte Carlo method to take into consideration the probability that a change in the value of the AROPE indicator will happen in 2021. The conclusions state clearly that the countries with a higher digitalization level have a lower percentage of people in poverty and lower social exclusion risk.

Other articles [18,19] argue that in the case of the African continent, mobile phone development has led to a significant increase in informal financial development, even though its effects are less noticeable at the macroeconomic level, and that the use of mobile phones with internet access in 44 African countries in the period between 2000 and 2016 has led to an increase in financial inclusion. Other literature review-based studies [20] claim that there are few papers that can present a causal inference between ICT development and poverty. The interaction between the internet and mobile phone access or other technologies and poverty is a topic of focus for many papers [21–25], which have applied a multitude of methodologies in order to analyze this relation for different countries.

Additionally, in the scientific literature, there has been a trend toward analyzing the impacts of technology as a means of inclusion and access to information on poverty in either South Asia or Sub-Saharan Africa [26] or in Latin America [27]. The studies conclude that in the case of South Asia and Sub-Saharan Africa, the adoption of new technologies is an important factor in sustaining the reduction of poverty in developing countries. In the case of Latin America, the study proposes a heterodox type of growth strategy in order to counter the perceived inequality generated by the acceleration of wealth creation. In studying individual countries, from several studies that we considered to be of interest [28–31], due to their implications for the present article, we found that the majority of the results indicate that the impact of internet adoption was mainly a positive one, as it reduced the rates of poverty. However, a problem still remains regarding the affordability of computers and internet access.

Furthermore, in several articles [32,33], there has been a focus on the relation between the internet and technology and the knowledge economy. This relation is significant because the growth in the percentage of internet users can increase the transition to the knowledge economy, and this favors the reduction of the poverty rate.

2.3. Using an Index to Measure Digital Development

The use of an index to measure digital development has been widely described in the scientific literature, and several articles [34–37] have proposed and used indices for measuring digital development, such as the one written by Archibugi and Coco [34], which had a focus on the developing countries and calculated a proprietary index—ArCo—based on three main components: the creation of technology, the available technological infrastructure, and the level of development of human skills.

In the present paper, we considered that a better focus for our index was the personal adoption of technological development. As such, the authors used indicators that were related to the adoption of technology by ordinary citizens. Approaches regarding the measurement of the impact of the personal adoption of technology have been published [38–41], with the novelty of our approach being the effort to quantify the level of digital personal adoption at the country level by using a digital development index built with data made available by the International Telecommunication Union.

Another important field of study in the scientific literature is the analysis of the differences in digital development between different regions of a country or between countries [42–52]. These studies analyze the concept of the digital divide. The digital divide

can be defined in a simple way as the gap present between the part of the population that has access to technology and the one that does not. In this context, some papers [45,47,49] analyze the digital divide for countries in a region in order to observe the level of development of each country and compare their indicators. A method that was used in the article written by Beynon-Davies and Hill [45] was the use of the digital divide index, which was used in analyzing the Wales region of the United Kingdom at two points in time: 1997 and 2000. In addition, in the scientific literature, there have been studies [43,46,50–52] that maintain the idea that the adoption of technology increases the participation of the population in the economy, promotes the sustainable development of the economy and leads to the eradication of poverty. The relation between the reduction of poverty and digital development appears in the paper written by Dawood [52]. This paper observes a relation between the digital development and the social and economic progress in the case of the rural communities of northern Malaysia, stating that there is a correlation that could be made stronger by correlated action at a central level and pragmatic action at the grass roots level.

2.4. Measuring Influence Using Panel Data Vector Autoregressive Models

In order to quantify the influence of digital development on the poverty headcount rate, we decided to implement a panel data vector autoregressive model. The method of modeling using the vector autoregressive model was developed for the first time in the paper written by Sims [53]. The methodology has been improved since its introduction in 1980, and important landmarks are represented by several articles [54–56]. One of the articles of interest in developing the present article is the one written by Andrews and Lu [57], in which the methodology for GMM estimation on dynamic panel data models was developed.

In order to measure the effect of digital development on the poverty headcount, the authors used the methodology presented in the paper written by Dahlberg and Johansson [58] to develop the present article.

2.5. The Economic Effect of the COVID-19 Pandemic

The connection between digitalization and the economy has been best observed in the last unique period, more precisely during the pandemic. In this sense, works such as the one written by Fernández-Portillo et al. [59] tracked the impact of innovation on the relationship between the digitalization of companies and their economic and financial performance. The conclusion that the authors reached was that to reach a certain level of performance, not only is digitization needed, but a new strategy that will lead to the improvement of the company's performance is needed as well. Khera et al. [60] showed that digital financial services have been a key factor in economic growth. Thus, for the developing countries studied, the notes from the results indicated that digital financial inclusion is positively associated with GDP growth per capita and accelerating economic growth, with their recommendations being related to the digitization of financial services. Dirk Kohnert [61] showed that in Africa, digitalization and mobile telecommunications have made a positive contribution to economic growth during the pandemic, even for less-developed regions. However, the population here is facing, with new forms of the digital divide, the gap between the poor and rich, between advanced and less advanced African countries as well as between Africa and the rest of the world. According to Amankwah-Amoaha et al. [62], this shows how the pandemic has driven or constrained the digitalization of business around the globe, moving to global acceleration in the use of modern, digitized technologies that have changed working patterns and business strategies in a word lifestyle. Guo et al. [63] showed that the pandemic has put small- and medium-sized enterprises under enormous pressure to survive, which has forced them to adopt various digital technologies to cope with the crisis. The empirical results of the analysis show that digitalization has allowed small- and medium-sized enterprises to respond effectively to the public crisis. In their study, Almeida et al. [64] analyzed the impact of

digital transformation processes during the pandemic in three business areas: labor and social relations, marketing and sales and technology. The result was that digitalization would increase in each of these areas and would encourage the emergence of new digital products and services.

Härting et al. [65] showed that the key driver of business development is digital transformation, and with the pandemic, the need for digital solutions became more acute considering the opportunities for digitalization, especially for small and medium enterprises. Singh et al. [66] conducted a survey to distribute and meet food demand during the pandemic, and the results confirmed the positive impact of information on cost-saving performance and supply chain relationships, where the online distribution and application process was used. Abidi et al. [67] showed that the pandemic has led to an unprecedented shock for businesses and the economy in general, while digitalization has acted as a fence or as a popular key used to mitigate economic losses. The results obtained by the authors illustrate that digitally activated companies were able to mitigate the economic losses resulting from the unique situation better than companies with digital restrictions in the Middle East and Central Asia regions.

Döhring et al. [68] showed in their work that in a pandemic, even if a persistent increase in the demand for digital services was expected, the estimated economic impact was unknown. This paper states that competition policy and the labor market have come to support the digital transition, making digitalization grow at the same pace as economic growth.

Ragoussis and Timmis [69] showed the crucial role played by digital technologies in helping companies cope with the shock caused by the pandemic and found that digitalization has transformed the trajectory of the online market, leading to significant growth.

Xiang et al. [70] illustrated in their study that the sectors severely affected by the pandemic did not use the necessary technological and digital strategies to sustain their economies, showing as a conclusion the vital role of information technology and digitalization in supporting economies and helping them sustain themselves during crises. Chauhan et al. [71] showed that global blockages due to the pandemic from different economic branches have accelerated the digitalization of various sectors of the economy from retail to finance, education and healthcare, but at the same time, they have intensified inequalities at the national level and between countries. The COVID-19 (or Coronavirus) pandemic has exacerbated inequalities in nationality, occupation, income, sex and race as well as, in fact, a decrease in global productivity. Claeys et al. [72] showed that the pandemic has led to a global recession, and although both developing and advanced countries have lost about the same proportion of production, the real annual decline in GDP was higher in advanced countries, except for China, which saw an increase in GDP but below the pre-pandemic forecasts. Dannenberg et al. [73] in their study showed the impact of the pandemic in online food retail in Germany and the fact that there has been a strong increase in food and a disproportionate increase in online food trade because of digitalization. Katz et al. [74] showed through empirical evidence the important role of digitalization and technology in mitigating the disruption of economic and social effects created by the pandemic while assessing the vulnerable population groups, unemployment rates and level of readiness of developing countries to meet the challenge. Chakravorti et al. [75] illustrated in their study the growth and development of pandemic digitalization. This has helped people to work, learn, shop and socialize safely during a pandemic, a unique situation, and to maintain a semblance of normalcy. With the expansion of digitalization, e-commerce has grown, video conferencing has become more widely used, and the Zoom platform has reached high levels, competing with IBM.

2.6. Conclusions of the Literature Review

In the preceding section, we presented the main influences on the development of the ideas and the way in which the research question was answered in this paper. By studying the literature, the authors identified a lack of a global and international vision regarding the

way in which the poverty rate headcount is influenced by digital development. The authors considered that only a global vision could highlight the benefits of digital development for emerging countries which, as seen in the previous sections, are a major focus of scientific research. In this way, the present research will extend the findings of the analyzed papers, such as the ones written by Asongu [18] and Evans [19], to a worldwide level. This could offer interesting insights regarding the patterns of digital development and their relation with poverty.

3. Materials and Methods

In this research paper, the authors present a digital development index calculated for 175 countries for the period between 2000 and 2019. The selected 175 countries were the following: Hong Kong (China), United Arab Emirates (UAE), Malta, Japan, Korea (Rep. of), Seychelles, Montenegro, Luxembourg, Germany, Singapore, Switzerland, Cyprus, the United Kingdom, France, the Netherlands, Iceland, Estonia, Lithuania, Taiwan (Province of China), the United States, Israel, Kuwait, the Russian Federation, Belarus, Denmark, Spain, Uruguay, Costa Rica, Sweden, Portugal, Austria, Thailand, Greece, Mauritius, Italy, Slovenia, Iran (Islamic Republic of), Canada, Qatar, Belgium, Brunei Darussalam, Slovakia, Serbia, Ireland, Malaysia, Finland, Norway, Monaco, the Czech Republic, Saudi Arabia, Oman, Hungary, Kazakhstan, Poland, Croatia, Bahrain, Georgia, South Africa, Puerto Rico, Romania, El Salvador, Latvia, Botswana, China, Vietnam, Panama, Gibraltar, Bosnia and Herzegovina, Ukraine, Bulgaria, Colombia, Azerbaijan, Armenia, Tunisia, North Macedonia, Morocco, Andorra, the Philippines, Cambodia, Mongolia, Liechtenstein, Trinidad and Tobago, Turkey, Brazil, Gabon, Mexico, Barbados, Uzbekistan, San Marino, Ghana, Paraguay, Cabo Verde, Côte d'Ivoire, Albania, the Faroe Islands, Algeria, Indonesia, Sri Lanka, the Dominican Republic, Curacao, the British Virgin Islands, Guatemala, Palestine, Suriname, Maldives, Egypt, Australia, Chile, Argentina, Bolivia (Plurinational State of), Gambia, the Bahamas, Namibia, Senegal, Greenland, Mali, Kyrgyzstan, the Syrian Arab Republic, Cuba, Moldova, India, Kenya, Jamaica, Nigeria, Saint Vincent and the Grenadines, Guinea, Lesotho, Cameroon, Bangladesh, Burkina Faso, Zimbabwe, Benin, Zambia, Ecuador, Iraq, Sao Tome and Principe, Guinea-Bissau, Timor-Leste, Djibouti, Mauritania, Tanzania, Sierra Leone, Sudan, Rwanda, Bhutan, Togo, Pakistan, Nicaragua, Haiti, Venezuela, Vanuatu, Honduras, Macao, Jordan, Angola, Lao P.D.R., Lebanon, Belize, Solomon Islands, Tonga, Comoros, Mozambique, Malawi, Burundi, Peru, Afghanistan, Chad, Uganda, the Democratic Republic of the Congo, Kiribati, the Central African Republic, Ethiopia, Grenada, Liberia and South Sudan.

In the last decade, digital technologies have had an impressive spread in the case of most countries in the world. However, the existing literature and specialized practice highlight the existence of certain internationally recognized indices for digital technologies. According to the World Bank (2016) in the Digital Dividends—World Development Report 2016, the Digital Adoption Index (DAI) includes a cluster of 180 countries and represents a worldwide index which measures countries' digital adoption across three main dimensions of the economy: people, government, and business. Moreover, it defines digital technologies as "the internet, mobile phones, and all the other tools to collect, store, analyze, and share information digitally" but considers the fact that "technology can be transformational" [76]. This digital technologies index covers 180 countries in a composite of DAI (Economy) = DAI (Business) + DAI (People) + DAI (Governments). Some researchers used this World Bank index in order to complete certain studies on digital technology [77].

Another important perspective on digital technologies is provided by the Institute for Management Development (IMD) World Digital Competitiveness Ranking, using a cluster of 64 economies which are ranked from the most to the least digitally competitive based on 52 certain ranked criteria. Digital competitiveness constitutes the essential pillar of "new technologies in transforming governments' and businesses' process as well as how society interacts" but also determines value creation on the long-term horizon [78].

Furthermore, the European Commission also provided the Digital Economy and Society Index (DESI), which encapsulates the indicators on Europe's digital performance while following the progress of European Union member states. Digital Economy and Society Index (DESI) annual reports have been published by the European Commission since 2014. For instance, regarding official statistics, the European Commission (2022) argued in the Digital Economy and Society Index (DESI) annual report for 2022 that despite the fact that around 87% of adults between the ages of 16 and 74 years old used the internet regularly in 2021, only 54% had basic qualifications regarding digital skills. The European Commission also argued that 56% of persons in the European Union can handle tasks using at least basic digital skills, but digital technologies still remain an important deficiency in the context of advanced digital skills [79].

According to the European Investment Bank, between digitalization and firm performance, there is a very strong linkage, considering that digital firms tend to exhibit higher productivity compared with non-digital firms, have more sustainable management practices, become more innovative, grow faster and generate higher-paying positions of employment. It seems that digital adoption rates in European Union countries are lower compared with the United States of America. For instance, only 66% of manufacturing firms in the European Union, compared with 78% in the US, reported using at least one digital technology, while in the construction field, the share of digital firms was 40% in the European Union and 61% in the United States of America [80].

However, our approach is original, being essential in research to identify optimal alternative solutions to well-known digitalization indices already established internationally. In the existing literature, there are many research studies that use these previously listed digitalization indices, so this article tried to provide a much more innovative framework. The focus of the index is on the personal adoption of digital technology. In order to measure these factors for the analyzed countries, we took into account the following indicators: the percentage of individuals using the internet, the mobile cellular subscriptions per 100 people and the fixed telephone subscriptions per 100 people, as published by the International Telecommunication Union [81]. The index is computed by adding up the percentages of the indicators to obtain a total score for each year.

An advantage of the index calculated in this article, when compared with the Digital Economy and Society Index [82] or the ICT Development Index [83], is that it focuses mainly on the adoption of digital technology at a personal level. The authors consider this approach to be interesting, due to the fact that it makes possible a comparison between the digital development levels of the analyzed countries. In the analysis, we used the following packages from the R software package: panel var [84] and data table [85]. The model that the authors implemented in order to analyze the connection between the digital development index and the poverty headcount, as calculated by the World Bank database, was the indicator of the poverty headcount ratio at USD 5.50 per day (2011 PPP) (percentage of population) [86]. The model that we implemented was the two-step generalized moments method with two lags, similar to the one implemented by Dahlberg and Johansson [58] to measure the impact of the log returns of the local government expenditures, grants and revenues in Sweden for the time period between 1979 and 1986. The model was tested according to the procedure indicated in the paper written by Andrews and Lu [57] in order to set the proper number of lags and to see if the eigenvalues of the model were inside the unit circle.

The presented methodology is in line with the scientific research and the results of the studies described in the literature review section. In the following section, we aim to present the most relevant results of our research in a clear and concise manner by explaining the results and their implications. These implications lead to the conclusion that by increasing digital development, it is possible to eradicate poverty. This is of great interest to the scientific community and the political decision factors. This relation could be used in order to reshape the political strategies of the ruling governments in developing and emerging world countries.

4. Results

4.1. The Digitalization Index

In order to calculate the index, the authors decided to add up the components of the index in order to calculate a composite score for each country. The index was calculated by adding up all the percentages in nominal values (i.e., 9% was considered 9) in order to obtain a total score of digital development and the adoption of technology by the general population. This method allowed us to calculate the index for a great number of countries (175 in 2019) and understand the patterns of digital development at a worldwide scale. We consider this of great importance to presenting discussions on a worldwide scale for topics such as the problems faced by developing nations.

To generate the results presented in Figures 1 and 2, the authors used the Plotly [87] and Geopandas [88] packages for Jupyter Notebook. In Figure 1, we can observe the distribution of the world's countries by their digital development index scores for the year 2019. In the darkest color are the most-developed countries, and within the lighter colors are the least-developed countries. We can state that the most-developed countries were Europe and North America, and the least-developed ones were in Africa. A full list of the index values and the ranking of the countries is presented in Table A1 in Appendix A.

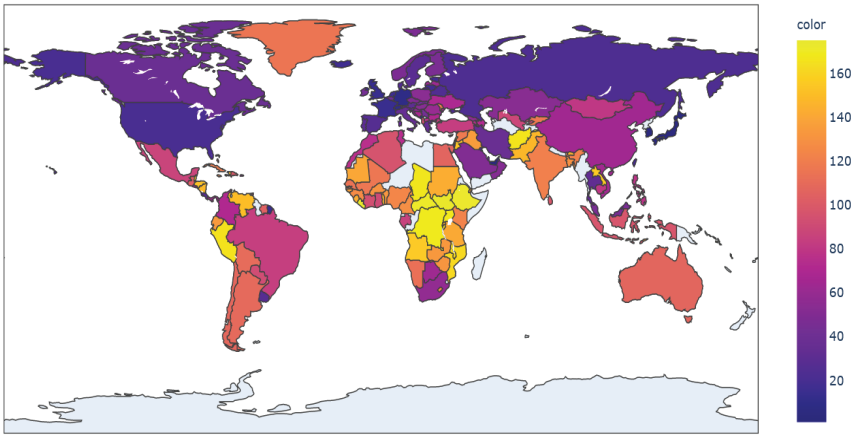

Figure 1. The results of the calculation of the digitalization index.

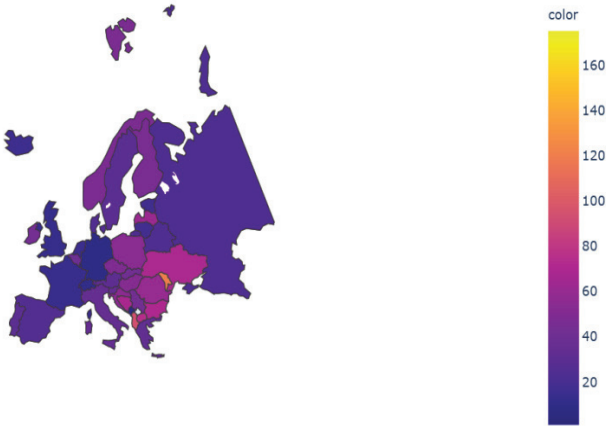

Figure 2. The results of the calculation of the digitalization index for Europe.

By analyzing Figure 1, we can state that the pattern of digital development was biased toward the Northern Hemisphere, with Europe being the most digitalized continent, along with North America and the southeast region of Asia. As we can see, the results for Africa show that this continent had the most developing countries, and access to technology was scarce.

In Figure 2, we present the European countries by the digitalization index score for each country, with the darkest color indicating the most digitalized countries and the lighter colors indicating the ones that were less developed.

From analyzing the results of the index, at a global level, we can see that the country considered the most developed from a digital standpoint was Hong Kong in the year 2019, and the least developed country was South Sudan. In the following part of the paper, we present several descriptive statistics regarding the values registered by the digital development index in 2000 and the values registered in 2019. The results are presented in Table 1.

Table 1. Comparative descriptive statistics for the index.

Statistic	2000	2019
Mean	50.2124	202.4483
Minimum	0.05857	46.5648
Maximum	191.9521	472.1837
Minimum/Maximum Percentage	0.031%	9.86%

In Table 1, we can see the way in which the digital development index depicts the evolution of the level of technological adoption of each country at the beginning and the end of the analyzed period. We can state that the difference between the most advanced country in the sample and the least advanced one was smaller in 2019 than it was in 2000. This is a clear indication that technology creates homogeneity in the development of countries. In this way, technology may accelerate the development of the economy and lead to a faster reduction in poverty. When taking into account the agenda of the Sustainable Development Goals, we can state that the advancement of technology should lead to the eradication of poverty, due to the effect of connecting the supply and demand of foreign markets. Another way in which digital development could lead to the eradication of poverty is by reducing unemployment. There have been several papers [89–92] that indicate a correlation between internet usage and employment (explained by the way in which the internet makes job opportunities more visible to the general public) or economic growth. Other interesting papers [91,92] regarding the development of digital technology and its effect on the business environment as part of the economy have been written, and the present paper acknowledges their contributions but aims to present a global image of digital development. Additionally, useful resources regarding the evolution of education and skills are presented on the OECD website [93], which are useful in gaining an overview of the presented problems regarding the effect of digital development on the reduction of poverty and its greater correlation with education and skill development (which is, in our opinion, essential in keeping up with technological advancement).

Moreover, the descriptive statistics show an increase in the level of the digital development of the analyzed countries, with the mean of the index being 50 in 2000 and reaching 202 in 2019. In addition, the ratio between the minimum value and the maximum value rose from 0.031% in 2000 to 9.86% in 2019.

In Table 2, the first 10 countries and the last 5, rated according to the digitalization development index, are presented. In the table, the authors presented only countries which had at least a population of 1.5 million people. The most developed countries, as calculated by our index, were Hong Kong, the United Arab Emirates, Japan, and South Korea.

Table 2. This table presents the rankings of the countries according to the index.

Rank	Country
1	Hong Kong, China
2	United Arab Emirates
3	Japan
4	Korea (Rep. of)
5	Germany
6	Singapore
7	Switzerland
8	United Kingdom
9	France
10	Netherlands
128	Central African Rep.
129	Ethiopia
130	Liberia
131	South Sudan

In Table 2, we decided to implement a restriction regarding the size of the population for the analyzed countries. This was performed to eliminate the bias of the index toward small countries (e.g., Luxembourg, Seychelles, etc.). The results for the full data sample are presented in Appendix A (Table A1). We decided to present a version of the table without the small countries because we considered that the results were significant for bigger and larger countries, due to the index being composed of indicators that were presented for 100 inhabitants.

In Figure 3, the authors present the evolution of four countries from the database that were considered to be of interest: Hong Kong, the United States of America, Germany, and South Africa. We can see that all the countries have evolved over time, but the digital index saw significant growth in the case of Hong Kong in the last 5 years. On the *y*-axis, we present the value of the digital development index, and on the *x*-axis, we present the years for which the index was calculated.

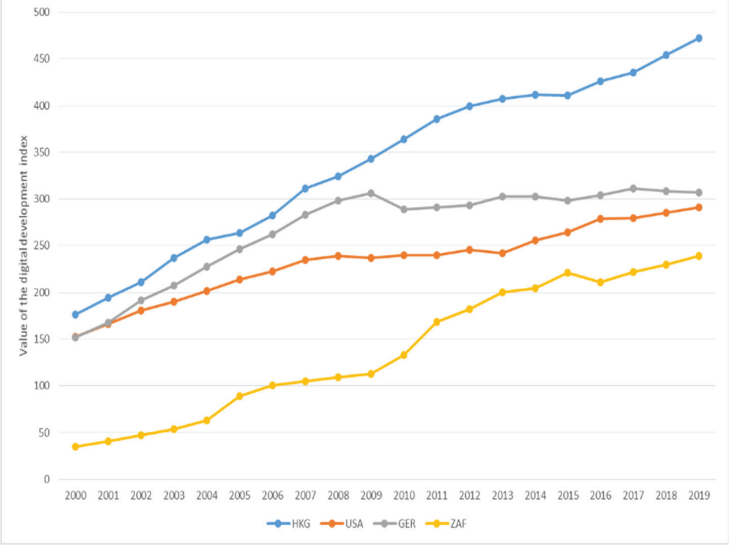

Figure 3. Evolution of the index for the selected countries.

By analyzing Figure 3, we can see that in the case of South Africa, the digital development index saw a significant increase in the analyzed time period. The authors also observed the fact that the analyzed countries experienced growth in digital development, but the difference between Hong Kong and South Africa remained relatively constant for

the analyzed time period. Moreover, the US, Germany, and South Africa were closer in the terms of digital development in 2019 compared with their positions in 2000.

4.2. The Relation between the Poverty Headcount Ratio and Digitalization

We decided to study the relation between the digital development index and the headcount poverty rate (as measured by the poverty headcount ratio at USD 5.50 a day (2011 PPP) (percentage of population) [64]) by applying a two-step dynamic panel vector autoregressive estimation with two lags. In the model, we used the first difference of the indicators by implementing a natural logarithm difference between the current value and the last value registered by the variable. The data used for the model were for the time period between 2005 and 2018 for the following countries: Armenia, Austria, Belgium, Belarus, Costa Rica, the Czech Republic, Denmark, the Dominican Republic, Ecuador, Spain, Estonia, Finland, France, Georgia, Greece, Honduras, Hungary, Indonesia, Kazakhstan, Lithuania, Latvia, Moldovia, the Netherlands, Norway, Panama, Peru, Poland, Portugal, Paraguay, the Russian Federation, Slovenia, Sweden, Turkey, Ukraine, and the United States of America. We selected these 35 countries due to the available data regarding the poverty headcount ratio. In this way, only these countries had all the data available for the analyzed time period. This explains the way in which the model was constructed. One useful indication was that we had countries from almost all of the continents (except Oceania), and this allowed us to still present a global overview for the selected data.

The results of the estimation of the model are presented in Figure 4. We can state that the poverty rate was influenced by the digital development index for both lags. For the first lag of the digital development index, the value of the coefficient was −1.7551 and was significant for a threshold of 95% for the poverty rate headcount. Moreover, the second lag of the digital development index was significant in the equation for the poverty rate, having a value of 1.3426. Consequently, we can state that the values of the poverty rate headcount were influenced by the values of the digital development index, with the value of the index in the previous year exerting a significant influence on reducing the poverty rate headcount, and the coefficient for the second lag indicated a positive influence on the poverty headcount rate. This could be due to the fact that the time interval was short and may have presented contradictory phases of the evolution of society.

```
-------------------------------------------------
Dynamic Panel VAR estimation, two-step GMM
-------------------------------------------------
Transformation: Forward orthogonal deviations
Group variable: ID
Time variable: Year
Number of observations = 385
Number of groups = 35
Obs per group: min = 11
avg = 11
               max = 11
Number of instruments = 308
====================================
               ID__1         Pov_rate
-------------------------------------------------
lag1_ID__1      1.1974 *     -1.7551 *
               (0.4971)      (0.7194)
lag1_Pov_rate   0.0599 (n.s) -0.1240 (n.s)
               (0.1956)      (0.1762)
lag2_ID__1     -0.4222 (n.s) 1.3426 *
               (0.4397)      (0.6733)
lag2_Pov_rate  -0.1414 (n.s) -0.0222 (n.s)
               (0.1352)      (0.1146)
==================================
* p < 0.05, n.s- not significant
```

Figure 4. Vector autoregression model results for the analyzed data.

In Figure 4, ID__1 represents the evolution of the digital development index, and the Pov_rate represents the evolution of the poverty rate calculated as the logarithmic difference of the values of the poverty headcount ratio at USD 5.50 a day (2011 PPP) (percentage of population) [86], as calculated by the World Bank. In Figure 5, we can see the results of the impulse response function for the vector autoregressive model.

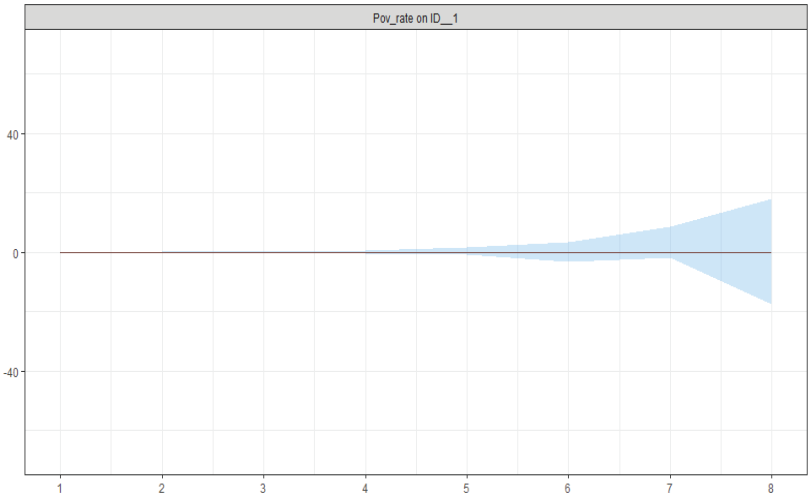

Figure 5. Impulse response function of the poverty headcount rate for the digitalization index.

By analyzing the results in Figure 5, we can see that there was a certain significant impact from the poverty rate headcount on the digital development index. This is important because it implies that the poverty rate can be decreased by the digital development index. Moreover, the shock had an effect on the last periods analyzed. Even though the impulse response function seemed to depict a small but significant effect, the results of the VAR model estimation as stated presented a significant coefficient of −1.7551 for the variable of the first lag of digital development in the equation that approximated the value of the poverty headcount ratio.

4.3. The Performance of the Digital Developed Economies during the COVID-19 Pandemic

In the following section, we present an analysis regarding the way in which the gross domestic products for the most digitally developed countries have evolved in the time of the COVID-19 pandemic. For this, we take the most developed countries according to our digital development index and compare them to the other countries in the sample.

In Figure 6, the authors depict the evolution of the economic growth values for four countries that were considered to be in the category of the most-developed countries from the studied sample (Switzerland, Germany, Japan and South Korea) and compared them to the average of the countries that are members of the OECD, European Union and the euro area.

By analyzing the figure, we can observe that the digitally developed countries had more stable economic growth in the pandemic period when compared with the average of the European Union, eurozone or the OECD. This fact indicates that a higher level of digital development led to a more equilibrated response to the pandemic's shock. The complete data of the figure are depicted in Table 3, with the data being available from the OECD database [93].

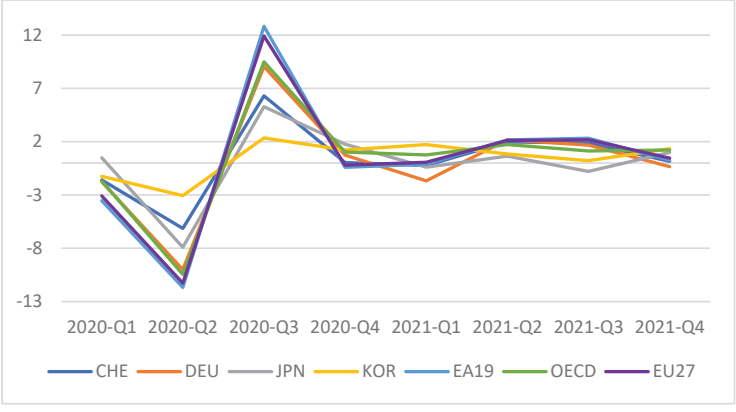

Figure 6. Evolution of the economic growth for the studied countries.

Table 3. Economic growth of the analyzed countries as percentages.

Date	CHE	DEU	JPN	KOR	EA19	OECD	EU27
2020-Q1	−1.59	−1.76	0.49	−1.26	−3.53	−1.70	−3.09
2020-Q2	−6.14	−10.00	−7.90	−3.05	−11.67	−10.45	−11.27
2020-Q3	6.30	9.04	5.28	2.35	12.82	9.49	11.91
2020-Q4	0.04	0.74	1.76	1.21	−0.40	1.02	−0.20
2021-Q1	−0.24	−1.68	−0.40	1.72	−0.12	0.75	0.07
2021-Q2	1.97	2.17	0.64	0.83	2.16	1.72	2.11
2021-Q3	1.87	1.67	−0.80	0.21	2.32	1.12	2.18
2021-Q4	0.16	−0.35	0.98	1.34	0.25	1.21	0.45

In Table 3, the authors present the results of presenting the economic growth from the first quarter of 2020 to the fourth quarter of 2021. The analyzed countries were Switzerland, Germany, Japan and Korea. In the table, we also present the values reported for the euro area, the OECD and the European Union. The countries that were the most digitally developed, such as Japan (ranked third in 2019) and South Korea (ranked fourth in 2019) had a growth rate higher than the eurozone, OECD and the European Union. In the following part, we present the discussions regarding the findings of this article and the conclusions.

By analyzing these results, we can conclude that the countries that had better digital development had a better evolution during the COVID-19 pandemic and also had a less powerful impact than in the case of the average of the OECD, the euro area and the European Union countries. The number of countries in the sample was relatively small compared with the number of countries used in the index (35 vs. 175) due to the lack of data regarding the poverty headcount ratio for the period between 2005 and 2018.

5. Discussion

In the present article, we described how to compute an index for digital development that takes into account the personal adoption of technology. This was achieved by taking into account data made available by the International Telecommunication Union in order to obtain a better understanding of the level of development of each country and offers the possibility of comparing the digital development of the countries.

Some researchers [94] revealed that the transportation and accommodation sectors have been significantly affected by COVID-19-related lockdowns, but on the contrary, other sectors of the sharing economy such as freelance work, streaming services and online deliveries have reached increasing levels of development and profit. At the quantitative level, the most likely effect of the COVID-19 pandemic on the global economy has been

quantified to be between USD 5.8 trillion and 8.8 trillion, equivalent to 6.4–9.7% of the global gross domestic product (GDP) as approximated by the Asian Development Bank (ADB) on May 2020 [95]. According to other researchers [96], the COVID-19 pandemic raised unprecedented challenges while earnestly affecting all businesses worldwide.

The results of the vector autoregressive model led to the conclusion that there is a significant statistical influence from the digital development index that we constructed in this paper and the poverty headcount rate as described by the World Bank indicator (poverty headcount ratio at USD 5.50 a day (2011 PPP) (percentage of population)) [86]. This led to the idea that by increasing the access to technology, governments could contribute to the reduction of poverty. This reduction in poverty could lead to the advancement of the Sustainable Development Goals and progress in implementing the 2030 Agenda of the UN [3]. The presented findings are similar to the ones obtained in other papers [26–31], with the exception that the data sample used in this article contained countries from all over the world, and we provided a comparison of the influence of digital development on the reduction of poverty that is easier to understand at a global level. In this context, we can state that the digital development of a country leads to a reduction in the poverty headcount. These results agree with those of the majority of the papers in the scientific literature. An interesting development contribution is the way in which digital development is measured in the present article. The authors decided to use an index that measured the personal adoption of technology due to the effect that technology at an individual level has on the reduction in poverty. The usefulness of the present research is the fact that it proves that the adoption of technology at the personal level leads to a reduction in poverty. This could be used as the basis for shaping policies regarding the eradication of poverty at the international level. By increasing the access to technology among the population, citizens could access job opportunities that they otherwise would not have seen, or they could have access to information at an unprecedented scale. These results could be seen as a continuation of the work conducted in several papers [43,46,50–52] regarding the way in which technology increases the opportunity to participate in the economy for all the citizens. In this case, the authors recommend an increase in the interest that governments have in the adoption of technology at the personal level by creating programs which encourage the use of and access to technology and also make the acquisition of IT devices easier (e.g., this could be achieved with vouchers or discounts for an individual's first computer).

In addition, we note that the results of this paper seem to generalize certain findings for specific continents [18,19,26,27], such as the beneficial effect of digital development on the reduction of poverty in Africa and for the 35 countries analyzed in the model (which are mostly in Europe and the North and South American continents). In this way, our study demonstrates a clear relation between digital development (concentrated on the personal adoption of technology due to the composition of the index: the percentage of individuals using the internet, the mobile cellular subscriptions for 100 people and the fixed telephone subscriptions for 100 people) and the reduction of poverty. This confirms the findings of several studies [43,46,50–52,67–70], which stated that the adoption of the internet leads to the reduction of poverty. The mechanism of this influence is, as stated by Dawood [52], for the case of the rural communities of northern Malaysia, and it works by encouraging a connection between individuals and action at the grass roots level. This implies that technology changes society by giving power to the people to communicate and create groups in an easier and more interest-based way. For example, a group that promotes the creation of parking lots in a certain area of the city could promote the idea on the internet and, by doing this, make it more visible for the city council. In this way, we consider that the adoption of the internet will lead to the reduction of poverty by increasing the freedom of the population and access to information, which promotes a better understanding of the way government functions.

Additionally, the index presented in this paper could be used on its own for assessing the digital development of the world's countries. In this way, the index is similar to the one developed by Archibugi and Coco [34] in their paper "A New Indicator of Technological

Capabilities for Developed and Developing Countries (Arco)", which ranked Sweden as the most digitally developed country in 2000. In our index, the most digitally developed country in 2019 was Hong Kong, which in [34] was number 21. This growth seems to be confirmed by the results presented in Figure 3. In this way, the index developed in our article, along with the digital divide indices developed in other papers [42–52], can offer a way to compare digital development and the progress of countries in the adoption of technology. Possible future researchers could, by using the methodology described in this paper, compare results and see the way in which countries evolved from a digital development standpoint. The present paper describes an original and interesting research study regarding the influence of the personal adoption of digital technology on the poverty rate. The authors also appreciate that the results of the present study could be of interest to governmental institutions and to international organizations such as the United Nations and the OECD due to its implications for the planning and achievement of the Sustainable Development Goals, as stated in the 2030 Agenda [3]. In this way, the present study could inspire similar approaches and lead to advancement of the rate of the eradication of poverty by making technology available to all citizens.

Regarding the relation between digital development and the COVID-19 pandemic, we can state that the economies of the more digitally developed countries have been more stable in the face of the COVID-19 pandemic. These observations are in line with the relevant scientific literature [59–75], meaning that digital development helps develop a stronger economy (that responds to external shocks, such as the COVID-19 pandemic, better). This observation leads to the idea that by developing the digital capacity of a country, the authors can improve its response in the face of the COVID-19 pandemic.

The presented results are similar to those in the scientific literature, and they present a correlated and significant view of digital development as a key factor in reducing the poverty headcount ratio. Our results are similar to the ones presented in several cited studies [43,46,50–52,67–70], and by generalizing aspects that were observed at continental level by several articles [18,19,26,27], these results should be of interest to the scientific and academic communities as well as researchers in the economic area.

6. Conclusions

Starting from the research hypothesis stated in the introduction, ("How does the increase in technological development influence the rate of poverty at the national level, and how does digital development relate to the response to the COVID-19 pandemic?") we can say that this research study presents a clear and significant influence between the digital development of a country and the poverty headcount ratio, as calculated by the World Bank [64]. The present paper shows a correlation between the adoption of technology at the personal level (due to the way in which the digital development index is calculated: considering the percentage of individuals using the internet, the mobile cellular subscriptions per 100 people and the fixed telephone subscriptions per 100 people) and the reduction in the poverty headcount ratio. In addition, this study's contributions to the general field of knowledge regarding the analysis of digital development, as well as its importance in the reduction of the poverty headcount ratio, are significant and interesting. First, this study establishes a connection between the development of the digital capacity of a country, as measured by using the digital development index, and economic development. The index is calculated as the sum of the following indicators: the percentage of individuals using the internet, the mobile cellular subscriptions per 100 people and the fixed telephone subscriptions per 100 people, as published by the International Telecommunication Union [76]. This connection is similar to the one described in several papers [34–37] that have proposed and used indices for measuring digital development, such as the one written by Archibugi and Coco [34]. These interesting results are doubled by the interesting connection between the digital development of a country and the reduction of the poverty headcount ratio. This result is of great interest due to the interesting effects that digitalization has for increasing the wealth of nations. In this case, such an

observation, though stated in several papers [18,19], only applied for limited datasets that were related to single continents. For example, Asongu [18] and Evans [19] presented a hypothesis that explains, in the case of the African continent, the way in which mobile phone development led to a significant increase in informal financial development, even though its effects were less noticeable at the macroeconomic level, and that the use of mobile phones with internet access in 44 African countries in the period between 2000 and 2016 led to an increase in financial inclusion, although the literature review-based studies [20] make claims that there are few papers that can present a causal inference between ICT development and poverty. The fact is that the interaction between the internet, mobile phone access or other technologies and poverty, which was also the focus of many papers [21–25], was demonstrated in this research paper for the 35 countries that were analyzed in the data sample.

Additionally, in the scientific literature, there has been a trend toward analyzing the impacts of technology as a means of inclusion and access to information on poverty, either in South Asia, Sub-Saharan Africa [26] or in Latin America [27]. This also makes our study of interest regarding the way in which digital development has led to worldwide developments instead of regionally based implications. This concentration of the study on proving and presenting results at the global level is, in our opinion, its biggest strength and sets it apart as an interesting and dynamic approach of a much-studied and debated economic and social phenomenon [97–99].

The results of this study suggest that by making technology more affordable and available for a population, the Sustainable Development Goal of eradicating poverty could be accomplished in a faster and more efficient way. One of the challenges that we met in the development of the present study was the lack of data regarding the poverty rate of the analyzed countries, with this being due to the fact that we determined the application of the model to only be for 35 countries and for the period between 2005 and 2018, as these were the only available data on the subject at the national level.

This paper presents a quantifiable method of analyzing the impact of digital technology adoption at the personal level on the poverty headcount ratio. This approach is an original one due to the way in which we can observe the impact of the possible increase in the adoption of technology. Of additional interest is the composition of the digital development index. The index allowed us to compare the evolution of the countries in the analyzed period of time. The index is easy to build and can offer a benchmark for developing a comparative analysis between different countries and observing the way in which policies have shaped the evolution of digital development in each country. Another contribution of the index could be its use in the better understanding of the problems of developing countries, as we observed that the countries of the African continent were the ones that presented the greatest gap in digital development. This is of interest due to the fact that sustainable development should promote growth at the global level. In this context, the calculation of this index in the future could provide researchers with a perspective of the progress made by developing countries, and it could also serve as an indicator of appropriate regional policy and a sustainable approach at the international level.

On the other hand, a notable research limitation is that the data analyzed in this paper deal with country-based indicators. This approach leads to the exclusion of the idea that within a country, there might be several levels of technological adoption, depending on the regions of the country or whether the population lives in rural or urban environments. Moreover, in the development of the study, the authors noticed a lack of data regarding the poverty headcount ratio for most of the world's countries. This fact led us to use only 35 countries in the final study in order to develop the vector autoregressive model. Another limitation to take into consideration is represented by the bias of the index toward small countries. This is explained by the way in which the index takes into account indicators that are expressed as percentages. Although such an approach could favor small countries, using nominal values of the indicators (e.g., millions of internet users) could lead to confusing results, and the index is more understandable as a total score of all the percentage-based

indicators. Another limitation is represented by the fact that poverty itself is a complex phenomenon, and in this paper, the authors attempted to analyze only the relation between digital development and poverty without taking into consideration other determining factors of poverty, such as government- and society-related factors, in order to analyze the relation at a fundamental and singular level. However, this approach has the advantage and the limitation of offering a clear view of only a small piece of the relations of poverty and its determining factors.

Another interesting effect of digital development on the economy is raising its resilience in front of external shocks. One such shock is the COVID-19 pandemic, with which the world has been confronted in the last two years. By analyzing the evolution of the most digitally developed economies, during the pandemic, we can conclude that the ones that were the most developed according to the digital development index (Japan and South Korea) performed better than the European Union, euro zone and OECD averages. This is of interest because it shows that by increasing the access to technology, the government not only reduces the poverty headcount ratio, but it also makes the economy more resilient to outside shocks. This leads to the idea that digital development has many positive impacts that should be further researched.

The present study also has interesting managerial implications for presenting a global perspective of the digital development of the world's countries. For a company that wants to become active in a digitally developed country, it could use the results of this study as a guideline to analyzing the development of each country. In addition, the relation between the digital development of a country and reduction of the poverty headcount is useful for quantifying the way in which a certain country could evolve in the future from a digital standpoint.

Further research studies should focus on investigation of the relation between technological adoption and other Sustainable Development Goals. This could be useful because it holds significance in demonstrating that technology is an important driving force in the creation of a more sustainable economy. Another interesting research direction could be the impact of the technology price level on the poverty headcount rate, so this could be of interest due to the connections between the affordability of technology and its adoption.

Thus, it can be concluded that the present research paper presents an established and clear correlation between digital development and the poverty headcount ratio. This is not only a new approach to the field of study but also presents significant relevance to the reader. In this way, this article is of great interest to all of the scientific community and the political decision factors due to the implications of the research performed. In this way, by encouraging digital development of the population (by adopting new technologies), the government can lead to reduction of the poverty headcount ratio. Even though investment in shelter and primary goods can be seen as the way to go for a developing nation, we conclude that better and more consistent results regarding the reduction of poverty can be obtained by increasing the digital development of the country.

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Appendix A

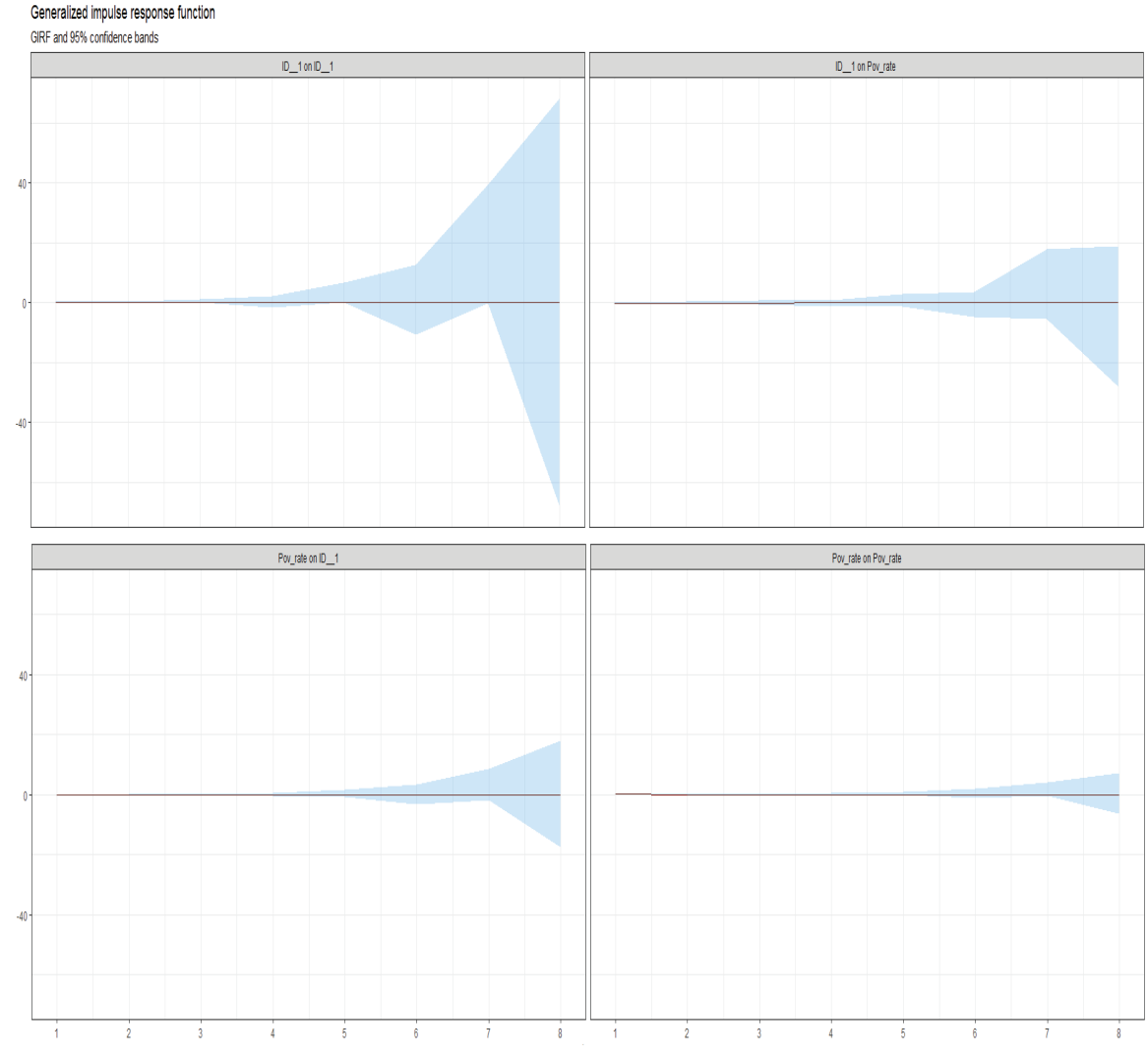

Figure A1. Generalized impulse response function.

Table A1. List of countries based on rank in 2019.

Country	Rank in 2019	Country	Rank in 2019
Hong Kong, China	1	San Marino	89
United Arab Emirates	2	Ghana	90
Malta	3	Paraguay	91
Japan	4	Cabo Verde	92
Korea (Rep. of)	5	Côte d'Ivoire	93
Seychelles	6	Albania	94
Montenegro	7	Faroe Islands	95
Luxembourg	8	Algeria	96
Germany	9	Indonesia	97

Table A1. *Cont.*

Country	Rank in 2019	Country	Rank in 2019
Singapore	10	Sri Lanka	98
Switzerland	11	Dominican Rep.	99
Cyprus	12	Curacao	100
United Kingdom	13	British Virgin Islands	101
France	14	Guatemala	102
Netherlands	15	Palestine	103
Iceland	16	Suriname	104
Estonia	17	Maldives	105
Lithuania	18	Egypt	106
Taiwan, Province of China	19	Australia	107
United States	20	Chile	108
Israel	21	Argentina	109
Kuwait	22	Bolivia (Plurinational State of)	110
Russian Federation	23	Gambia	111
Belarus	24	Bahamas	112
Denmark	25	Namibia	113
Spain	26	Senegal	114
Uruguay	27	Greenland	115
Costa Rica	28	Mali	116
Sweden	29	Kyrgyzstan	117
Portugal	30	Syrian Arab Republic	118
Austria	31	Cuba	119
Thailand	32	Moldova	120
Greece	33	India	121
Mauritius	34	Kenya	122
Italy	35	Jamaica	123
Slovenia	36	Nigeria	124
Iran (Islamic Republic of)	37	Saint Vincent and the Grenadines	125
Canada	38	Guinea	126
Qatar	39	Lesotho	127
Belgium	40	Cameroon	128
Brunei Darussalam	41	Bangladesh	129
Slovakia	42	Burkina Faso	130
Serbia	43	Zimbabwe	131
Ireland	44	Benin	132
Malaysia	45	Zambia	133
Finland	46	Ecuador	134
Norway	47	Iraq	135
Monaco	48	Sao Tome and Principe	136
Czech Republic	49	Guinea-Bissau	137
Saudi Arabia	50	Timor-Leste	138
Oman	51	Djibouti	139
Hungary	52	Mauritania	140
Kazakhstan	53	Tanzania	141
Poland	54	Sierra Leone	142
Croatia	55	Sudan	143
Bahrain	56	Rwanda	144
Georgia	57	Bhutan	145
South Africa	58	Togo	146
Puerto Rico	59	Pakistan	147
Romania	60	Nicaragua	148
El Salvador	61	Haiti	149
Latvia	62	Venezuela	150
Botswana	63	Vanuatu	151
China	64	Honduras	152
Vietnam	65	Macao, China	153
Panama	66	Jordan	154
Gibraltar	67	Angola	155

Table A1. *Cont.*

Country	Rank in 2019	Country	Rank in 2019
Bosnia and Herzegovina	68	Lao P.D.R.	156
Ukraine	69	Lebanon	157
Bulgaria	70	Belize	158
Colombia	71	Solomon Islands	159
Azerbaijan	72	Tonga	160
Armenia	73	Comoros	161
Tunisia	74	Mozambique	162
North Macedonia	75	Malawi	163
Morocco	76	Burundi	164
Andorra	77	Peru	165
Philippines	78	Afghanistan	166
Cambodia	79	Chad	167
Mongolia	80	Uganda	168
Liechtenstein	81	Dem. Rep. of the Congo	169
Trinidad and Tobago	82	Kiribati	170
Turkey	83	Central African Rep.	171
Brazil	84	Ethiopia	172
Gabon	85	Grenada	173
Mexico	86	Liberia	174
Barbados	87	South Sudan	175
Uzbekistan	88		

Figure A2. The flow diagram of the main phases of the research.

References

1. United Nations World Commission on Environment and Development (Ed.) *Report of the World Commission on Environment and Development: Our Common Future*; Oxford University Press: Oxford, UK, 1987.
2. International Union for Conservation of Nature and Natural Resources. 1980. World Conservation Strategy: Living Resource Conservation for Sustainable Development. Available online: https://www.a21italy.it/medias/31C2D26FD81B0D40.pdf (accessed on 17 March 2022).

3. United Nations Statistics Division (UNSD). SDG Indicators—Global Indicator Framework for the Sustainable Development Goals and Targets of the 2030 Agenda for Sustainable Development. Available online: https://unstats.un.org/sdgs/indicators/indicators-list (accessed on 17 March 2022).
4. Griggs, D.J.; Stafford-Smith, M.; Gaffney, O.; Rockström, J.; Öhman, M.C.; Shyamsundar, P.; Steffen, W.; Glaser, G.; Kanie, N.; Noble, I.R. Policy: Sustainable development goals for people and planet. *Nature* **2013**, *495*, 305–307. [CrossRef] [PubMed]
5. French, D.; Kotzé, L.J. *Sustainable Development Goals*; Edward Elgar Publishing: Cheltenham, UK, 2018. [CrossRef]
6. Pradhan, P.; Costa, L.; Rybski, D.; Lucht, W.; Kropp, J.P. A Systematic Study of Sustainable Development Goal (SDG) Interactions. *Earth's Future* **2017**, *5*, 1169–1179. [CrossRef]
7. Leal Filho, W.; Tripathi, S.K.; Andrade Guerra, J.B.; Giné-Garriga, R.; OrlovićLovren, V.; Willats, J. Using the sustainable development goals towards a better understanding of sustainability challenges. *Int. J. Sustain. Dev. World Ecol.* **2018**, *26*, 179–190. [CrossRef]
8. Folke, C.; Carpenter, S.; Elmqvist, T.; Gunderson, L.; Holling, C.S.; Walker, B. Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. *Ambio* **2002**, *31*, 437–440. [CrossRef]
9. Hickel, J. The contradiction of the sustainable development goals: Growth versus ecology on a finite planet. *Sustain. Dev.* **2019**, *27*, 873–884. [CrossRef]
10. Coscieme, L.; Mortensen, L.F.; Anderson, S.J.; Ward, J.D.; Donohue, I.; Sutton, P.C. Going beyond Gross Domestic Product as an indicator to bring coherence to the Sustainable Development Goals. *J. Clean. Prod.* **2020**, *248*, 119232. [CrossRef]
11. Kubiszewski, I.; Mulder, K.; Jarvis, D.; Costanza, R. Toward better measurement of sustainable development and wellbeing: A small number of SDG indicators reliably predict life satisfaction. *Sustain. Dev.* **2022**, *30*, 139–148. [CrossRef]
12. MacFeely, S. Measuring the Sustainable Development Goal Indicators: An Unprecedented Statistical Challenge. *J. Off. Stat.* **2020**, *36*, 361–378. [CrossRef]
13. Schmidt-Traub, G.; Kroll, C.; Teksoz, K.; Durand-Delacre, D.; Sachs, J.D. National baselines for the Sustainable Development Goals assessed in the SDG Index and Dashboards. *Nat. Geosci.* **2017**, *10*, 547–555. [CrossRef]
14. Allen, C.; Nejdawi, R.; El-Baba, J.; Hamati, K.; Metternicht, G.I.; Wiedmann, T.O. Indicator-based assessments of progress towards the sustainable development goals (SDGs): A case study from the Arab region. *Sustain. Sci.* **2017**, *12*, 975–989. [CrossRef]
15. Federal Register: Annual Update of the HHS Poverty Guidelines. Available online: https://www.govinfo.gov/content/pkg/FR-2020-01-17/pdf/2020-00858.pdf (accessed on 24 April 2022).
16. Government of India, Press Information Bureau, Poverty Estimates for 2004-05. Available online: https://web.archive.org/web/20120917001050/http://planningcommision.gov.in/news/prmar07.pdf (accessed on 24 April 2022).
17. Kwilinski, A.; Vyshnevskyi, O.; Dzwigol, H. Digitalization of the EU Economies and People at Risk of Poverty or Social Exclusion. *J. Risk Financ. Manag.* **2020**, *13*, 142. [CrossRef]
18. Asongu, S.A. How has Mobile Phone Penetration Stimulated Financial Development in Africa? *J. Afr. Bus.* **2013**, *14*, 7–18. [CrossRef]
19. Evans, O. Connecting the poor: The internet, mobile phones and financial inclusion in Africa. *Digit. Policy Regul. Gov.* **2018**, *20*, 568–581. [CrossRef]
20. May, J.; Diga, K. Progress Towards Resolving the Measurement Link Between ICT and Poverty Reduction. In *Impact of Information Society Research in the Global South*; May, J., Diga, K., Eds.; Springer: Singapore, 2015; pp. 83–104. [CrossRef]
21. James, J. The Internet and poverty in developing countries: Welfare economics versus a functionings-based approach. *Futures* **2006**, *38*, 337–349. [CrossRef]
22. Adomi, E.E. *Frameworks for ICT Policy: Government, Social and Legal Issues*; IGI Global: Hershey, PA, USA, 2011. [CrossRef]
23. Ramírez, R. Appreciating the Contribution of Broadband ICT with Rural and Remote Communities: Stepping Stones toward an Alternative Paradigm. *Inf. Soc.* **2007**, *23*, 85–94. [CrossRef]
24. Rao, S.S. Role of ICTs in India's rural community information systems. *Info* **2004**, *6*, 261–269. [CrossRef]
25. Cecchini, S.; Scott, C. Can information and communications technology applications contribute to poverty reduction? Lessons from rural India. *Inf. Technol. Dev.* **2003**, *10*, 73–84. [CrossRef]
26. Lyons, A.; Kass-Hanna, J.; Greenlee, A.J. Impacts of Financial and Digital Inclusion on Poverty in South Asia and Sub-Saharan Africa. *Food Sustain. Secur. Ejournal* **2020**. [CrossRef]
27. Arocena, R.; Senker, P. Technology, Inequality, and Underdevelopment: The Case of Latin America. *Sci. Technol. Hum. Values* **2003**, *28*, 15–33. [CrossRef]
28. Dercon, S.; Christiaensen, L. Consumption Risk, Technology Adoption, and Poverty Traps: Evidence from Ethiopia. *J. Dev. Econ.* **2011**, *96*, 159–173. [CrossRef]
29. Lee, J.N.; Morduch, J.; Ravindran, S.K.; Shonchoy, A.S.; Zaman, H. Poverty and Migration in the Digital Age: Experimental Evidence on Mobile Banking in Bangladesh. *Am. Econ. J. Appl. Econ.* **2021**, *13*, 38–71. [CrossRef]
30. Mora-Rivera, J.; García-Mora, F. Internet access and poverty reduction: Evidence from rural and urban Mexico. *Telecommun. Policy* **2021**, *45*, 102076. [CrossRef]
31. Tayo, O.; Thompson, R.J.; Thompson, E.J. Impact of the Digital Divide on Computer Use and Internet Access on the Poor in Nigeria. *J. Educ. Learn.* **2016**, *5*, 1–6. [CrossRef]

32. Pînzaru, F.; Zbuchea, A.; Anghel, L.C. Knowledge Development through the Internet. In Proceedings of the International Conference on Intellectual Capital, Knowledge Management & Organisational Learning, Sydney, Australia, 6–7 November 2014. [CrossRef]
33. Massimo, G.C.; Luca, G. Technology policy for the knowledge economy: Public support to young ICT service firms. *Telecommun. Policy* **2007**, *31*, 573–591. [CrossRef]
34. Archibugi, D.; Coco, A. A New Indicator of Technological Capabilities for Developed and Developing Countries (Arco). *SSRN Electron. J.* **2004**, *32*, 629–654. [CrossRef]
35. Álvarez, I.G.; Magaña, G. ICT and development: A new indicator for international comparisons. *Int. J. Technol. Glob.* **2008**, *4*, 170–185. [CrossRef]
36. Nevado-Peña, D.; López-Ruiz, V.; Alfaro-Navarro, J. An analysis of the key role of human and technological development in the smart specialization of smart European regions. *Inf. Technol. Dev.* **2020**, *26*, 728–741. [CrossRef]
37. Hongxi, C.; Juan, P. A Study on the Dynamic Relationship between Digital Financial Development, Social Consumption and Economic Growth. *J. Econ. Public Financ.* **2021**, *7*, 56–69. [CrossRef]
38. Fornerino, M. Internet adoption in France. *Serv. Ind. J.* **2003**, *23*, 119–135. [CrossRef]
39. Martínez-Domínguez, M.; Mora-Rivera, J. Internet adoption and usage patterns in rural Mexico. *Technol. Soc.* **2020**, *60*, 101226. [CrossRef]
40. Masaki, T.; Rodríguez-Castelán, C.; Ochoa, R.; Lach, S. Mobile Internet Adoption in West Africa. *Technol. Soc.* **2021**, *68*, 101845. [CrossRef]
41. Pénard, T.; Poussing, N.; Mukoko, B.; Piaptie, G. Internet adoption and usage patterns in Africa: Evidence from Cameroon. *Technol. Soc.* **2015**, *42*, 71–80. [CrossRef]
42. Cavalcanti, D.R.; Oliveira, T.; Santini, F.D. Drivers of Digital Transformation Adoption: A Weight and Meta-Analysis. *Heliyon* **2022**, *8*, e08911. [CrossRef] [PubMed]
43. Jovanović, M.; Dlačić, J.; Okanovic, M. Digitalization and society's sustainable development—Measures and implications. *Proc. Rij. Fac. Econ. J. Econ. Bus.* **2018**, *36*, 905–928. [CrossRef]
44. Bagchi, K.K. Factors Contributing to Global Digital Divide: Some Empirical Results. *J. Glob. Inf. Technol. Manag.* **2005**, *8*, 47–65. [CrossRef]
45. Beynon-Davies, P.; Hill, R.A. Evaluating a digital divide index in a regional context. *J. Syst. Inf. Technol.* **2007**, *9*, 46–59. [CrossRef]
46. Taylor, D.; Packham, G.A. Social Inclusion through ICT: Identifying and Overcoming Barriers to ICT Use. *Strateg. Change* **2016**, *25*, 45–60. [CrossRef]
47. Ayanso, A.; Cho, D.I.; Lertwachara, K. The digital divide: Global and regional ICT leaders and followers. *Inf. Technol. Dev.* **2010**, *16*, 304–319. [CrossRef]
48. Ayanso, A.; Cho, D.I.; Lertwachara, K. Information and Communications Technology Development and the Digital Divide: A Global and Regional Assessment. *Inf. Technol. Dev.* **2014**, *20*, 60–77. [CrossRef]
49. Chinn, M.D.; Fairlie, R.W. ICT Use in the Developing World: An Analysis of Differences in Computer and Internet Penetration. *Inf. Syst. Behav. Soc. Methods* **2006**, *18*, 153–167. [CrossRef]
50. Dijk, J.V. *The Deepening Divide: Inequality in the Information Society*; SAGE Publications Inc.: Thousand Oaks, CA, USA, 2005. [CrossRef]
51. Warren, M. The digital vicious cycle: Links between social disadvantage and digital exclusion in rural areas. *Telecommun. Policy* **2007**, *31*, 374–388. [CrossRef]
52. Dawood, S.R. Digital Divide and Poverty Eradication in the Rural Region of Northern Peninsular Malaysia. *Indones. J. Geogr.* **2019**, *51*, 172–182. [CrossRef]
53. Sims, C.A. Macroeconomics and Reality. *Econometrica* **1980**, *48*, 1–48. [CrossRef]
54. Kiviet, J. On Bias, Inconsistency, and Efficiency of Various Estimators in Dynamic Panel Data Models. *J. Econom.* **1995**, *68*, 53–78. [CrossRef]
55. Bond, S.R. Dynamic Panel Data Models: A Guide to Micro Data Methods and Practice. *Port. Econ. J.* **2002**, *1*, 141–162. [CrossRef]
56. Anderson, T.; Hsiao, C. Formulation and Estimation of Dynamic Models Using Panel Data. *J. Econom.* **1982**, *18*, 47–82. [CrossRef]
57. Andrews, D.; Lu, B. Consistent Model and Moment Selection Procedures for GMM Estimation with application to dynamic panel data models. *J. Econom.* **2001**, *101*, 123–164. [CrossRef]
58. Dahlberg, M.; Johansson, E. Behavior of Local Governments Using GMM Bootstrapping Methods. *J. Appl. Econom.* **2000**, *15*, 401–416. [CrossRef]
59. Fernández-Portillo, A.; Almodóvar-González, M.; Sánchez-Escobedo, M.C.; Coca-Pérez, J.L. The role of innovation in the relationship between digitalisation and economic and financial performance. *Eur. Res. Manag. Bus. Econ.* **2022**, *25*, 100190. [CrossRef]
60. Khera, P.; Ng, S.; Ogawa, S.; Sahay, R. Is Digital Financial Inclusion Unlocking Growth? IMF Working Paper. 2021, p. 167. Available online: https://ssrn.com/abstract=4026364 (accessed on 23 July 2022).
61. Kohnert, D. The Impact of Digitalization on Poverty Alleviation in Africa. Munich Personal RePEc Archive (MAPRA). 2021, p. 110296. Available online: https://mpra.ub.uni-muenchen.de/110296/ (accessed on 25 July 2022).
62. Amankwah-Amoaha, J.; Khan, Z.; Wood, G.; Knight, G. COVID-19 and digitalization: The great acceleration. *J. Bus. Res.* **2021**, *136*, 602–611. [CrossRef]

63. Guo, H.; Yang, Z.; Guo, A. The digitalization and public crisis responses of small and medium enterprises: Implications from a COVID-19 survey. *Front. Bus. Res. China* **2020**, *19*, 1–25. [CrossRef]
64. Almeida, F.; Santos, J.D.; Monteiro, J.A. The Challenges and Opportunities in the Digitalization of Companies in a Post-COVID-19 World. *IEEE Eng. Manag. Rev.* **2020**, *48*, 20022139. [CrossRef]
65. Härting, R.-C.; Rösch, A.-L.; Serafino, G.; Häfner, F.; Bueechl, J. Opportunities and Barriers of Digitization in the COVID-19 Crisis for SMEs. In *Smart and Sustainable Technology for Resilient Cities and Communities. Advances in Sustainability Science and Technology*; Springer: Singapore, 2022; pp. 47–60. [CrossRef]
66. Kashav, S.; Singh, R.; Centobelli, P.; Cerchione, R. Digitization of Information Sharing to Minimize the Impact of COVID-19 in the Food Supply Chain. In *Handbook of Research on the Platform Economy and the Evolution of E-Commerce*; IGI Global: Hershey, PA, USA, 2021; pp. 251–272. [CrossRef]
67. Abidi, N.; Herradi, M.E.; Sakha, S. *Digitalization and Resilience: Firm-Level Evidence During the COVID-19 Pandemic*; IMF Working Papers; International Monetary Fund: Washington, DC, USA, 2022; p. 034. [CrossRef]
68. Döhring, B.; Hristov, A.; Maier, C.; Roeger, W.; Thum-Thysen, A. COVID-19 acceleration in digitalisation, aggregate productivity growth and the functional income distribution. *Int. Econ. Econ. Policy* **2021**, *18*, 571–604. [CrossRef]
69. Ragoussis, A.; Timmis, J. Global Transition Online. World Bank Group. Working Paper 2022. Available online: https://openknowledge.worldbank.org/handle/10986/37103 (accessed on 10 June 2022).
70. Xiang, S.; Rasool, S.; Hang, Y.; Javid, K.; Javed, T.; Artene, E.A. The Effect of COVID-19 Pandemic on Service Sector Sustainability and Growth. *Front. Psychol* **2021**, 1178. [CrossRef]
71. Chauhan, N.; Corredera, M.; Lukasik, K.; Reis, F. Post-pandemic future of work—How does digitization impact labour? *Explor. Econ.* **2021**. Available online: https://www.exploring-economics.org/en/discover/post-pandemic-future-of-work-digitization-labour/ (accessed on 10 June 2022).
72. Claeys, G.; Darvas, Z.; Demertzis, M.; Wolff, G.B. The Great COVID-19 Divergence: Managing a Sustainable and Equitable Recovery in the EU. *Intereconomics* **2021**, *56*, 211–219. [CrossRef]
73. Dannenberg, P.; Fuchs, M.; Riedler, T.; Wiedemann, C. Digital Transition by COVID-19 Pandemic? The German Food Online Retail. *J. Econ. Human Geogr.* **2020**, *111*, 543–560. [CrossRef]
74. Katz, R.; Jung, J.; Callorda, F. Can digitization mitigate the economic damage of a pandemic? Evidence from SARS. *Telecommun. Policy* **2020**, *44*, 102044. [CrossRef]
75. Chakravorti, B.; Chaturvedi, R.S.; Filipovic, C.; Brewer, G. *Digital in the Time of COVID*; The Fletcher School at Tufts University: Medford, MA, USA, 2020.
76. World Bank. *Digital Dividends—World Development Report 2016*; International Bank for Reconstruction and Development/The World Bank: Washington, DC, USA, 2016; ISBN1 978-1-4648-0671-1, ISBN2 978-1-4648-0672-8. Available online: https://books.google.com.au/books?hl=zh-CN&lr=&id=dAl-CwAAQBAJ&oi=fnd&pg=PP1&dq=10.1596/978-1-4648-0671-1.&ots=E6aPxif7cu&sig=Ouvz1fjHt79d2DrTs2eX9t6WL94&redir_esc=y#v=onepage&q=10.1596%2F978-1-4648-0671-1.&f=false (accessed on 17 July 2022).
77. Skare, M.; Soriano, D.R. How globalization is changing digital technology adoption: An international perspective. *J. Innov. Knowl.* **2021**, *6*, 222–233. [CrossRef]
78. Institute for Management Development (IMD) World Competitiveness Center. IMD World Digital Competitiveness Ranking 2021, 186p. Available online: https://www.google.com.hk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjlz42KiOT5AhUTU_UHHfB4DFwQFnoECBwQAQ&url=https%3A%2F%2Fwww.imd.org%2Fglobalassets%2Fwcc%2Fdocs%2Frelease-2021%2Fdigital_2021.pdf&usg=AOvVaw3W8RN2Qr4bg8Wkw_X4vZBY (accessed on 10 July 2022).
79. European Commission. Digital Economy and Society Index (DESI) 2022 Thematic Chapters, 2022. 88p. Available online: https://digital-strategy.ec.europa.eu/en/policies/desi (accessed on 15 July 2022).
80. European Investment Bank. Who Is Prepared for the New Digital Age? Evidence from the EIB Investment Survey, 2020. 134p, Report of the EIB Economics Department, ISBN 978-92-861-4582-7. Available online: https://www.eib.org/attachments/efs/eibis_2019_report_on_digitalisation_en.pdf (accessed on 10 August 2022). [CrossRef]
81. International Telecommunication Union. Available online: https://www.itu.int/en/ITU-D/Statistics/Pages/stat/default.aspx (accessed on 17 March 2022).
82. Digital Economy and Society Index. Available online: https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2021 (accessed on 17 March 2022).
83. International Telecommunication Union. Available online: https://www.itu.int/en/ITU-D/Statistics/Pages/publications/mis2017/methodology.aspx (accessed on 17 March 2022).
84. The Comprehensive R Archive Network. Available online: https://CRAN.R-project.org/package=panelvar (accessed on 17 March 2022).
85. The Comprehensive R Archive Network. Available online: https://CRAN.R-project.org/package=data.table (accessed on 17 March 2022).
86. World Bankhttps. Available online: https://data.worldbank.org/indicator/SI.POV.UMIC (accessed on 17 March 2022).
87. Plotly Python Open Source Graphing Library. Available online: https://plotly.com/python/ (accessed on 17 March 2022).
88. Geopandas Pyhton Library. Available online: https://geopandas.org/en/stable/ (accessed on 17 March 2022).

89. Akerman, A.; Gaarder, I.; Mogstad, M. The Skill Complementarity of Broadband Internet. *Q. J. Econ.* **2015**, *130*, 1781–1824. [CrossRef]
90. Atasoy, H. The Effects of Broadband Internet Expansion on Labor Market Outcomes. *Macroecon. Employ* **2013**, *66*, 315–345. [CrossRef]
91. Holt, L.; Jamison, M.A. Broadband and Contributions to Economic Growth: Lessons from the U.S. Experience. *Telecommun. Policy* **2009**, *33*, 575–581. [CrossRef]
92. Ford, G.S.; Koutsky, T. Broadband and Economic Development: A Municipal Case Study from Florida. *Rev. Urban Reg. Dev. Stud.* **2005**, *17*, 177–270. [CrossRef]
93. OECD Database. Available online: https://data.oecd.org/ (accessed on 17 June 2022).
94. Batool, M.; Ghulam, H.; Hayat, M.A.; Naeem, M.Z.; Ejaz, A.; Imran, Z.A.; Spulbar, C.; Birau, R.; Gorun, T.H. How COVID-19 has shaken the sharing economy? An analysis using Google trends data. *Econ. Res. EkonomskaIstraživanja* **2020**, *34*, 2374–2386. [CrossRef]
95. Zheng, C.; Zhang, J. The impact of COVID-19 on the efficiency of microfinance institutions. *Int. Rev. Econ. Financ.* **2021**, *71*, 407–423. [CrossRef]
96. Pourmansouri, R.; Mehdiabadi, A.; Shahabi, V.; Spulbar, C.; Birau, R. An Investigation of the Link between Major Shareholders' Behavior and Corporate Governance Performance before and after the COVID-19 Pandemic: A Case Study of the Companies Listed on the Iranian Stock Market. *J. Risk Financ. Manag.* **2022**, *15*, 208. [CrossRef]
97. Ionescu, C.A.; Fülöp, M.T.; Topor, D.I.; Căpuşneanu, S.; Breaz, T.O.; Stănescu, S.G.; Coman, M.D. The New Era of Business Digitization through the Implementation of 5G Technology in Romania. *Sustainability* **2021**, *13*, 13401. Available online: https://www.mdpi.com/2071-1050/13/23/13401 (accessed on 15 July 2022). [CrossRef]
98. Gupta, S.; Rhyner, J. Mindful application of digitalization for sustainable development: The Digitainability Assessment Framework. *Sustainability* **2022**, *14*, 3114. Available online: https://www.mdpi.com/2071-1050/14/5/3114 (accessed on 8 July 2022). [CrossRef]
99. Future of Education and Skills. 2030. Available online: https://www.oecd.org/education/2030-project/ (accessed on 7 July 2022).

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Assessment of the Similarity of the Situation in the EU Labour Markets and Their Changes in the Face of the COVID-19 Pandemic

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Abstract: The aim of the study is to assess the similarity of the situation in the EU labour markets and their evolution using selected indicators in the period before and during the COVID-19 pandemic. The benchmark are the countries that most closely meet the Sustainable Development Goals related to the labour market. We use quarterly data from Eurostat presenting the basic indicators of the labour market: unemployment, employment, and activity rates. We analyse all indicators for the total population, young people, and people aged 55+. We assess the similarity of the situation using the TOPSIS method and similarity of changes by means of the Dynamic Time Warping. We obtain homogeneous groups of countries due to similarity of time series using hierarchical clustering. We conduct the analysis in two periods: the years 2018 and 2019 (pre-pandemic period) and from the beginning of 2020 to the present (pandemic period). The composition of the clusters in the pre-pandemic and pandemic periods is different. The impact of the COVID-19 pandemic on the situation in the labour market can be noted. This is a result of different degree of development of labour markets, which had an impact on coping with the effects of the crisis caused by the pandemic.

Keywords: labour market in the EU; COVID-19 pandemic; TOPSIS method; dynamic time warping; cluster analysis

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1. Introduction

The outbreak of the pandemic brought significant changes to the economic landscape at both national and international levels. Crisis-related policies have changed both economic behaviour and the labour market. From time to time, the world's economies are shaken by the emergence of various crises. However, the challenges associated with the emergence of the COVID-19 pandemic are much higher than during previous crises. This is mainly caused by the fact that today's world is much more globalised. The current pandemic has significant potential to slow down economic development and, in many cases, even lead to recession. The lockdowns and the uncertainty about of the outcomes of the pandemic have spread throughout society and compounded its negative economic impact [1].

One of the most important challenges facing policy makers is how to effectively govern the economy so as to minimise the negative impact of any restrictions [2,3]. The negative effects of the pandemic, which were first observed in China, have spread globally since 2020. China is a significant global commodity importer. The outbreak of the pandemic in China had a domino effect on the global commodity market, which in turn affected economic growth [4–6]. The negative effects included disruptions in global supply and demand chains and consequent disturbances in the supply of goods. In particular, lockdowns and suspensions of international travel resulted in decreased fuel consumption and consequently a lack of demand for oil [7]. The demand for energy has declined due to the partial cessation of industrial activities, stagnation in the transport sector (aviation, public, and individual transport), among other factors. Additionally, fluctuations in metal and

agricultural commodity prices were much greater than they used to be in recent years [8]. Unconventional policy decisions introduced by national governments may have been more dangerous than the pandemic itself [9]. Western societies, including the European ones, appeared more vulnerable in the face of a new pandemic compared to Eastern ones [10]. Achieving sustainable development, with respect to the environment and economics has become quite a challenging task in recent years. This has been influenced by the recent economic crisis and the effects of climate change. In the context of the COVID-19 pandemic outbreak, sustainability can be considered not only from an economic or environmental point of view, but also from a public health perspective [11]. The pandemic crisis has demonstrated the existence of a complex set of inequalities that have emerged within the global system at different levels: the global economy and finance, healthcare, education, the judiciary, governance, the non-governmental sphere, public affairs, business and entrepreneurship, political rights and civil liberties, family life, etc. The downturn in industrial production and introduced restrictions hampering economic activity have particularly affected the labour market.

EU Member States have significant differences in the level of human development. A distinction has been made between dynamically developing regions and regions that differ significantly from this level [12–17]. In such situation, it is extremely important to constantly supervise changes in the level of social development of the EU countries and to determine the rank that a given country occupies in relation to the other ones.

The Sustainable Development Goals Report 2021 indicates that the COVID-19 crisis disturbed economic activities in the whole world and caused the strongest recession since the Great Depression [18]. Around 255 million full-time jobs were lost in 2020—about four times more than during the global financial crisis of 2007–2009. The pandemic has caused great risk to the workers in informal employment because they do not have protection against illness or lockdowns. The crisis affected young workers and women particularly strongly.

The aim of the study is the assessment of the similarity of the situation in the EU labour markets and their changes using selected indicators in the period before and during the COVID-19 pandemic. Therefore, two research questions arise:

Q1–Does the COVID-19 pandemic influence similarities of the labour markets in the EU countries?
Q2–Does the COVID-19 pandemic influence similarities of changes in the labour markets in the EU countries?

Until now, many scientific articles have appeared on the economic impact of the COVID-19 pandemic. These are mostly studies on individual countries or small groups of them. However, to our knowledge, there have been no published studies comparing time series for all EU countries before and during the pandemic. There is therefore a research gap in this area, which we are trying to fill with our study.

We refer our analysis to the benchmark countries, i.e., the ones that most closely meet the Sustainable Development Goals related to the labour market. We assess the similarity of the situation by using the TOPSIS method, and the similarity of changes by using the Dynamic Time Warping method. We obtain homogeneous clusters of countries due to time series similarity using hierarchical clustering.

The manuscript is organised as follows: Section 2 presents the literature review. In Section 3, we present the materials and research methods. Section 4 presents the results of empirical analysis. In Section 5, we present the discussion of obtained results. The manuscript ends with conclusions.

2. Literature Review

Achieving sustainable development worldwide requires a fair and balanced social and economic environment [19]. Barska et al. [20] assess the human development of EU countries in the background of sustainable development from 2014 to 2018. On the basis of their results, we can draw a conclusion that many countries experience positive trends

that bring them closer to the successful implementation of the sustainable development paradigm. However, they are also observing unfavourable trends. In almost half of the EU countries, the percentage of poverty-stricken working people and the risk of poverty for older people (65+) increased between 2014 and 2018. The analysis also reveals that there are large discrepancies between the countries studied, relating to different areas of human development. They are particularly clear for labour market indicators. Sweden, Denmark, and The Netherlands are among the highest-ranking countries for several thematic areas. At the opposite end of the spectrum are Romania, Bulgaria, Greece, and Italy. In many countries, there are significant gaps between the thematic areas. They perform very well in some areas and very poorly in others. Every EU country has a room for improvement in at least one of the analysed areas, but there are also countries (e.g., Romania, Bulgaria, and Greece) that need to change and improve in all examined areas.

Sustainable economic development needs a well-balanced workforce of young and older people [21]. As the balance is moving towards older people, the productivity tends to suffer. Furthermore, the older people demand more from health services. The results show that there is a significant difference between the developed and developing EU countries. It suggests the need for specific policies and strategies for the labour market integration of older people. It also implies higher public health expenditures, which has consequences for EU labour market performance.

Crises of all kinds have a negative impact on labour market equilibrium. The recovery period poses significant risk for sustainable development goals. It is therefore important for communities in pandemic-affected countries to prepare for a return to sustainable growth. Kapecki [22] analyses the impact of environmental, financial, and humanitarian crises on sustainable development. He pays particular attention to the financial crisis of 2007 and the crisis caused by the outbreak of the COVID-19 pandemic.

Since the onset of the pandemic, various studies have been carried out on its impact on the economies of particular countries and the world economy. As the pandemic continues to develop, the results of early studies are also changing. Studies on the negative impact of the pandemic on global GDP have started to appear in the global literature [23–27] and on financial performance on global stock exchanges [28–32]. In line with previous literature [33,34], the COVID-19 pandemic can trigger financial panics and lead governments to adjust their economic policies, as in other crisis periods [35].

Su et al. [36] (2022) analyse the relation of COVID-19 to corporate sustainability from the point of view of both internal organization and external social environment. They attempt to analyse and find implications for companies and society to better cope with crises and achieve sustainable development in the post-pandemic era. They conclude that if enterprises aim at maintaining sustainable development in the post-COVID-19 era with coexistence of challenges and opportunities, they must have full integration of internal and external resources. They should also rely on digital transformation to achieve survival, development, and upgrade. The pandemic causes many negative emotions amongst employees such as loneliness, anxiety, fear, worry, or collapse. This, in turn, affects job performance and employee satisfaction, then poses dangers to sustainable human resource management.

In analyses related to the impact of COVID-19 on the economic and financial situation, a trend of research on the impact of COVID-19 on the labour market has emerged. In times of crisis, the labour market becomes one of the first to experience severe turbulence. Employability is one of the parameters that has changed significantly due to the existence of the global health crisis. People employed in flexible forms of employment, which are hardly subject to any legal protection, are the first to lose their jobs [37,38]. Informal workers, youth, and women [39], as well as small traders, the self-employed, migrant workers, and daily wage earners [40] were the first to experience employment problems. Nivakoski and Mascherini [41] note that the COVID-19 may have had a different impact on gender equality than previous recessions. Emerging evidence suggests that women's paid work has declined in many countries due to both labour demand and labour supply factors.

Demand for labour declined because women's work is often associated with close contact with other people, for example hospitality, travel, personal care, and cleaning. These are the industries for which activities were significantly reduced at the start of the pandemic. Botha et al. [42] showed the significant negative relationship between labour market shocks triggered by the COVID-19 crisis and financial wellbeing. They show these labour market shocks are disproportionately felt by people at the lower end of the financial wellbeing distribution. In 2020, the tourism industry was particularly affected, including that in European countries. Changes in the number of arrivals and overnight stays were related to the degree of restrictions imposed [43].

Svabova et al. [44] analyses changes in unemployment in the Slovak Republic due to the impact of the anti-spreading regulations adopted by the government. The authors showed that the reduction in economic activity of firms operating in Slovakia resulted in a decrease in consumer demand, which put pressure on employers to reduce costs through lay-offs. This resulted in an increase in unemployment. The restrictions adopted to prevent the spread of COVID-19 had a negative impact on the Slovak labour market.

Many analyses highlight the major change brought about in the EU-27 by 'teleworking' and the instability of traditional jobs in the new context based on digitisation [45–48]. This situation was exacerbated during the pandemic period. The empirical findings point to a situation of deep economic crisis generated by the economic downturn and high unemployment rates in the EU-27.

Galik et al. [49] assess labour market flexibility using the TOPSIS method and multi-criteria decision analysis (MCDA) methods. The processes of sustainable industrial relations are considered in the context of shaping labour market flexibility in 15 European Union countries between 2009 and 2018. Their results indicate that the TOPSIS method is a suitable approach for measuring labour market flexibility on the international scale. Moreover, with regard to labour force phenomena, this method provides an opportunity to examine the impact of individual factors related to social and employment policies in the context of sustainable development and socio-economic growth. The lack of precise tools for forecasting the development of national and transnational labour markets, especially in the COVID-19 era, highlights the importance of such a method for planners and policy makers.

The empirical study by Gavriluta et al. [50] presents the situation of employability in the EU-27 under the conditions of the COVID-19 pandemic. The crisis caused by the pandemic highlights existing differences in the labour market in different regions of Europe. These differences have often increased under the influence of regulations introduced by national governments. The socio-economic category most affected by the economic impact of the COVID-19 pandemic is young people with primary or secondary education. In their conclusions, the authors stress that such phenomena as an increase in education levels and a reduction in gender inequalities and material and social deprivation should be correlated with economic freedom and increased opportunities for entrepreneurship. Such measures are beneficial in the context of sustainable development in the EU.

An interesting study is conducted by Guo et al. [51] on the economic impact on COVID-19 vaccination rates in the USA. They find that there is positive correlation between both the county-level per capita income and county-level unemployment rates and county-level COVID-19 vaccination rates across the U.S. However, these associations are divergent with respect to race/ethnicity.

3. Materials and Methods

3.1. Materials

We use the quarterly Eurostat data for all 27 EU member states, available online at: https://ec.europa.eu/eurostat/web/main/data/database (accessed on 7 February 2022). The data cover the basic indicators of labour market:

- unemployment rate;
- activity rate;
- employment rate.

We consider every indicator for the total population, for young people (aged 15–24 years), and for people aged 55 years or more. The only exception is the unemployment rate, which excludes the data for people aged 55 years or more. The reason for this is the lack of data for Malta and Luxembourg. The data cover the period starting at the 1st quarter of 2018 and ending at the 3rd quarter of 2021. We divide the period into two sub-periods. The first (1st quarter 2018–4th quarter 2019) is the pre-pandemic period, and the second (1st quarter 2020–3rd quarter 2021) is the pandemic period.

We consider the countries that closely meet the Sustainable Development Goal (SDG) related to the labour market as the benchmark ones. The SDG that includes the indicators related to the labour market is the SDG8 (Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all). SDG8 is one of the 17 Sustainable Development Goals (SDGs) that were established by the United Nations General Assembly in 2015 [52]. Progress towards the goals is measured, monitored, and evaluated through 17 indicators. SDG8 has a total of twelve targets. These are: sustainable economic growth (8.1); diversify, innovate, and upgrade for economic productivity (8.2); promote policies to support job creation and growing enterprises (8.3); improve resource efficiency in consumption and production (8.4); full employment and decent work with equal pay (8.5); promote youth employment, education, and training (8.6); end modern slavery, trafficking, and child labour (8.7); protect labour rights and promote safe working environments (8.8); promote beneficial and sustainable tourism (8.9); universal access to banking, insurance, and financial services (8.10); increase aid for trade support (8.a); and develop a global youth employment strategy (8.b). SGD8 is the aspiration that the economic sector of each country should provide its citizens with the necessary needs for a good life, regardless of their origin, race, or culture. As we wish to assess the SDG indicators for every analysed quarter, we select the following, as only they were available in the form of quarterly data:

- young people neither in employment nor in education or training (NEET);
- employment rate;
- long-term unemployment rate.

3.2. Methods

We perform the analysis in the following steps:

1. By means of the TOPSIS method, we create the ranking of the countries with respect to fulfilment of the sustainable development goals regarding the labour market. The best countries in the whole period create the benchmark.
2. For every quarter, by means of the TOPSIS method, we assess the situation of the EU countries in their labour markets, using unemployment, activity, and employment rates for total population, for young people, and for people aged 55 years or more.
3. With respect to the values of the TOPSIS measure, we select the groups of countries with very good, rather good, rather poor, and very poor situation in their labour markets.
4. We analyse similarities of time series of the situation in the labour markets (assessed by the TOPSIS method) between the countries by means of the Dynamic Time Warping (DTW) method in the pre-pandemic and pandemic periods.
5. The similarities between the time series are assessed by means of the DTW distance.
6. The DTW distance is then used in hierarchical clustering to distinguish the homogeneous clusters of countries with respect to similarity of changes of the situation in their labour markets in both pre-pandemic and pandemic periods.

3.2.1. The TOPSIS Method

The TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) is the technique created for the need of the multi-criteria decision making. It is, however, also widely used in the multivariate statistical analysis. It was created by Hwang and Yoon [53] and is based on the weighed distance of each object (in our case country) from the so-called

pattern (i.e., the best values of variables in the dataset) and from the anti-pattern (i.e., the worst values of variables in the dataset).

A starting point of the TOPSIS method is the observation matrix X:

$$\mathrm{X} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{1}$$

where x_{ij} is the value of j-th variable in i-th object ($i = 1, \ldots, n$, $j = 1, \ldots, m$), m is the number of variables, and n is the number of objects.

As all variables in our dataset are measured on the ratio scale, we can normalise them by means one of the quotient inversions (such normalisation method preserves the scale strength):

$$z_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x_{ij}^2}} \tag{2}$$

where z_{ij} is the normalised value of j-th variable in i-th object ($i = 1, \ldots, n$, $j = 1, \ldots, m$).

The next step of the TOPSIS method is determination of weights. The problem of determining the variables' weights is not an easy task. There is also no single method of weights determination recognised as best. We can assign weights of variables statistically (on the basis of variables' dispersion, mutual correlations, or entropy measures) or by using the expert methods. The first method would cause weights in every analysed period to be different, and the second would indicate a high degree of subjectivism. If there is no clear indication that some variables are more important than the others, we should assume equal weights.

We multiply the normalised values of variables by their weights, thus creating the weighed, normalised observation matrix:

$$t_{ij} = w_j z_{ij}, \quad i = 1, \ldots, n, \quad j = 1, \ldots, m \tag{3}$$

where $w_j = \frac{1}{m}$ are the variables' weights ($j = 1, \cdots, m$).

In the next step of the TOPSIS method we calculate the pattern (A_b) and the anti-pattern (A_w):

$$A_b = \left\{ \left(\max_i t_{ij} | j \in J^+ \right), \left(\min_i t_{ij} | j \in J^- \right) | i = 1, \ldots, n \right\} = \left\{ t_{b1}, \ldots, t_{bj}, \ldots, t_{bm} \right\} \tag{4}$$

$$A_w = \left\{ \left(\min_i t_{ij} | j \in J^+ \right), \left(\max_i t_{ij} | j \in J^- \right) | i = 1, \ldots, n \right\} = \left\{ t_{w1}, \ldots, t_{wj}, \ldots, t_{wm} \right\} \tag{5}$$

where J^+ indicates stimulants (variables for which the highest values are the most desirable) and J^- indicated destimulants (variables for which the lowest values are the most desirable).

Next, we calculate the weighed distances of each object from the pattern (d_{i0}^+) and anti-pattern (d_{i0}^-) by means of the Euclidean metric:

$$d_{i0}^+ = \sqrt{\sum_{j=1}^{m} \left(t_{ij} - t_{bj} \right)^2}, \quad i = 1, \ldots, n \tag{6}$$

$$d_{i0}^- = \sqrt{\sum_{j=1}^{m} \left(t_{ij} - t_{wj} \right)^2}, \quad i = 1, \ldots, n \tag{7}$$

Finally, we calculate the composite measure q_i:

$$q_i = \frac{d_{i0}^-}{d_{i0}^- + d_{i0}^+}, \quad i = 1, \ldots, n \tag{8}$$

The composite measure q_i has the following properties: $q_i \in [0,1]$, $\max_i\{q_i\}$—the best object, and $\min_i\{q_i\}$—the worst object.

3.2.2. The Dynamic Time Warping Method

The Dynamic Time Warping (DTW) method was invented by Bellman and Kalaba [54]. Originally, it was used for speech recognition problems [55–57]. Other fields of its application include music information retrieval [58], gesture recognition [59], or in bioinformatics [60]. It is now more and more often used in research on time series describing economic and social phenomena. Landmesser [61] uses it to find similarities in time series describing the dynamics of the number of cases and deaths of COVID-19 in the provinces of Poland. Dmytrów and Bieszk-Stolorz [62] look for correlations and links between unemployment rates and unemployment duration in the Visegrad countries. Dmytrów et al. [63] assess the links between the number of COVID-19 cases and the energy commodity sector. Denkowska and Wanat [64] use the DTW algorithm to group insurance institutions by the similarity of their contribution to systemic risk, as expressed by DeltaCoVaR. Stübinger [65] uses the DTW method to find optimal causal path algorithm for the minute-by-minute data of the S&P 500 constituents from 1998 to 2015.

By using the DTW algorithm we can measure similarity between two time series. The DTW method looks for an optimal alignment between them by using the dynamic programming. The alignment is described by a given scoring function. Let $X = (x_1, x_2, \ldots, x_N)$ and $Y = (y_1, y_2, \ldots, y_M)$ be two time series. In order to be able to compare them, both time series must be normalised. The most frequently used method is z-normalisation. The need for normalisation of time series is often highlighted in classification or clustering methods with the DTW and other distance measures [66,67].

Next, we define the local cost measure for two elements of X and Y by means of the equation:

$$c(x_i, y_j) = |x_i - y_j|, \quad i = 1, \ldots, N, j = 1, \ldots, M \tag{9}$$

We calculate this measure for every pair of elements of X and Y, thus obtaining the local cost matrix $\left(LCM \in \mathbb{R}^{N \times M}\right)$. The optimal alignment between time series X and Y is the one having minimal overall cost.

The point-to-point match between the time series X and Y is represented by the time warping path. It is a sequence $p = (p_1, \ldots, p_L)$, where $p_l = (n_l, m_l) \in \{1, \ldots, N\} \times \{1, \ldots, M\}$ for $l \in \{1, \ldots, L\} (L \in \{\max(N, M), \ldots, N + M - 1\})$. The sequence satisfies three conditions: boundary, monotonicity, and step size conditions [68]. The boundary condition ensures that the first and the last element of p are $p_1 = (1,1)$ and $p_L = (N, M)$, respectively. It means that the first (last) index from the first sequence must be matched with the first (last) index from the second one. The monotonicity condition ensures that the path always moves up, right, or up and right of the current position, i.e., $p_{l+1} - p_l \in \{(1,0), (0,1), (1,1)\}$ for $l = 1, \ldots, L-1$. The step size condition ensures that every index from the time series X must be matched with one or more indices from the time series Y (and vice versa).

The optimal match is the one that satisfies all the above-mentioned conditions and that has the minimal total cost. The total cost $c_p(X, Y)$ of a warping path p is defined as:

$$c_p(X, Y) = \sum_{l=1}^{L} c(x_{nl}, y_{ml}) = \sum_{l=1}^{L} |x_{nl} - y_{ml}| \tag{10}$$

The optimal match between X and Y is then:

$$DTW(X,Y) = c_{p^*}(X,Y) = \min\{c_p(X,Y)|p \in P\} \quad (11)$$

where P is the set of all possible warping paths.

By means of the DTW algorithm, we find the path that minimises the alignment between X and Y. It iteratively steps through the local cost matrix and aggregates the cost. We find the optimal path p^* by using a dynamic programming algorithm. The obtained value $DTW(X,Y)$ is the measure of distance between the time series X and Y.

We use obtained by the Equation (11) distances between all time series to create the dissimilarity matrix. In the next step, we use this matrix in agglomerative hierarchical clustering of time series [69]. Its main advantage is the visualisation capabilities. In our research we use the Ward's method to minimise the variance within the clusters. We check the robustness of the clustering algorithm and set the number of clusters by means of the silhouette index.

Clustering methods are used in many economic and social issues. Rozmus [70] uses different measures of stability to group EU member states by their level of sustainability. Zalewska [71] uses cluster analysis to identify and compare determinants influencing the opinion of students and lecturers on the evaluation of the possibility and effectiveness of introducing the CQI system in Polish higher education. Sikora-Alicka [72] performs a comparative analysis of Polish teaching hospitals. The aim of her study is to confirm the thesis that teaching hospitals, despite significant organisational and functional differences, due to the specificity of their activities, do not differ significantly in the structure of generated costs. Małkowska et al. [73] use the TOPSIS method and cluster analysis to measure and assess the impact of digital transformation on the EU countries. Roman et al. [43] use cluster analysis to group European countries in terms of changes in tourism due to the outbreak of the pandemic.

4. Results

4.1. Sustainable Development Goals Related to Labour Market

In the first step of the analysis, we create the ranking of countries with respect to fulfilment of the sustainable development goals (SDG) regarding the labour market. We consider the following variables: young people neither in employment nor in education or training (NEET) $(SDG8_1)$, employment rate $(SDG8_2)$, and long-term unemployment rate $(SDG8_3)$. Variables $SDG8_1$, $SDG8_2$, and $SDG8_3$ are related to the implementation of SDG8 targets 8.5 and 8.6 and relate directly to the labour market. The first and the third variables are the destimulants, while the second is the stimulant. We set the pattern and anti-pattern values for the whole period (Table 1).

Table 1. Pattern and anti-pattern values of the SDG-related variables. *Source*: own calculations on the basis of the Eurostat data.

Specification	$(SDG8_1)$	$(SDG8_2)$	$(SDG8_3)$
pattern	5.0%	71.5%	12.5%
anti-pattern	24.4%	43.3%	73.1%

The best (pattern) value of the percentage of NEETs (5.0%) is in the first quarter of 2020 in the Netherlands and the worst (anti-pattern) (24.4%) in the second quarter of 2020 in Italy. The best value of the employment rate (71.5%) is in the third quarter of 2021 in the Netherlands and the worst (43.3%) in the second quarter of 2020 in Greece. The pattern value of the long-term unemployment rate (12.5%) is observed in the third quarter of 2019 in Sweden and the anti-pattern (73.1%) in the third quarter of 2018 in Slovakia. For the the percentage of NEETs and the long-term unemployment rate, the relative differences between the best and the worst values are very large. The best value of the former is just above $\frac{1}{5}$ of the worst and for the latter this ratio equals about $\frac{1}{6}$.

We then apply the Equations (1)–(8) to calculate the TOPSIS measure for every quarter of the analysed period. Having calculated the TOPSIS measures, for every quarter we calculate the median (Me), the first (Q_1) and the last (Q_3) quartile, and divide the countries into four groups (Table 2).

Table 2. Groups with respect to fulfilment of the SDGs. *Source*: own elaboration.

Group	Value of the TOPSIS Measure
A—very high fulfilment	$(Q_3, 1]$
B—rather high fulfilment	$(Me, Q_3]$
C—rather low fulfilment	$(Q_1, Me]$
D—very low fulfilment	$[0, Q_1]$

The countries, for which the TOPSIS measure calculated for labour market variables that are related to SDGs falls in the first interval—$(Q_3, 1]$ in the largest number of quarters of the analysed period, create the benchmark.

In the whole analysed period (first quarter 2018–third quarter 2021) we can distinguish four countries that fulfil the sustainable development goals related to the labour market to the highest degree—Denmark, The Netherlands, Finland, and Sweden. Therefore, we treat these countries as the benchmark in further analysis. It is also worth noting that, on the other side, there are countries with very low fulfilment of the SDGs—Bulgaria, Greece, Spain, Italy, Romania, and Slovakia. These countries have the lowest degree of fulfilment of SDGs related to the labour market in the whole analysed period. We present the results of grouping countries with respect to the fulfilment of the SDGs related to the labour market in Table 3.

Table 3. Groups of countries with respect to fulfilment of the SDGs. *Source*: own calculations on the basis of the Eurostat data.

Country	2018Q1	2018Q2	2018Q3	2018Q4	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2	2020Q3	2020Q4	2021Q1	2021Q2	2021Q3
Belgium	C	C	C	C	C	C	C	C	D	D	C	D	C	C	C
Bulgaria	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Czechia	A	A	B	B	B	B	B	B	B	A	A	B	A	B	A
Denmark	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Germany	B	B	B	B	C	C	C	B	B	C	C	B	B	B	B
Estonia	A	B	B	A	B	A	A	A	A	A	A	A	B	A	B
Ireland	B	C	C	C	B	C	C	B	B	C	C	C	A	A	A
Greece	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Spain	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
France	B	B	B	B	B	B	B	B	B	B	B	B	C	C	B
Croatia	D	D	D	D	D	C	D	D	C	C	C	C	D	C	D
Italy	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Cyprus	C	C	C	C	C	D	C	C	C	C	D	C	C	D	C
Latvia	C	C	C	C	C	C	C	B	C	B	B	B	C	B	B
Lithuania	B	A	A	B	B	B	B	C	C	C	C	B	C	C	C
Luxembourg	A	A	A	A	A	A	A	A	A	B	A	A	B	B	C
Hungary	C	C	B	B	B	C	B	B	B	B	B	C	C	C	B
Malta	C	B	C	C	A	A	A	C	A	A	B	A	A	C	A
Netherlands	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Austria	B	B	A	A	A	B	B	A	B	B	B	B	B	A	B
Poland	C	C	C	C	C	B	B	C	C	B	C	C	B	B	C
Portugal	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
Romania	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Slovenia	B	B	B	B	C	B	C	C	C	C	B	C	B	B	C
Slovakia	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Finland	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Sweden	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A

4.2. Assessment of the Situation of EU Countries in Their Labour Markets

We use the following variables for assessment of the situation in the labour markets of the EU countries:

x_1—total unemployment rate (in %);
x_2—unemployment rate for people aged 15–24 years (in %);
x_3—total activity rate (in %);

x_4—activity rate for people aged 15–24 years (in %);
x_5—activity rate for people aged 55 years or more (in %);
x_6—total employment rate (in %);
x_7—employment rate for people aged 15–24 years (in %);
x_8—employment rate for people aged 55 years or more (in %).

Many authors also identify other indicators of labour market conditions, including job finding and separation rates, job vacancy rate, long-term unemployment rate, hours of work, wages and compensation costs, labour productivity, and employment in the informal economy [74,75]. However, including them in our analysis is impossible for two main reasons. First, they are not always quarterly, but annual data. Second, they are not available for all EU countries. As the time series used must be complete due to the methods used, we have decided to limit ourselves to only the selected variables.

In order to initially assess the general situation in the labour market in the EU, we present some basic descriptive statistics (arithmetic mean, standard deviation, coefficient of variation, median, skewness, minimum, and maximum) for total unemployment, activity, and employment rates in Tables A1–A3 in Appendix A. The average and median values of analysed variables had been improving during the pre-pandemic period. When the state of the pandemic was declared (11 March 2020), the indicators had begun to deteriorate and reached their worst values in the third quarter of 2020. The general situation then started to improve. All analysed indicators reached the best values in the whole analysed period in the third quarter of 2021. We may have been observing a revival from the recession caused by the COVID-19 pandemic. However, further data on the situation in the EU labour market are rather unclear due to the ongoing war in Ukraine.

The unemployment rate has much higher volatility than the activity and employment rates. It means that there is much higher difference between the best (Czechia, Germany, and The Netherlands) and the worst (Greece, Spain, or Italy) countries. Additionally, in case of Greece and Italy, we can observe high, outlying values of the unemployment rate. This causes a high, positive skewness of the distribution of this indicator. In case of the activity and employment rates, the distributions have moderate, negative skewness.

The pattern and anti-pattern values for all variables in the whole period are presented in Table 4.

Table 4. Pattern and anti-pattern values. *Source*: own calculations on the basis of the Eurostat data.

Specification	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8
pattern	2.0%	5.1%	74.4%	79.9%	83.6%	71.5%	73.5%	78.7%
anti-pattern	20.7%	44.0%	53.3%	19.4%	39.0%	43.3%	11.8%	37.6%

The best values of the unemployment rates (total and for young people) are in Czechia (in the whole year 2019 and in the first quarter of 2020 for the former and in the fourth quarter of 2019 for the latter). The worst values of the unemployment rates are in Greece (in the first quarter of 2018 for both rates). The pattern values of activity and employment rates for total population and for young people are in the Netherlands (all of them in the third quarter of 2021), while the pattern values of these indicators for people aged 55 years or more are in Sweden (for activity rate in the fourth quarter of 2020 and for employment rate in the fourth quarter of 2018). The anti-pattern value of total activity rate is in Italy (in the second quarter of 2020), activity rate for young people in Bulgaria (in the third quarter of 2021) and activity rate for people aged 55 years or more in Romania (in the second quarter of 2018). The worst values of total employment rate and employment rate for young people are in Greece (both in the second quarter of 2020), employment rate for young people in and employment rate for people aged 55 years or more in Romania (in the second quarter of 2018). Interestingly, we cannot say that the pandemic period has brought a worsening of the labour market indicators—in 6 out of 8 cases, the best values have been achieved

during the pandemic period. In half of cases, the worst values of indicators have happened in the pre-pandemic period.

In addition, as in the case of indicators related to the sustainable development goals, the differences are sometimes very high. Such a situation is the case of total unemployment rate (the worst value is over 10 times higher than the best one) and unemployment rate for young people (the worst value is almost 9 times higher than the best one).

We now repeat the TOPSIS method for the variables describing the situation in the labour market. After applying Equations (1)–(8) and calculating the TOPSIS measure, we obtain the assessment of the situation in the labour market. We then calculate median and quartiles for every quarter in the analysed period and create the groups of countries. The intervals are the same as in Table 2. However, in case of the assessment of the situation, the groups are as follows: A—very good situation, B—rather good situation, C—rather poor situation, and D—very poor situation. We present the results in Table 5.

Table 5. Groups of countries with respect to the situation in their labour markets. *Source*: own calculations on the basis of the Eurostat data.

Country	2018Q1	2018Q2	2018Q3	2018Q4	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2	2020Q3	2020Q4	2021Q1	2021Q2	2021Q3
Belgium	C	D	C	C	C	C	C	C	C	C	C	C	C	C	C
Bulgaria	C	C	D	C	C	C	C	C	C	D	C	C	C	C	C
Czechia	B	B	B	B	B	B	B	B	B	A	A	B	B	A	B
Denmark	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Germany	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Estonia	A	A	B	A	A	B	A	A	A	B	B	B	A	B	B
Ireland	B	B	A	B	A	A	A	A	A	B	B	A	B	B	A
Greece	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Spain	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
France	D	D	D	D	D	D	D	D	D	C	C	C	C	C	C
Croatia	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Italy	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Cyprus	D	C	C	D	D	C	C	C	C	C	C	C	C	C	B
Latvia	C	C	B	C	C	C	C	B	C	B	B	B	C	C	C
Lithuania	C	B	B	B	B	B	B	C	C	C	C	C	B	C	C
Luxembourg	C	C	C	C	C	C	D	C	D	D	D	D	C	B	C
Hungary	B	B	B	B	B	C	B	B	B	B	B	B	B	B	B
Malta	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Netherlands	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Austria	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Poland	B	C	C	C	C	B	B	B	B	A	B	B	B	B	B
Portugal	C	C	C	C	C	D	C	D	C	C	D	D	D	D	D
Romania	D	D	D	D	D	D	D	D	D	D	D	D	D	D	D
Slovenia	B	B	C	B	B	B	C	C	B	C	C	C	C	C	B
Slovakia	C	C	C	C	C	C	C	C	C	C	C	C	D	D	D
Finland	B	B	B	B	B	B	B	B	B	B	A	A	A	A	A
Sweden	A	A	A	A	B	A	B	B	B	B	B	B	B	B	C

Denmark, Germany, Malta, The Netherlands, and Austria are amongst the countries with the best situation in their labour markets in the whole analysed period (in both pre-pandemic and pandemic periods). On the other hand, Greece, Spain, Croatia, Italy, and Romania are the countries with the worst situation in the whole analysed period. When we compare the results of analysis of the situation in the labour markets to fulfilment of SDGs, it turns out that the best situation does not always correspond with the highest fulfilment of the SDGs. Denmark and The Netherlands are the countries with the best outlook with respect to both their labour markets and fulfilment of SDGs (in the whole analysed period). Finland and Sweden are always among the best with respect to fulfilment of the SDGs, but not in the case of their general situation in their labour markets. Interestingly, their situation changes in different directions. Finland, since the beginning until the end of 2nd quarter 2020, is in group "B" and in group "A" afterwards, while Sweden is in group "A" until the 2nd quarter 2019, in group "B" afterwards and until the end of the 2nd quarter 2021. In the last analysed period, it falls into the group "C". It is mostly caused by relatively high (as compared to the best countries) unemployment rates. Finland's situation improves mostly due to increase in activity and employment rates.

Germany, Malta, and Austria—the remaining countries with the best situation in their labour markets—are not in the group of countries with the highest degree of fulfilment of

the SDGs. Germany is with this respect in the group "B", or "C" (there is no difference in the pre-pandemic and pandemic periods). Malta's membership varies from "A" to "C" (also with no relation to the existence of the pandemic), and Austria's from "A" to "B" (also with no relation to the existence of the pandemic).

The majority countries with the lowest fulfilment of the SDGs during the whole period (Greece, Spain, Italy, and Romania) also have the worst situation in their labour markets. For the remaining countries with lowest degree of fulfilment of SDGs (Bulgaria and Slovakia), their general situation in their labour markets is generally better.

There are several interesting cases for which there is high discrepancy between fulfilment of the SDGs and situation in their labour markets. The first is Germany. When we consider the degree of fulfilment of SDGs, Germany did not place in the best group in any of the analysed quarters. However, when we look at their situation in the labour market, it was always in the best group. The opposite situation occurs in the case of Luxembourg. This country was, in most of analysed quarters, amongst the countries with the highest degree of fulfilment of the SDGs. When we consider its situation in the labour market, it was generally in the group of countries for which the situation was generally poor.

For most countries, we can hardly see the difference in membership of countries to specific groups of countries with respect to their situation in their labour markets. There are several countries where this difference can be seen. France and Finland, in the pandemic period, moved to the groups with better situation in their labour markets. For Sweden, the situation was the opposite. Therefore, for the majority of cases, we should answer the research question Q1 negatively.

4.3. Analysis of Changes of Situation of EU Countries in Their Labour Markets

We make pairwise comparisons of time series with synthetic TOPSIS measure between all EU countries. We make these comparisons in two periods: pre-pandemic and pandemic ones. We then estimate the DTW distance matrices for these two periods. On their basis, we perform the hierarchical cluster analysis. For the pre-pandemic period, we present the clusters of countries with respect to their situation in their labour markets in Figure 1.

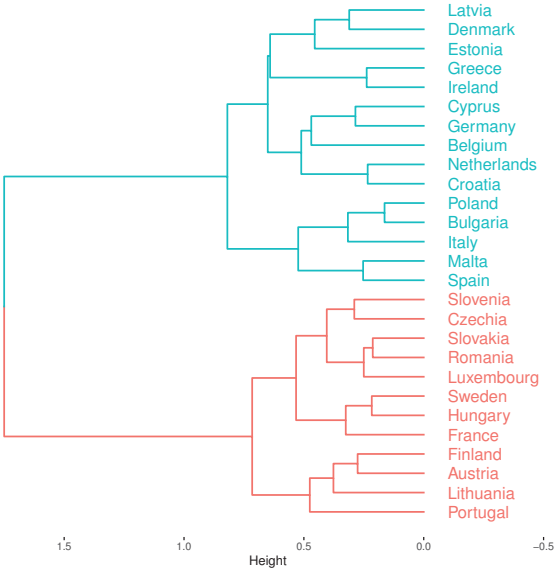

Figure 1. Clusters of the EU countries with respect to the situation in their labour markets in the pre-pandemic period. *Source*: own elaboration on the basis of the Eurostat data.

We can distinguish the two clearly separated clusters of countries. The first, slightly bigger (coloured blue), contains countries where the situation in their labour markets in the pre-pandemic period was generally at the constant level. The second, smaller cluster (coloured red) contains countries where the situation in their labour markets deteriorated. If we consider the benchmark countries (these with the highest degree of fulfilment of the SDGs), two of them (Denmark and The Netherlands) are in the first cluster, and the remaining two (Finland and Sweden) are the members of the second cluster.

We present the clusters of EU countries with respect to change of situation in their labour markets in the pandemic period in Figure 2.

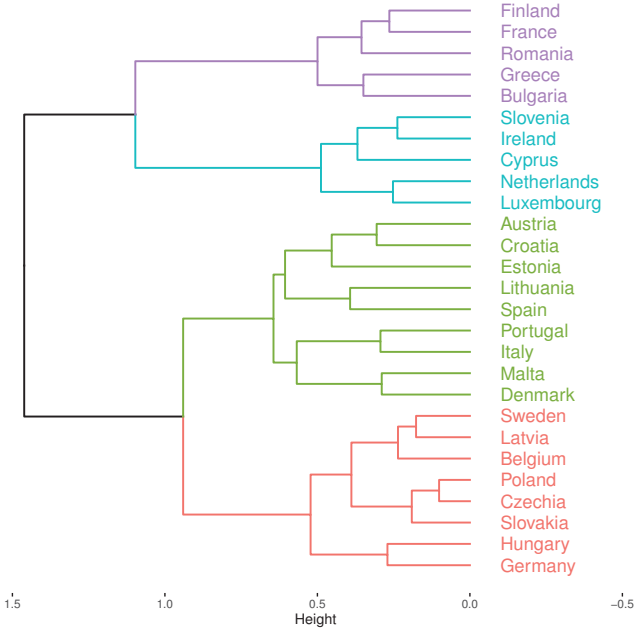

Figure 2. Clusters of the EU countries with respect to the situation in their labour markets in the pandemic period. *Source*: own elaboration on the basis of the Eurostat data.

In the pandemic period we can distinguish four clusters of countries. The first, coloured purple, contains countries for which the situation was generally stable during the whole pandemic period. The second cluster (coloured blue) consists of countries in which the situation deteriorated at the beginning and increased at the end of the analysed period. The third cluster (coloured green) consists of countries in which the situation in their labour markets fluctuated during the whole pandemic period. Finally, the fourth cluster (coloured red) consists of countries in which the situation slightly deteriorated during the pandemic period.

When we look for the benchmark countries (those which have the highest degree of fulfilment of labour market related sustainable development goals), we can see that Finland, The Netherlands, Denmark, and Sweden are in the first, second, third, and fourth cluster, respectively.

The number and composition of clusters with respect to changes of the situation in their labour markets are different in the pre-pandemic and the pandemic periods. In addition, the direction of changes of the situation for many countries was different during the pre-pandemic and the pandemic periods. The examples of such countries can be found in the second (coloured red) cluster in the pre-pandemic period—Sweden, Romania, or France. These countries were characterised by a slightly deteriorating situation in their labour markets. In the pandemic period, their situation stabilised. When we look at

the first cluster in the pre-pandemic period (coloured blue), there are countries (Poland, Belgium, Germany, and Latvia) in which the situation in their labour markets was stable, while during the pandemic period they were in the cluster with the countries in which the situation had deteriorated.

For the pre-pandemic period, we obtain the optimal (highest) value of the silhouette index for two clusters. In the pandemic period, the highest value of the silhouette index is in case of four clusters. Therefore, we set the number of clusters in both periods correctly.

When we analyse the membership to clusters in the pre-pandemic and the pandemic periods, there are clear differences in both similarities between countries and the number of clusters. Therefore, the answer to the research question Q2 should be affirmative.

5. Discussion

Our research covers a limited set of variables, as only these ones are available on a quarterly basis. Our results with respect to the fulfilment of the sustainable development goals (Table 3) are, however, similar to research conducted by Jianu et al. [76]. They apply the hierarchical clustering and analyse the labour market inequalities—SDG8 (Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all) indicators. Countries that are the benchmark in our research (Denmark, Finland, The Netherlands, and Sweden) are also in the same cluster in their research. Therefore, we may confirm that the benchmark countries have been selected properly.

We can compare our results to the previous ones we obtained using the multidimensional scaling [77] and the clustering with the use of the DTW method [78] in the pre-pandemic period. These analyses use yearly data and the different set of variables (total, young, and long-term unemployment rates, median unemployment duration, total employment and activity rates, duration of working life, and age dependency ratio). Analysis with the use of multidimensional scaling [77] indicates that, even with the different set of variables, the same countries (Denmark, Germany, The Netherlands, Finland, Sweden, Czechia, or Estonia) are among the best and the same (Greece, Italy, Spain, or Croatia) are classified as the worst (of course, these data refer to a similar period—2018–2019). Rollnik-Sadowska and Jarocka [79] perform similar analysis for year 2019 for Central European and Eastern (CEE) countries. Our results confirm their research—Czechia, Estonia, and Poland are among the countries with the best situation in their labour markets, while Bulgaria, Croatia, Romania, and Slovakia are among the countries with the worst situation in their labour markets.

When we compare the analysis of changes in the situation in the labour markets obtained on the different set of variables in the pre-pandemic period [78] with the present research, we can see many similarities. In both analyses, the countries (especially those with the best and the worst situation) are in the same respective clusters.

The labour market situation affects the size of the living cost gap, i.e., the differential between income, expenditure, and poverty lines. This gap tends to widen as a result of economic crises and recessions [80–83]. Comparing the results of our study with the research presented by Kučas et al. [84], it can be seen that the obtained clusters do not overlap. This indicates that the labour market situation is not the main determinant of the living cost gap, which is also strongly influenced by factors such as the level of GDP, trade flows, migration, and savings.

Economic convergence is a declared objective of the EU. It is considered a fundamental mechanism for achieving socio-economic cohesion. For example, the 2007 economic crisis had an uneven impact on EU countries and brought the process of economic and social convergence to a halt [85]. In our study, the clusters formed do not show an east–west or north–south geographical pattern. The identified groups include both highly developed and developing countries. Similar observations are made by Lafuente et al. [85] when analysing convergence in poverty and social exclusion indicators for EU countries. They show that convergence in each identified cluster tends to be in a catching-up process, with eastern countries coming closer to their western counterparts.

The COVID-19 pandemic has shown that people with digital skills quickly adjust to new situation. The economies need to be urgently reshaped in order to follow up-to-date technological trends. Consistent action is needed to improve people's digital skills to achieve a more efficient and flexible labour market. Equally important components are internet accessibility, cost of device, cost of service, cost of electricity, and access to native language content. Piroşcă et al. [86] analyse the relationship between wage and salary per hour and Internet coverage dimension score for the 27 EU member states. These authors' studies partly explain the unstable or weak labour market during the pandemic period. In Figure 2 of our research, such countries are marked in green and red, respectively. Some of these countries are characterised by poor access to the Internet, which makes it difficult to work remotely. Some are countries with economies based largely on tourism. Restrictions introduced in connection with the development of the pandemic were quite effective in hindering the activities of the tourism industry. In addition, these countries already had a weaker labour market before the pandemic than other European countries (Figure 1).

6. Conclusions

The aim of our research is assessment of the similarity of the situation in labour markets of the EU countries and its changes in the pre-pandemic and the pandemic periods. We present this analysis on the background of countries that fulfil the sustainable development goals (SDG) related to the labour market. The pre-pandemic period contains the years 2018–2019 and the pandemic contains the years 2020–2021. Our analysis shows that the countries that satisfy the sustainable development goals to the highest degree during the whole period (the benchmark countries—Denmark, Finland, The Netherlands, and Sweden) are also among the those with the best situation in their labour markets. There are, however, countries that have a very good situation in their labour markets and at the same time poor degree of fulfilment of the SDGs related to the labour market (Germany and Malta). The opposite situation is in the case of Luxembourg. When we analyse the situation of countries and their labour markets, it turns out that the membership of countries in particular groups are very often the same during the whole period. This means that the mutual relationship between the countries did not change much during the pandemic period with regard to the pre-pandemic one. Therefore, we should answer the research question Q1 negatively.

Quite the opposite is true in the analyses of changing situations of the EU countries in their labour markets. The number of clusters and their composition is different in the pre-pandemic and the pandemic periods. This means that the answer to the research question Q2 is affirmative. The benchmark countries are divided among the clusters in both periods equally. Therefore, we can take these countries as the benchmark in assessment of the situation in the labour market, but not in assessment of changes of such situation.

The situation in labour markets and its change varies across countries. This is a result of different degrees of social and economic development. We can, however, provide some policy recommendations. Analysis of dynamics of situation in labour markets can give the directions of activities counteracting the unemployment and other unfavourable phenomena. Clusters of countries with deterioration of the situation in their labour markets indicate where such activities should be addressed.

Our study has some limitations due to the lack of availability of data that fully describe the labour market. The applied method of comparing time series (DTW) does not require their equal length, but the same frequency is necessary. Very often, labour market data are annual, while the applied methods require at least quarterly data. The Eurostat database is a good source of data, but not all countries collect and make available accurate data that cover their labour market.

The Sustainable Development Goals Report 2021 [18] highlights that, for many countries, economic growth will remain below pre-pandemic trends for a prolonged period. The USA and China, the world's most developed economies, are forecast to be the fastest to emerge from the crisis. However, the economic situation of the whole world, and of Europe

in particular, will also be affected by the war in Ukraine and the migration of millions of its citizens. This will certainly change the European labour market.

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Appendix A. Descriptive Statistics for Main Variables

We present the basic descriptive statistics for three variables (total unemployment rate, total activity rate and total employment rate) in order to initially assess the situation in the EU labour market for the analysed period. We present the following statistics:

$\bar{x}$—arithmetic mean,
S_x—standard deviation,
V_S—coefficient of variation,
M_e—median,
Skew—skewness,
min—minimal value,
max—maximal value.

Table A1. Descriptive statistics for the unemployment rate. *Source*: own calculations on the basis of the Eurostat data.

Statistics	2018Q1	2018Q2	2018Q3	2018Q4	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2	2020Q3	2020Q4	2021Q1	2021Q2	2021Q3
$\bar{x}$	7.2	6.8	6.7	6.5	6.4	6.1	6.1	6.0	6.2	7.0	7.5	7.2	7.2	6.9	6.4
S_x	3.818	3.656	3.523	3.469	3.484	3.290	3.256	3.173	3.125	3.388	3.256	3.198	3.039	3.028	2.837
V_S	53.27%	53.95%	52.82%	53.76%	54.82%	53.55%	53.43%	52.59%	50.80%	48.66%	43.33%	44.53%	42.01%	43.74%	44.20%
M_e	6.3	5.9	5.9	5.8	5.6	5.4	5.4	5.3	5.2	6.6	7.0	6.5	6.9	6.8	6.0
Skew	1.949	2.061	2.082	2.056	2.149	2.030	2.043	1.931	1.887	2.177	1.406	1.601	1.605	1.424	1.456
min	2.3	2.3	2.3	2.1	2.0	2.0	2.0	2.0	2.0	2.5	2.8	3.1	3.3	3.1	2.7
max	20.7	19.9	19.4	18.9	19.2	17.8	17.6	17.0	16.8	19.4	17.2	17.0	16.5	15.6	14.8

Table A2. Descriptive statistics for the activity rate. *Source*: own calculations on the basis of the Eurostat data.

Statistics	2018Q1	2018Q2	2018Q3	2018Q4	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2	2020Q3	2020Q4	2021Q1	2021Q2	2021Q3
$\bar{x}$	64.8	64.9	65.2	65.2	65.3	65.3	65.3	65.5	65.3	64.0	65.0	65.1	65.0	65.6	66.0
S_x	4.474	4.530	4.548	4.612	4.538	4.556	4.587	4.636	4.731	5.273	4.819	4.901	4.768	4.756	4.842
V_S	6.90%	6.98%	6.98%	7.07%	6.95%	6.97%	7.02%	7.08%	7.25%	8.24%	7.41%	7.25%	7.34%	7.25%	7.34%
M_e	65.1	65.3	65.5	65.7	65.8	65.9	66.1	66.1	65.9	64.7	65.6	65.6	65.4	66.2	66.2
Skew	−0.347	−0.378	−0.487	−0.465	−0.434	−0.490	−0.455	−0.395	−0.382	−0.372	−0.339	−0.380	−0.289	−0.393	−0.441
min	54.7	54.6	54.9	54.8	55.0	55.1	55.4	55.7	55.8	53.3	55.6	55.3	55.1	55.8	56.2
max	72.9	73.1	72.8	73.1	73.5	73.1	73.3	73.6	73.4	72.8	73.3	73.6	73.5	74.1	74.4

Table A3. Descriptive statistics for the employment rate. *Source*: own calculations on the basis of the Eurostat data.

Statistics	2018Q1	2018Q2	2018Q3	2018Q4	2019Q1	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2	2020Q3	2020Q4	2021Q1	2021Q2	2021Q3
$\bar{x}$	60.2	60.6	60.9	61.1	61.2	61.4	61.4	61.6	61.3	59.6	60.2	60.5	60.3	61.1	61.8
S_x	5.439	5.416	5.392	5.442	5.321	5.301	5.335	5.268	5.311	5.857	5.303	5.344	5.266	5.264	5.318
V_S	8.88%	8.94%	8.86%	8.91%	8.70%	8.64%	8.69%	8.55%	8.67%	9.83%	8.81%	8.83%	8.74%	8.61%	8.60%
M_e	61.4	61.7	62.1	62.3	62.5	62.3	62.3	62.3	61.9	60.5	61.0	61.4	61.4	62.7	62.9
Skew	−0.628	−0.607	−0.711	−0.653	−0.668	−0.690	−0.671	−0.595	−0.639	−0.893	−0.684	−0.742	−0.616	−0.642	−0.608
min	47.2	47.6	47.7	48.3	48.6	48.9	48.8	49.7	48.7	43.3	48.0	47.5	47.8	49.0	50.6
max	68.3	68.7	68.1	69.4	68.5	68.8	68.9	69.6	69.0	67.9	68.2	68.5	69.7	70.9	71.5

References

1. Onvista. MSCI World Index: Kurs, Chart News. Available online: https://www.onvista.de/index/MSCI-WORLD-Index-3193857 (accessed on 1 July 2020).
2. Anjorin, A.A.A. The coronavirus disease 2019 (COVID-19) pandemic: A review and an update on cases in Africa. *Asian Pac. J. Trop. Med.* **2020**, *13*, 199–203. [CrossRef]
3. Feinstein, M.M.; Niforatos, J.D.; Hyun, I.; Cunningham, T.V.; Reynolds, A.; Brodie, D.; Levine, A. Considerations for ventilator triage during the COVID-19 pandemic. *Lancet Respir. Med.* **2020**, *8*, 53. [CrossRef]
4. De Vijlder, W. *The COVID-19 Pandemic: Economic Consequences Pervasive Uncertainty, Delayed Recovery*; BNP Paribas, Economic Research Department: Paris, France, 2020; pp. 1–51.
5. CRISIL (An S&P Global Company). The COVID-19 Fallout: Quantifying First-Cut Impact of the Pandemic. Impact Note, 2020, pp. 1–44. Available online: https://www.spglobal.com/en/research-insights/articles/the-covid-19-fallout-quantifying-first-cut-impact-of-the-pandemic (accessed on 15 February 2021).
6. Hunter, C.L.; Kim, K.; Rubin, H. COVID-19 Economic Impacts: Beware of March A Day Romans Settled Debts. KPMG Economics, 2020. Available online: https://assets.kpmg/content/dam/kpmg/cl/pdf/2020-03-kpmg-chile-advisory-coronavirus-mapping.pdf (accessed on 15 February 2021).
7. Shaikh, I. Impact of COVID-19 pandemic on the energy markets. *Econ. Chang. Restruct.* **2022**, *55*, 433–484. [CrossRef]
8. Tröster, B.; Küblböck, K. Unprecedented but not Unpredictable: Effects of the COVID 19 Crisis on Commodity Dependent Countries. *Eur. J. Dev. Res.* **2020**, *32*, 1430–1449. [CrossRef] [PubMed]
9. Zhang, D.; Hu, M.; Ji, Q. Financial markets under the global pandemic of COVID-19. *Finance Res. Lett.* **2020**, *36*, 101528. [CrossRef] [PubMed]
10. Trompenaars, F.; Hampden-Turner, C. *Culture, Crisis and COVID-19: The Great Reset*; Cambridge Scholars Publishing: Cambridge, UK, 2021.
11. Nelson, P. *Global Development and Human Rights. The Sustainable Development Goals and Beyond*; University of Toronto Press: Toronto, ON, Canada, 2021.
12. Remeikiene, R.; Belas, J.; Kliestik, T.; Lubos Smreka, L. Quantitative Assessment of Dynamics of Economic Development in the Countries of the European Union. *Technol. Econ. Dev. Econ.* **2020**, *26*, 933–946. [CrossRef]
13. Sebestyén, V.; Domokos, E.; Abonyi, J. Focal points for sustainable development strategies—Text mining-basedcomparative analysis of voluntary national reviews. *J. Environ. Manag.* **2020**, *263*, 110414. [CrossRef] [PubMed]
14. Soava, G.; Mehedintu, A.; Sterpu, M. Relations Between Income Inequality, Economic Growth and Poverty Threshold: New Evidences from EU Countries Panels. *Technol. Econ. Dev. Econ.* **2020**, *26*, 290–310. [CrossRef]
15. Cyrek, M.; Fura, B. Employment for Sustainable Development: Sectoral Efficiencies in EU Countries. *Soc. Indic. Res.* **2019**, *143*, 277–318. [CrossRef]
16. Ezcurra, R. Regional Disparities and Within-country Inequality in the European Union. *Rev. Econ. Mund.* **2019**, *51*, 139–162. [CrossRef]
17. Compagnolo, L.; Carraro, C.; Eboli, F.; Farnia, L.; Parrado, R.; Pierfederici, R. The Ex-Ante Evaluation of Achieving Sustainable Development Goals. *Soc. Indic. Res.* **2018**, *136*, 73–116. [CrossRef]
18. The Sustainable Development Goals Report 2021. Available online: https://unstats.un.org/sdgs/report/2021/ (accessed on 11 March 2022).
19. Ruesga-Benito, S.M.; González-Laxe, F.; Picatoste, X. Sustainable Development, Poverty, and Risk of Exclusion for Young People in the European Union: The Case of NEETs. *Sustainability* **2018**, *10*, 4708. [CrossRef]
20. Barska, A.; Jędrzejczak-Gas, J.; Wyrwa, J.; Kononowicz, K. Multidimensional Assessment of the Social Development of EU Countries in the Context of Implementing the Concept of Sustainable Development. *Sustainability* **2020**, *12*, 7821. [CrossRef]
21. Cristea, M.; Noja, G.G.; Stefea, P.; Sala, A.L. The impact of population aging and public health support on EU labor markets. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1439. [CrossRef]
22. Kapecki, T. Elements of Sustainable Development in the Context of the Environmental and Financial Crisis and the COVID-19 Pandemic. *Sustainability* **2020**, *12*, 6188. [CrossRef]
23. Ayittey, F.K.; Ayittey, M.K.; Chiwero, N.B.; Kamasah, J.S.; Dzuvor, C. Economic impacts of Wuhan 2019-nCoV on China and the world. *J. Med. Virol.* **2020**, *92*, 473–475. [CrossRef]
24. Alfaro, L.; Chari, A.; Greenland, A.N.; Schott, P.K. Aggregate and Firm-Level Stock Returns during Pandemics. In *Real Time*; NBER Working Papers 26950; National Bureau of Economic Research: Cambridge, MA, USA, 2020.
25. Michelsen, C.; Baldi, G.; Dany-Knedlik, G.; Engerer, H.; Gebauer, S.; Rieth, M. Coronavirus causing major economic shock to the global economy. *DIW Wkly. Rep.* **2020**, *10*, 180–182.
26. Ruiz Estrada, A.M. Economic Waves: The Effect of the Wuhan COVID-19 on the World Economy (2019–2020), 2020. Available online: https://ssrn.com/abstract=3545758 (accessed on 26 March 2021).
27. Albulescu, C. Coronavirus and Oil Price Crash, 2020. Available online: https://ssrn.com/abstract=3553452 (accessed on 26 March 2021).
28. Ahmar, A.S.; del Val, E.B. SutteARIMA: Short-term forecasting method, a case: Covid-19 and stock market in Spain. *Sci. Total Environ.* **2020**, *729*, 138883. [CrossRef]

29. Al-Awadhi, A.M.; Al-Saifi, K.; Al-Awadhi, A.; Alhamadi, S. Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns. *J. Behav. Exp. Finance* **2020**, *27*, 100326. [CrossRef] [PubMed]
30. Bieszk-Stolorz, B.; Dmytrów, K. A survival analysis in the assessment of the influence of the SARS-CoV-2 pandemic on the probability and intensity of decline in the value of stock indices. *Eurasian Econ. Rev.* **2021**, *11*, 363–379. [CrossRef]
31. Bieszk-Stolorz, B.; Dmytrów, K. Evaluation of Changes on World Stock Exchanges in Connection with the SARS-CoV-2 Pandemic. Survival Analysis Methods. *Risks* **2021**, *9*, 121. [CrossRef]
32. Bieszk-Stolorz, B.; Markowicz, I. Decline in Share Prices of Energy and Fuel Companies on the Warsaw Stock Exchange as a Reaction to the COVID-19 Pandemic. *Energies* **2021**, *14*, 5412. [CrossRef]
33. Baker, S.R.; Bloom, N.; Davis, S.J.; Terry, S.J. *Covid-Induced Economic Uncertainty (No. w26983)*; National Bureau of Economic Research: Cambridge, MA, USA, 2020. [CrossRef]
34. Sharif, A.; Aloui, C.; Yarovaya, L. COVID-19 pandemic, oil prices, stock market, geopolitical risk and policy uncertainty nexus in the US economy: Fresh evidence from the wavelet-based approach. *Int. Rev. Financ. Anal.* **2020**, *70*, 101496. [CrossRef]
35. McIver, R.P.; Kang, S.H. Financial crises and the dynamics of the spillovers between the US and BRICS stock markets. *Res. Int. Bus. Financ.* **2020**, *54*, 101276. [CrossRef]
36. Su, R.; Obrenovic, B.; Du, J.; Godinic, D.; Khudaykulov, A. COVID-19 Pandemic Implications for Corporate Sustainability and Society: A Literature Review. *Int. J. Environ. Res. Public Health* **2022**, *19*, 1592. [CrossRef] [PubMed]
37. Schoon, I.; Bynner, J. Young people and the great recession: Variations in the school-to-work transition in Europe and the United States. *Longitud. Life Course Stud.* **2019**, *10*, 153–173. [CrossRef]
38. Mikołajczak, P. What affects employment by NGOs? Counteraction to precarious employment in the Polish non-profit sector in the perspective of COVID-19 pandemic crises. *Oeconomia Copernic.* **2021**, *12*, 761–788. [CrossRef]
39. Lee, S.; Schmidt-Klau, D.; Verick, S. The Labour Market Impacts of the COVID-19: A Global Perspective. *Indian J. Labour Econ.* **2020**, *63*, 11–15. [CrossRef] [PubMed]
40. Mamgain, R.P. Understanding labour market disruptions and job losses amidst COVID-19. *J. Soc. Econ. Dev.* **2021**, *23*, 23. [CrossRef] [PubMed]
41. Nivakoski, S.; Mascherini, M. Gender Differences in the Impact of the COVID-19 Pandemic on Employment, Unpaid Work and Well-Being in the EU. *Inter Econ.* **2021**, *56*, 254–260. [CrossRef] [PubMed]
42. Botha, F.; de New, J.P.; de New, S.C.; Ribar, D.C. Salamanca, N. Implications of COVID-19 labour market shocks for inequality in financial wellbeing. *J. Popul. Econ.* **2021**, *34*, 655–689. [CrossRef]
43. Roman, M.; Roman, M.; Grzegorzewska, E.; Pietrzak, P.; Roman, K. Influence of the COVID-19 Pandemic on Tourism in European Countries: Cluster Analysis Findings. *Sustainability* **2022**, *14*, 1602. [CrossRef]
44. Svabova, L.; Tesarova, E.N.; Durica, M.; Strakova, L. Evaluation of the impacts of the COVID-19 pandemic on the development of the unemployment rate in Slovakia: Counterfactual before-after comparison. *Equilib. Q. J. Econ. Econ. Policy* **2021**, *16*, 261–284. [CrossRef]
45. Dunphy, D.; Benveniste, J.; Griffiths, A.; Sutton, P. *Sustainability. The Corporate Challenge of the 21st Century*; Allen & Unwin: Crows Nest, Australia, 2000.
46. Hodder, A. New Technology, Work and Employment in the era of COVID-19: Reflecting on legacies of research. *New Technol. Work. Employ.* **2020**, *35*, 262–275. [CrossRef] [PubMed]
47. Fana, M.; Torrejón Pérez, S.; Fernández-Macías, E. Employment impact of COVID-19 crisis: From short term effects to long terms prospects. *J. Ind. Bus. Econ.* **2020**, *47*, 391–410. [CrossRef]
48. Webb, A.; McQuaid, R.; Rand, S. Employment in the informal economy: Implications of the COVID-19 pandemic. *Int. J. Sociol. Soc. Policy* **2020**, *40*, 1005–1019. [CrossRef]
49. Galik, A.; Bąk, M.; Bałandynowicz-Panfil, K.; Cirella, G.T. Evaluating Labour Market Flexibility Using the TOPSIS Method: Sustainable Industrial Relations. *Sustainability* **2022**, *14*, 526. [CrossRef]
50. Gavriluta, N.; Grecu, S.-P.; Chiriac, H.C. Sustainability and Employability in the Time of COVID-19. Youth, Education and Entrepreneurship in EU Countries. *Sustainability* **2022**, *14*, 1589. [CrossRef]
51. Guo, Y.; Kaniuka, A.R.; Gao, J.; Sims, O.T. An Epidemiologic Analysis of Associations between County-Level Per Capita Income, Unemployment Rate, and COVID-19 Vaccination Rates in the United States. *Int. J. Environ. Res. Public Health* **2022**, *19*, 1755. [CrossRef] [PubMed]
52. Transforming Our World: The 2030 Agenda for Sustainable Development. Available online: https://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E (accessed on 11 March 2022).
53. Hwang, C.-L.; Yoon, K. *Multiple Attribute Decision Making. Methods and Applications. A State-of-the-Art Survey*; Springer: Berlin/Heidelberg, Germany, 1981.
54. Bellman, R.; Kalaba, R. On adaptive control processes. *IRE Trans. Autom. Control.* **1959**, *4*, 1–9. [CrossRef]
55. Rabiner, L.; Rosenberg, A.; Levinson, S. Considerations in dynamic time warping algorithms for discrete word recognition. *IEEE Trans. Acoust. Speech, Signal Process.* **1978**, *26*, 575–582. [CrossRef]
56. Sakoe, H.; Chiba, S. Dynamic programming algorithm optimization for spoken word recognition. *IEEE Trans. Acoust. Speech Signal. Process.* **1978**, *26*, 43–49. [CrossRef]
57. Myers, C.S.; Rabiner, L.R. A comparative study of several dynamic time-warping algorithms for connected word recognition. *Bell Syst. Tech. J.* **1981**, *60*, 1389–1409. [CrossRef]

58. Müller, M. *Information Retrieval for Music and Motion*; Springer: Berlin/Heidelberg, Germany, 2007.
59. Arici, T.; Celebi, S.; Aydin, A.S.; Temiz, T.T. Robust gesture recognition using feature pre-processing and weighted dynamic time warping. *Multimed. Tools Appl.* **2014**, *72*, 3045–3062. [CrossRef]
60. Aach, J.; Church, G.M. Aligning gene expression time series with time warping algorithms. *Bioinformatics* **2001**, *17*, 495–508. [CrossRef] [PubMed]
61. Landmesser, J. The use of the dynamic time warping (DTW) method to describe the COVID-19 dynamics in Poland. *Oeconomia Copernic.* **2021**, *12*, 539–556. [CrossRef]
62. Dmytrów, K.; Bieszk-Stolorz, B. Mutual relationships between the unemployment rate and the unemployment duration in the Visegrad Group countries in years 2001–2017. *Equilib. Q. J. Econ. Econ. Policy* **2019**, *14*, 129–148. [CrossRef]
63. Dmytrów, K.; Landmesser, J.; Bieszk-Stolorz, B. The Connections between COVID-19 and the Energy Commodities Prices: Evidence through the Dynamic Time Warping Method. *Energies* **2021**, *14*, 4024. [CrossRef]
64. Denkowska, A.; Wanat, S. Dynamic Time Warping Algorithm in Modeling Systemic Risk in the European Insurance Sector. *Entropy* **2021**, *23*, 1022. [CrossRef]
65. Stübinger, J. Statistical arbitrage with optimal causal paths on high-frequency data of the S&P 500. *Quant. Finance* **2019**, *19*, 921–935. [CrossRef]
66. Keogh, E.; Kasetty, S. On the need for time series data mining benchmarks: A survey and empirical demonstration. *Data Min. Knowl. Discov.* **2003**, *7*, 349–371. [CrossRef]
67. Łuczak, M. Combining raw and normalized data in multivariate time series classification with dynamic time warping. *J. Intell. Fuzzy Syst.* **2018**, *34*, 373–380. [CrossRef]
68. Keogh, E.; Ratanamahatana, C.A. Exact indexing of dynamic time warping. *Knowl. Inf. Syst.* **2005**, *7*, 358–386. [CrossRef]
69. Sardá-Espinosa, A. Time-series clustering in R using the dtwclust package. *R J.* **2019**, *11*, 22–43. [CrossRef]
70. Rozmus, D. Clustering Poland Among Eu Countries in Terms of a Sustainable Development Level in the Light of Various Cluster Stability Measures. *Folia Oeconomica Stetin.* **2020**, *20*, 319–340. [CrossRef]
71. Zalewska, E. The Application of Continuous Quality Improvement Methods at Universities in the Opinion of Students and Lecturers of the University of Lodz. *Folia Oeconomica Stetin.* **2021**, *21*, 175–189. [CrossRef]
72. Sikora-Alicka, J. A Taxonomic Analysis of the Structure of Prime Costs in Polish Clinical Hospitals. *Folia Oeconomica Stetin.* **2021**, *21*, 118–131. [CrossRef]
73. Małkowska, A.; Urbaniec, M.; Kosała, M. The impact of digital transformation on European countries: Insights from a comparative analysis. *Equilib. Q. J. Econ. Econ. Policy* **2021**, *16*, 325–355. [CrossRef]
74. Key Indicators of the Labour Market, Ninth Edition. Available online: https://www.ilo.org/wcmsp5/groups/public/---dgreports/---stat/documents/publication/wcms_498929.pdf (accessed on 11 March 2022).
75. Botelho, V.; Da Silva, A.D. Indicators of Labour Market Conditions in the Euro Area. Available online: https://www.ecb.europa.eu/pub/economic-bulletin/focus/2019/html/ecb.ebbox201908_04~f77013b361.en.html (accessed on 11 March 2022).
76. Jianu, E.; Pîrvu, R.; Axinte, G.; Toma, O.; Cojocaru, A.V.; Murtaza, F. EU Labor Market Inequalities and Sustainable Development Goals. *Sustainability* **2021**, *13*, 2675. [CrossRef]
77. Bieszk-Stolorz, B.; Dmytrów, K. Influence of Accession of the Visegrad Group Countries to the EU on the Situation in Their Labour Markets. *Sustainability* **2020**, *12*, 6694. [CrossRef]
78. Dmytrów, K.; Bieszk-Stolorz, B. Comparison of changes in the labour markets of post-communist countries with other EU member states. *Equilib. Q. J. Econ. Econ. Policy* **2021**, *16*, 741–764. [CrossRef]
79. Rollnik-Sadowska, E.; Jarocka, M. CEE Labour Markets—Homogenity or Diversity? *Technol. Econ. Dev. Econ.* **2021**, *27*, 1142–1158. [CrossRef]
80. Lustig, N. Economic crisis, adjustment and living standards in Mexico, 1982–1985. *World Dev.* **1990**, *19*, 1325–1342. [CrossRef]
81. Colombo, E.; Menna, L.; Tirelli, P. Informality and the labor market effects of financial crises. *World Dev.* **2019**, *119*, 1–22. [CrossRef]
82. Gilbert, A. Third World Cities: Housing, Infrastructure and Servicing. *Urban Stud.* **1992**, *29*, 435–460. 00420989220080521. [CrossRef]
83. Pratt, A.C.; Hutton, T.A. Reconceptualising the relationship between the creative economy and the city: Learning from the financial crisis. *Cities* **2013**, *33*, 86–95. [CrossRef]
84. Kučas, A.; Kavalov, B.; Lavalle, C. Living Cost Gap in the European Union Member States. *Sustainability* **2020**, *12*, 8955. [CrossRef]
85. Lafuente, J.Á.; Marco, A.; Monfort, M.; Ordóñez, J. Social Exclusion and Convergence in the EU: An Assessment of the Europe 2020 Strategy. *Sustainability* **2020**, *12*, 1843. [CrossRef]
86. Piroşcă, G.I.; Şerban-Oprescu, G.L.; Badea, L.; Stanef-Puică, M.-R.; Valdebenito, C.R. Digitalization and Labor Market—A Perspective within the Framework of Pandemic Crisis. *J. Theor. Appl. Electron. Commer. Res.* **2021**, *16*, 2843–2857. [CrossRef]

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The Impact of the COVID-19 Pandemic on the Situation of the Unemployed in Poland. A Study Using Survival Analysis Methods

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Abstract: Many studies point to the impact of the COVID-19 pandemic on the socio-economic situation of countries and, consequently, on the achievement of sustainable development goals. Although termed a health crisis, the pandemic has also had an impact on the labour market. The imposed restrictions caused companies to close or reduce their operations. Employees switched to remote work, but also often lost their jobs temporarily or permanently. However, the impact of the pandemic on the labour market is not so obvious. This is indicated by our research and that of other researchers. In this paper, we used individual data on the unemployed registered at the labour office in Szczecin (Poland) and were thus able to apply survival analysis methods. These methods allowed us to assess changes in the duration of unemployment and the intensity of taking up work for individual cohorts (unemployed people deregistered in a given quarter). The results indicate, on the one hand, the problems in the labour market during the pandemic and, on the other hand, the adapted reaction of the unemployed to the situation and the acceleration of the decision to accept an offered job.

Keywords: registered unemployment; COVID-19 pandemic; survival analysis

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1. Introduction

Even before the pandemic emerged, the global economy had slowed down. According to The Sustainable Development Goals Report 2021 [1], the health crisis caused by COVID-19 disrupted economic activity worldwide and caused the worst recession since the Great Depression. COVID-19 created a heightened adverse impact on human life, the economy, the environment, and the energy and transport sectors compared to the pre-COVID-19 scenario [2]. In 2020, 255 million full-time jobs were lost. This is about four times the number lost during the global financial crisis in 2009. The pandemic has placed informally employed workers, young workers, workers with disabilities, and women at a particular risk. There is a high probability of job loss for temporary agency workers, marginal part-time workers, on-call workers, and independent contractors in sectors that are heavily affected [3]. The authors of the Sustainable Development Goals Report 2022 [4] found that in 2021 the global economy started to rebound and effected some improvement in terms of unemployment. However, this recovery varied considerably across regions, countries, sectors, and labour market groups. In low- and lower middle-income countries, small firms were particularly disadvantaged. The conflict in Ukraine is expected to seriously slow global growth in 2022.

In the face of all these events, the process of achieving the Sustainable Development Goals is threatened. The COVID-19 pandemic increased unemployment as manufacturing and other industries closed due to mandated social isolation, resulting in a descent into poverty [5]. Adverse changes have affected many spheres of human life. Environmental pollution increased due to an increase in organic and inorganic waste [6]. With the development of the COVID-19 pandemic, very severe economic degrowth and imbalances

began [7–10]. Among other things, the achievement of SDG Goal 8—to promote sustained, inclusive, and sustainable economic growth; full and productive employment; and decent work for all—was threatened. Alibegovic et al. [11] ranked this goal among the most threatened by the pandemic. High unemployment rates in the EU suggested labour market imbalances and signalled an economic recession. A study by Gavriluță et al. [12] suggests that the labour market situation in Poland during the pandemic was not bad. The unemployment rate increased between 2020 and 2021 but was much lower than in many EU-27 countries (below average). Poland's employment rate was only slightly lower than the average set for the EU-27. Poland's relatively good position is also confirmed by a study by Lee et al. [13]. In the ranking of economic resilience for 52 countries worldwide, Poland achieved an average score. However, as Lee et al. [14] point out, the labour market indicators in the initial phase of the pandemic should be viewed with caution. Unemployment does not indicate the actual scale of disruption for workers, as many people keep their jobs but are not working (therefore, they are considered employed), have lost their jobs but do not search for jobs (therefore, they are considered inactive), or are working shorter hours (therefore, they are considered employed again). In the longer term, the impact of the pandemic on labour markets in the EU will become evident once protective labour market policies are abolished [15]. Currently, the labour market situation in Poland is good considering the situation in EU countries (Figure 1). In terms of the harmonised unemployment rate, Poland ranks third among the countries with the lowest rates.

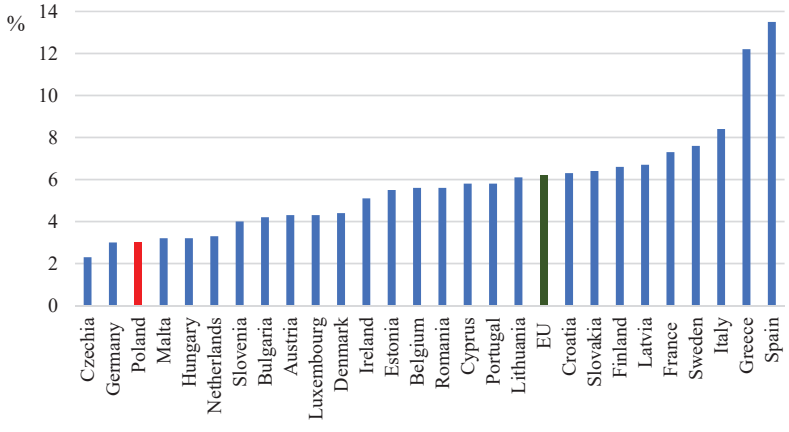

Figure 1. Harmonised unemployment rate in EU countries in the 1st quarter of 2022. Source: own elaboration on the basis of data from Statistics Poland—registered unemployment quarter 2022 (https://stat.gov.pl/en, accessed on 1 June 2022).

The unemployment rate in Poland has been steadily decreasing since the beginning of its EU accession. In May 2004, it was 19.4% and in October 2019 it was only 5.0%. This trend was unfortunately bucked during the pandemic period. At the end of 2020, the unemployment rate was 6.3% and at the end of 2021 it was 5.4%. The year 2020 was unique due to the global COVID-19 pandemic. This also severely influenced the labour market, which, similar to a lens, concentrates the effects of the major changes taking place in both the economy and social life. In Poland, a state of epidemic was announced in March 2020. Both its course and the measures taken to prevent the spread of the virus disrupted the typical market game of supply and demand for labour [16].

In this emergency situation, many companies closed down or reduced their activities. Of course, this translated into job losses, increased unemployment, and a decrease in the population's income. As we have already noted, this situation was temporary. In many countries, legislation, online learning, and work opportunities have been put in place to reduce the negative effects of the pandemic. Nevertheless, it has been pointed out that 2020

was of a specific significance to the labour market situation. In Poland, the situation before the pandemic was systematically improving (the working population was increasing, and the unemployed population was decreasing). The positive trends in the labour market, as indicated by the increasing employment rate, the stabilisation of the activity rate, and the decreasing unemployment rate, were disrupted after the announcement of the epidemic in March 2020.

As Statistics Poland points out, the largest changes in the economic activity of the population—resulting from the circumstances accompanying the fight against the COVID-19 pandemic—took place in the second quarter of 2020. The introduction of remote work and the reduction in the average weekly working time were important aspects. It should be noted that in the years of an economic boom, the second and the third quarter of a year compared to the fourth and the first quarter are usually characterised by decreasing unemployment, whereas this seasonal periodicity was not maintained in 2020.

We put forward the following research hypotheses:

Hypothesis 1 (H1): *An increase in unemployment as a result of the health crisis.*

Hypothesis 2 (H2): *A longer job search time after the onset of the pandemic.*

Hypothesis 3 (H3): *A reduced intensity of taking up work after the onset of the pandemic.*

These hypotheses were based on the belief that the pandemic, as a crisis phenomenon, would have a negative impact on the labour market. The closure of companies or the reduction in their activities clearly indicates a reduced demand for labour during a difficult period.

The aim of the research is to assess the impact of the COVID-19 pandemic on the situation of the unemployed in Szczecin. The study uses individual data on the duration of unemployment for people registered with the Poviat Labour Office in the period from Q1 2019 to Q1 2022. Such data enable the use of survival analysis methods to indicate whether the duration of a job search by the unemployed changed during the period of the pandemic's emergence. Thanks to the possibility of using censored data, it was possible to include people who were deregistered for work and those who were deregistered for other reasons.

It should be added that Szczecin is a large voivodeship city. It is located in the north-western part of Poland. It has around 400,000 inhabitants. As in other cities, it is not only a place of work for the inhabitants of Szczecin, but also for the inhabitants of the region. Its location on the Bay of Pomerania makes Szczecin a port city with access to the Baltic Sea. Szczecin used to be a shipbuilding city. Today, employment in the shipyards is marginal. However, Szczecin still has a port that forms a single entity with the port of Świnoujście. It is dominated by the growing e-commerce sector, the logistics sector, the information technology sector, and modern business services. Special economic zones and large warehouses (Zalando, Amazon, etc.) are being established in the vicinity of Szczecin. This creates jobs for the capital of the region. Thus, the directions of the development of the labour market in Szczecin are the same as in other cities and the research results obtained may be helpful in creating labour market policies in crisis periods in other cities, Poland, and other countries.

The manuscript is organised as follows: Section 2 presents the literature review. In Section 3, we present the data and research methods. Section 4 presents the results of the empirical analysis. In Section 5, we present the discussion of the obtained results. The manuscript ends with our conclusions.

2. Literature review

The dynamics of the COVID-19 pandemic and its impact on the socio-economic situation have become the subject of many scientific studies [17–25]. The results of these studies have been published in a number of journals [26]. These studies include the impact

of COVID-19 on the efficiency of healthcare systems [27], on energy markets [28,29], on labour markets [30–32], on capital markets [33–35], and on selected industries [36,37]. For the most part, the results of the studies indicate a negative impact of the pandemic on the socio-economic situation. The emergence of COVID-19 caused an economic shock in many countries on an unprecedented scale. This manifested itself as a decline in the value of the GDP. For example, during the first wave of the pandemic, the decline in the value of the GDP in the UK was 21%—the largest in over 60 years [38]. The decline in the value of the GDP in the USA during the same period was 31.7% [39]. However, some researchers also highlight the positive impact of COVID-19 on sustainable development. This refers to the reduction in greenhouse gas emissions [40]. The level of greenhouse gas emissions could have decreased by about 10%. According to Cortes and Forsythe [41], the pandemic has exacerbated pre-existing inequalities in the Canadian labour market. The employment losses were widespread. They more intensely affected the lower-paying occupations and industries. People from disadvantaged groups were in a particularly difficult situation in the labour market, such as Hispanics, younger workers, those with lower levels of education, and women. Blustein et al. [42] also report that the pandemic reveals and exacerbates existing inequalities in the labour market. They think that the COVID-19 pandemic grants the opportunity to define and describe how precarious work creates physical, behavioural, relational, economic, psychological, and emotional vulnerabilities that worsen outcomes from crises. The authors also postulate the application of rigorous quantitative methods to develop a new understanding of the nature of unemployment during this period and to develop and assess interventions. Antipova [43] studied economic impacts in the context of social disadvantage. This work specifically considers economic conditions in regions with pre-existing inequalities and examines labour market outcomes in already socially vulnerable areas. More marginalised regions may have broader economic damages related to the pandemic. The outcomes of the study in [44] highlight that the pandemic increases the unemployment rate robustly mostly in European economies. The results show that Germany, Spain, and the UK have experienced a positive and significant change in unemployment due to COVID-19. France and Italy are experiencing a better employment situation with respect to the COVID-19 pandemic. That is one of the rare negative effects of the virus on the European labour market. Botha et al. [45] analysed the impact of COVID-19 on the labour market in Australia. They showed that the introduction of a wage subsidy (JobKeeper) and increased welfare benefit payments were unable to eliminate the uncertainty felt by individuals about their future financial situation. Mamgain [46] analysed the labour market in India during the pandemic. He pointed out that those at risk of losing their jobs during this period were mainly migrant workers, self-employed, small traders, daily wage labourers, youth, and women, with the latter two being the worst affected, as they mostly work in the grey zone of the Indian economy. The agricultural sector absorbed surplus labour. The author points out that in addition to measures aimed at improving the current labour market situation, the skilling/reskilling of the labour force to work in post-COVID-19-changed situations is important. According to Edwards et al. [47], the U.S. labour market continued to recover in 2021 from the recession caused by the coronavirus pandemic. Both the number of people who were unemployed and the unemployment rate decreased over the year, although both measures were still above their pre-pandemic levels. At the start of the pandemic in the USA, the number of unemployed in each category separated by the duration of unemployment increased. In 2021, the number of short-term unemployed persons declined. That number began to decrease as people either returned to work, stopped looking, or moved into the longer duration categories. This is evidenced by the number of long-term unemployed and their share of total unemployment in 2021. Both these indicators remained well above the levels seen before the pandemic. Gherghina et al. [48] showed that e-commerce has largely saved jobs, reduced spending, and provided employment.

Of course, the pandemic is one of many factors affecting the labour market in Poland. Geopolitical factors, which can be external and internal, have a large impact. Among the

external factors, the labour market in Poland is influenced by its EU membership [49,50]. The internal factors may include the efficiency of the use of funds earmarked for counteracting unemployment [51]. Dmytrów and Bieszk-Stolorz [52] analysed the relationship between the unemployment rate and the median duration of unemployment in the Visegrad countries between 2001 and 2017. The research indicated the existence of a lag in the response of the duration of unemployment to changes in the unemployment rate. The authors showed that in the analysed years, Poland had the shortest lag (1 year) and the highest correlation between these indicators. The implication is that an increase in the duration of unemployment can occur even one year after an increase in the unemployment rate. Thus, the effects of the pandemic may still be felt after the fluctuations caused by the pandemic, i.e., in 2022 or even 2023. However, the study of this relationship will be hampered by the rapid changes in the Polish labour market caused by the outbreak of the war in Ukraine.

During the pandemic, a remote form of working became widespread. In Poland, these changes were not that favourable. In 2018, before the pandemic, the share of remote work was 4.6%, lower than the EU average of 5.2%. In 2021, the share in Poland increased to 8.9%, while the EU average was 12.3% [32]. However, the percentage has varied from quarter to quarter. The research conducted by Statistics Poland showed that the percentage of people working remotely in Poland was 11% in Q1 of 2020, 2.8% in Q3 of 2020, and 14.2% in Q1 of 2021 [53].

Pavolová et al. [7] analysed the impact of COVID-19 on the economic development of selected EU countries in terms of selected macroeconomic indicators. The selected countries were the Visegrad group countries. They found that during the pandemic years (2020–2021), Poland showed the best economic development and Slovakia showed the worst. Abrhám and Vošta [8] assessed the selected economic indicators in the Member States of the EU in the period from 2010–2020. They showed that in 2020, the unemployment rate for the EU27 countries increased by 5.9%, while in 2021 it decreased by 2.8%. In some countries, including Poland, it was the opposite. The unemployment rate in Poland decreased by 3% in 2020 and increased by 6.2% in 2021.

In order to discuss unemployment in Poland during the pandemic, it is necessary to mention the determinants of this phenomenon. At the turn of the 20th and 21st centuries, unemployment in Poland was characterised by fluctuations. At the end of the 20th century, there was a large increase in unemployment as a result of the economic slowdown and the transformation of the economy (16.4% in 1993). After Poland's accession to the EU (2004), unemployment fell steadily from 19.0% as a result of economic recovery. By the onset of the pandemic, unemployment was decreasing (to 5.2% in 2019). It is emphasised that this decline is the result of an increase in demand for labour and that state policy should be directed towards the creation of new jobs. In Poland, the situation on the labour market until the pandemic was very favourable. The number of unemployed was decreasing. The unemployment rate in Poland in 2019 was at the lowest level in the EU, just after Czechia. During the pandemic, the registered unemployment rate rose from 5.2 per cent to a maximum of 6.6 per cent in February 2021. During a health crisis, a policy of increasing labour demand is difficult or even impossible. Existing jobs are shrinking, no new jobs are being created, and no new companies are being established. This situation applies to all countries.

The labour market has undoubtedly suffered during the pandemic both in Poland and elsewhere. Research shows that employment in U.S. fell by 21% in April 2022 compared to February and an increase was seen in June [54]. Research also confirms that the pandemic is the cause of increased unemployment in Slovakia [55]. Since March 2020, the registered unemployment rate has increased (from 6.2% to 8.4% in July) and there was a large influx of jobseekers in April.

3. Materials and Methods

3.1. Data

Our research is based on the individual data from the Poviat Labour Office (Polish abbreviation PUP) in Szczecin (Poland). The study, therefore, focused on registered unemployment. It should be noted that only Poviat Labour Offices in Poland are the source of such data. The Central Statistical Office in Poland and Eurostat only have aggregated data, which are not useful for studies using survival analysis models. For this reason, the data used in the study are unique. The data extracted included 31,961 people deregistered from the labour office in the period 01.01.2019–31.03.2022. The data included the date of registration and the date of deregistration, as well as the reason for deregistration. The reasons for deregistration can vary, and there are dozens of them. Since we analysed the event of taking up a job, we divided all the unemployed into two groups: those who took up a job and those who were deregistered for other reasons (e.g., resignation from the agency of the office, going abroad, or retirement). Based on the date of registration and deregistration, we determined the duration of registered unemployment—the random variable T. The end event of the observation is taking up a job. Deregistration for other reasons was taken as a censored observation. The analysis was conducted for the 13 quarters comprising the research period. The size of each subgroup is shown in Table 1.

Table 1. Persons deregistered from the PUP in Szczecin in the period Q1 2019–Q1 2022.

Quarter	Complete Observations	Censored Observations	Total
I 2019	1490	1853	3343
II 2019	1429	1826	3255
III 2019	1402	1788	3190
IV 2019	1499	1589	3088
I 2020	1426	1337	2763
II 2020	1000	309	1309
III 2020	1529	332	1861
IV 2020	1518	449	1967
I 2021	1359	632	1991
II 2021	1467	727	2194
III 2021	1417	1041	2458
IV 2021	1424	913	2337
I 2022	1188	1017	2205
Total	18,148	13,813	31,961

The observation was terminated in the first quarter of 2022. There were two reasons for this:

1. Reduction in the number of cases and deaths due to COVID-19. Accordingly, the Polish government lifted sanitary regime restrictions in 2022.
2. The labour market in Poland in the next quarter, i.e., Q2 2022, was undoubtedly heavily influenced by the start of war in Ukraine. Poland has taken in several million refugees, who have had a major influence on the labour market, also in Szczecin.

3.2. Methodology

In the study of the duration of unemployment, we used the survival analysis methods. These methods enabled the use of censored data. The basis of the survival analysis is a random variable T describing the duration (survival time) of an individual in a particular state. The observation of an individual continues until an event occurs that ends the observation. If the event does not occur within the specified time interval, such an observation is assumed to be censored. The inclusion of censored observations in subsequent analyses is one of the many advantages of survival analysis. Originally, these methods were used in demography, medicine, and reliability theory. In the case of the duration of a person's life or the operating time of a device, certain regularities have been observed that make

parametric methods possible. In the case of the duration of socio-economic phenomena, the distribution of the duration of the phenomenon is mostly unknown, so non-parametric or semiparametric methods are used. Methods of the survival analysis are used in the real estate market [56,57], in the capital market [29,34] in the study of the duration of firms [58,59], in the study of duration of trade relationships [60], and in the labour market [61,62]. The cumulative distribution function of random variable T ($F(t)$) describes the probability of an event occurring no later than time t. The basic function in survival analysis is the survival function $S(t)$, which describes the probability that an event will not occur by time t. It is described by the following formula [63]:

$$S(t) = P(t > T) = 1 - F(t) \tag{1}$$

where
T—duration;
$F(t)$—cumulative distribution function of random variable T.

Since for most socio-economic phenomena the distribution of duration is not known, studies often use the non-parametric Kaplan–Meier estimator [64]:

$$\hat{S}(t_i) = \prod_{j=1}^{i} \left(1 - \frac{d_j}{n_j}\right) \text{ for } i = 1,\ 2,\ \ldots, k, \tag{2}$$

where
t_i—the point in time when at least one event occurs, $t_1 < t_2 < \cdots < t_k, t_0 = 0$;
d_i—number of events in time t_i;
n_i—number of units observed in time t_i, $n_i = n_{i-1} - d_{i-1} - z_{i-1}$;
z_i—number of censored observations in time t_i.

Quartiles of the random variable with the cumulative distribution function $F(t)$ are determined from the relation: $F(t) = 0.25$, $F(t) = 0.50$ and $F(t) = 0.75$. Duration quartiles are moments of time for which the survival function $S(t)$ takes the following values: $S(t) = 0.25$, $S(t) = 0.50$, and $S(t) = 0.75$. Not all quartiles of duration can exist. This is because of the existence of censored observations. During the observational period, not all individuals belonging to the cohort experience the event. These ones still remain in the cohort.

Two survival curves can be compared. Appropriate tests can be used for this purpose. They allow us to analyse the significance of differences between two survival curves. There are many of them, and we do not have a consistent set of criteria to decide which test has the greatest power and should be used in the analysis. Some of them are more sensitive to the course of the survival curve in its initial part and others in its final part. The sample size, probability density of the survival function, and censorship mechanism determine the power of these tests [65]. We used two tests in the study: the log-rank test and Gehan's generalised Wilcoxon test. The log-rank test (also known as the Mantel log-rank test, the Cox Mantel log-rank test, and the Mantel–Haenszel test) is the most commonly used test for comparing survival distributions. It can be applied to data with progressive censoring and gives equal weight to early and late failures. It assumes that survival curves for the two groups are parallel. In practice, this is often not the case. Then, the generalised Wilcoxon Gehan test (also known as the Breslow's test and Gehan's test) can be applied. It is applicable to data where there is progressive censoring. When the survival functions are not parallel and when there are few censored data, the Wilcoxon Gehan test has greater power than the log-rank test. It has low power when the degree of censoring is high. It gives more weight to early failures [66]. If we are comparing survival curves in the initial run, we should use this test.

The survival analysis examines the intensity of occurrence of an event in the moment t under the condition of survival until time t. This intensity is described by the hazard

function $h(t)$. It is the second most important function in the survival analysis. It is given by means of the formula [63]:

$$h(t) = \lim_{\Delta t \to 0} \frac{P(t \leq T < t + \Delta t | T \geq t)}{\Delta t} \tag{3}$$

Another non-parametric model in survival analysis consists of the duration tables. These are called a tabular model and assume intervals of a fixed length. In the study of unemployment duration, we assume a monthly period for the empirical cohort tables created. The tables present different quantities and functions [67]. Of great importance in the study of socio-economic phenomena is the hazard function (event intensity), which determines the risk of a specific event occurring in a short time interval $(t;\ t + \Delta t)$, provided that it has not occurred by time t. The estimator of the hazard function is determined as [68]:

$$h_t^* = \frac{z_t}{(n_t^* - \frac{z_t}{2})a_t} \tag{4}$$

where
z_t—number of units experiencing the analysed event per time interval $\langle t,\ t+1)$;
n_t^*—number of units exposed (at risk) in the interval, $n_t^* = n_t - c_t/2$;
n_t—number of surviving units, $n_t = n_{t-1} - (z_t + c_t)$;
c_t—number of censored units, i.e., units that had not experienced an event by the end of the observation period of the cohort;
a_t—duration of the interval (1 month in the study).

To determine the average hazard, we used the formula [63]:

$$\bar{h}_2(t) = \frac{\#\, failures}{\sum_{j=1}^{n} t_j} \tag{5}$$

where
$\#\, failures$—the total number of failures;
$\sum_{j=1}^{n} t_j$—the sum of the observed survival times t_j.

4. Empirical results

The survey was conducted in three stages, as shown in Figure 2. In stage 1, aggregated data were used, and in stages 2–3, individual data on the registered unemployed were used. In the first stage, the overall unemployment situation in Szczecin was assessed against the background of Poland. The registered unemployment rate (the ratio of registered unemployed persons to the economically active civilian population) and inflow into registered unemployment rate (the percentage share of inflow into those registered unemployed in the total economically active population, at the end of the reporting period) in Poland and in Szczecin in the quarters of 2019–2022 are presented in Figure 3. It appears that in Q2 2021, the unemployment rate increased slightly, and the inflow rate decreased during this period. This situation is observed both in Szczecin and in Poland in general. This indicates a reduced outflow from unemployment during the initial period of the pandemic.

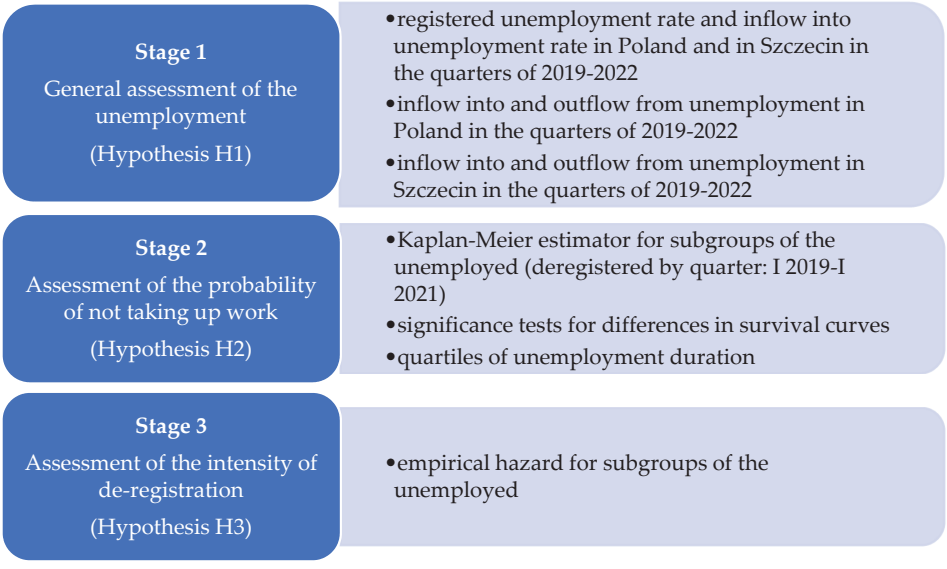

Figure 2. Scheme of the study.

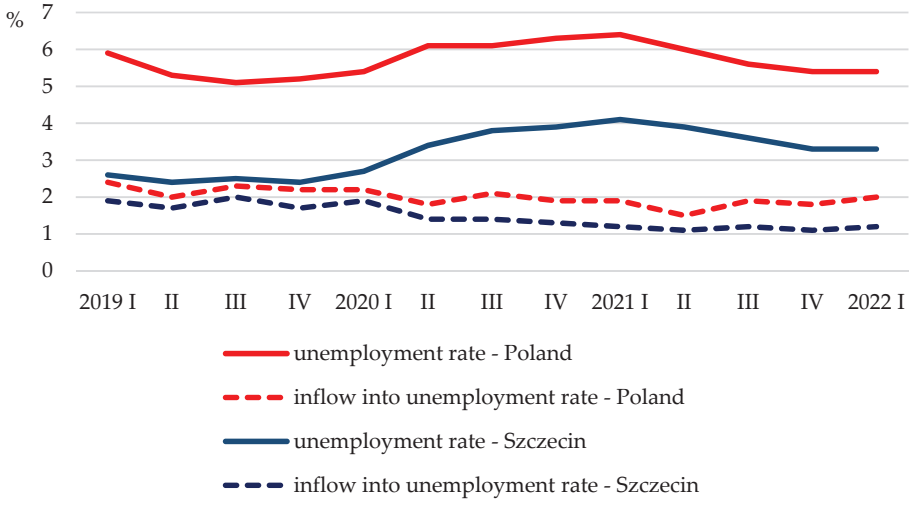

Figure 3. Registered unemployment rate and inflow into unemployment in Poland and in Szczecin in the quarters of 2019–2022. Statistics Poland. Source: own elaboration on the basis of data from Database—Local Data Bank (https://stat.gov.pl/en, accessed on 1 June 2022).

In fact, when comparing the inflow into and outflow from unemployment, we can see a clear predominance of inflow and a reduction in outflow in Q2 2020 in Poland (Figure 4). This was also the case in Szczecin and throughout 2020 until Q1 2021 (Figure 5). Thus, during the COVID-19 pandemic, the inflow of unemployed people did not increase, but the outflow from unemployment decreased markedly. It became more difficult to obtain work.

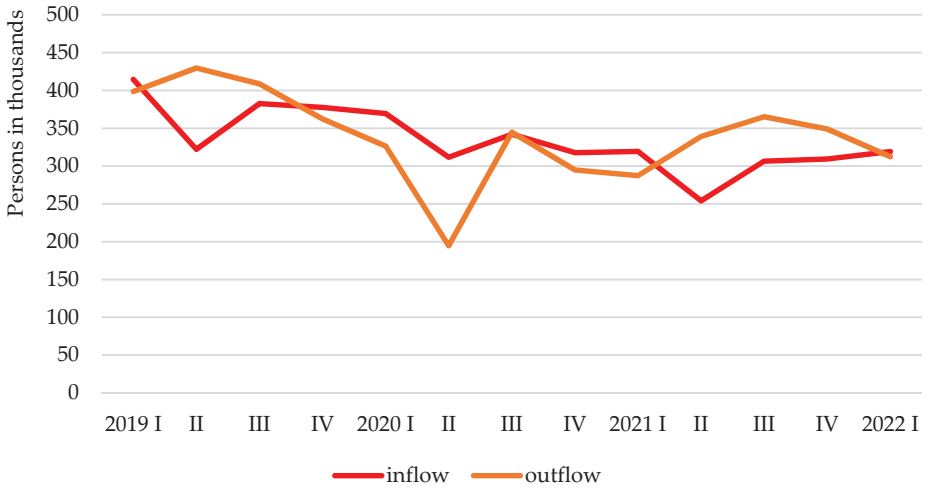

Figure 4. Inflow into and outflow from unemployment in Poland in the quarters of 2019–2022. Source: own elaboration on the basis of data from Statistics Poland—Registered unemployment quarters 2019, 2020, 2021, and 2022 (https://stat.gov.pl/en, accessed on 1 June 2022).

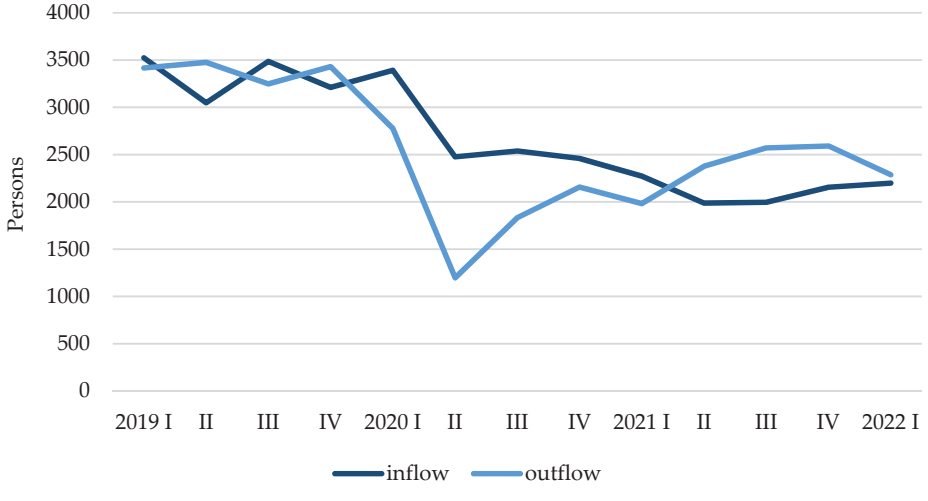

Figure 5. Inflow into and outflow from unemployment in Szczecin in the quarters of 2019–2022, Source: own elaboration on the basis of data from Statistics Poland—Registered unemployment quarters 2019, 2020, 2021, and 2022 (https://stat.gov.pl/en, accessed on 1 June 2022).

In the second stage of the study, we obtained the Kaplan–Meier estimators for persons deregistered from the labour office in subsequent quarters. As a result, 13 survival curves were obtained. From these, the duration quartiles were determined (Figure 6). Figure 7 shows the estimators of the survival curves for the selected quarters (for better clarity of the figure): the first (I/2019) and last (I/2022) and for III/2019 and II/2020 (specific results). In quarter III/2019, there was an increase in the median and third quartile of duration. Quarter II/2020 had the lowest median and third quartile of duration values.

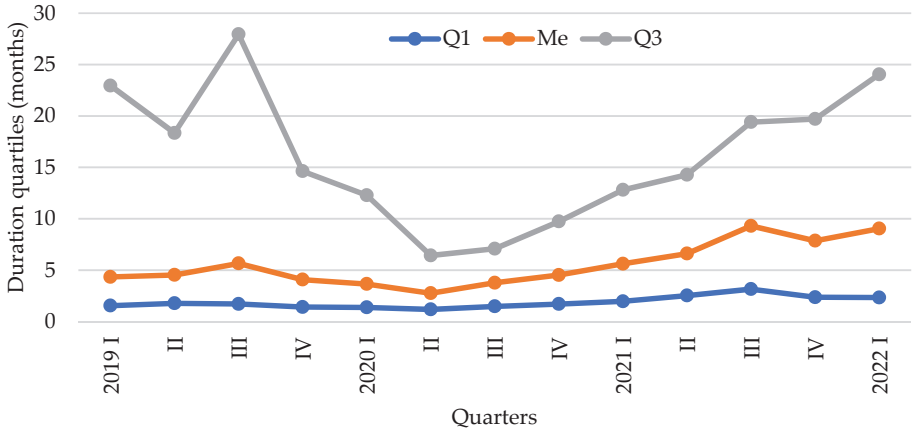

Figure 6. Duration quartiles.

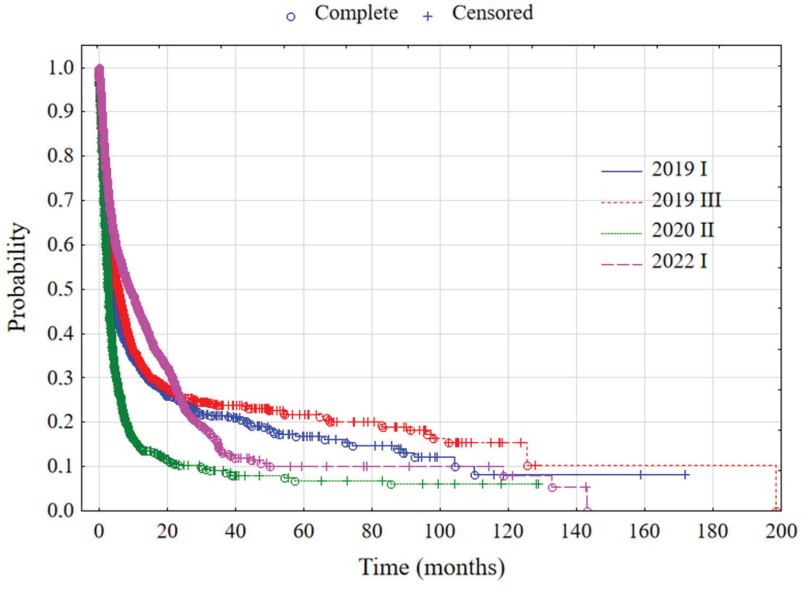

Figure 7. Kaplan–Meier estimators for deregistered persons in the following quarters: 2019 I, 2019 III, 2020 II, and 2022 I.

In the second stage of the study, the obtained survival curves were also compared pairwise. Two tests were used for this purpose: the log-rank test and the Gehan's test. The first test allowed for the comparison of the duration curves over their entire course. In most cases, the differences between them were statistically significant. This shows that the situation of the registered unemployed was not stable over the analysed period. The probability of exiting unemployment changed from quarter to quarter. The Gehan's test allowed for the comparison of the duration curves over the initial duration period. This test produced similar results. We have presented the results of both tests in Table 2. In several cases, the log-rank test showed no significant differences in the duration curves, while the Gehan's test showed differences. It follows that in these cases, the probability of exiting unemployment for the long-term unemployed did not differ.

Table 2. Log-rank test and Gehan's test (in parentheses) for pairs of survival curves.

Quarters	I 2019	II 2019	III 2019	IV 2019	I 2020	II 2020	III 2020	IV 2020	I 2021	II 2021	III 2021	IV 2021	I 2022
I 2019	x	- (*)	*** (**)	** (-)	*** (***)	*** (***)	*** (***)	*** (-)	- (***)	** (***)	*** (***)	*** (***)	*** (***)
II 2019	- (*)	x	** (-)	*** (***)	*** (***)	*** (***)	*** (***)	*** (-)	- (**)	** (***)	*** (***)	*** (***)	*** (***)
III 2019	*** (**)	** (-)	x	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (-)	- (***)	*** (***)	* (***)	*** (***)
IV 2019	** (-)	*** (***)	*** (***)	x	** (*)	*** (***)	*** (***)	*** (-)	- (***)	*** (***)	*** (***)	*** (***)	*** (***)
I 2020	*** (***)	** (***)	** (***)	** (*)	x	*** (***)	*** (-)	- (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)
II 2020	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	x	* (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)
III 2020	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	* (***)	x	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)
IV 2020	*** (-)	*** (-)	*** (***)	*** (-)	- (***)	*** (***)	*** (***)	x	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)
I 2021	- (***)	- (**)	*** (-)	- (***)	*** (***)	*** (***)	*** (***)	*** (***)	x	*** (***)	*** (***)	*** (***)	*** (***)
II 2021	** (***)	** (***)	- (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	x	*** (***)	*** (*)	*** (***)
III 2021	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	x	*** (***)	- (***)
IV 2021	** (***)	** (***)	* (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (*)	*** (***)	x	*** (-)
I 2022	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	*** (***)	- (***)	*** (-)	x

Note: *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively; -, (-) denote lack of significance; x—not applicable.

The third stage of the study is the assessment of the intensity of deregistration of the unemployed in individual subgroups, i.e., the unemployed that deregistered from the labour office in Szczecin in the subsequent quarters of the years 2019–2022. In this part of the analysis, an empirical hazard (formula 4) was applied, which indicates the intensity of taking up work by the existing unemployed in the subsequent months of unemployment. The starting point was the determination of cohort tables of the duration of unemployment for the established subgroups. These assumed monthly intervals. Therefore, the determined hazards values indicate the intensity of exiting from unemployment. It is the ratio of the number of people deregistered due to taking a job in a given duration interval of unemployment to the number of unemployed in the middle of the interval (the number exposed to the defined event). Thus, the more people who take up work, the higher the value of the empirical hazard. In Figure 8, the determined empirical hazard in the first 12 months of unemployment for the subgroups according to the quarter of deregistration of the unemployed from the register is presented. These first 12 months are a period of short-term unemployment, which is a period of intensive job search by the unemployed person. In general, discouragement due to a long search, nervousness, or frustration does not yet appear at that time. When analysing the magnitude of the hazard for individual subgroups, it is important to note the predominance of its values for two subgroups. It turns out that the unemployed deregistered in Q2 2020 in the first five months of unemployment were characterised by a higher intensity of taking up work, while from the sixth to ninth months, the advantage applied to the unemployed deregistered in Q3 2020. Therefore, it can be concluded that in the period of the beginning of the pandemic, when the spread of the virus was already confirmed and the future of the economy was

uncertain, the unemployed were quicker to decide to take up the job offered by the office. It seems that the spectre of a worsening situation in the labour market caused the acceleration of decisions among the unemployed.

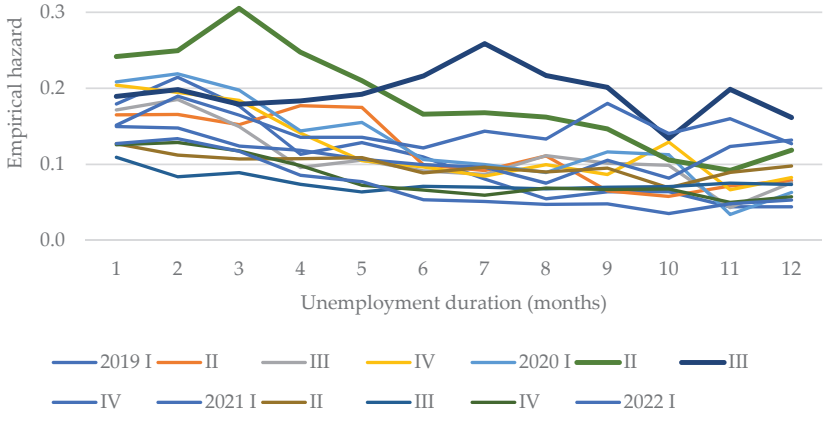

Figure 8. Empirical hazard in the first 12 months of unemployment for subgroups of the unemployed deregistered in particular quarters in 2019–2022 in Szczecin.

As already indicated, the hazard values were analysed precisely for the first twelve months of unemployment. After the first year, i.e., entering long-term unemployment, no major differences in the magnitude of the hazards were noticeable. However, the average monthly hazards (formula 5) were determined for the entire duration of unemployment of the individuals in each subgroup. The results are presented in Figure 9. This confirmed that the highest intensity of taking up a job was experienced by those deregistered in Q2 2020, regardless of the duration of their unemployment.

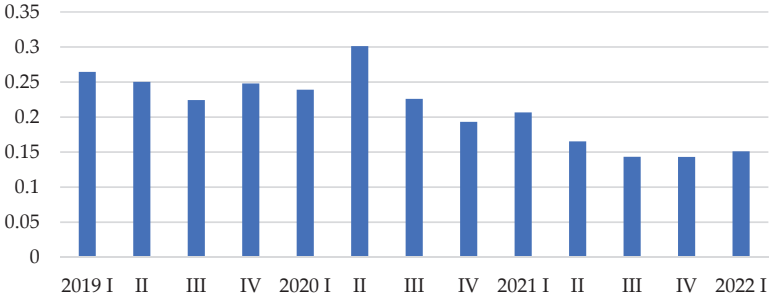

Figure 9. Average monthly hazard for subgroups of the unemployed deregistered by quarters 2019–2022 in Szczecin.

5. Discussion

The results of the research carried out did not confirm the proposed hypotheses. It is true that the unemployment rate in Szczecin increased at the beginning of 2020. This was an obvious consequence of the emergence of the health crisis, but the increase was not as large as might have been expected. Very importantly, it turned out that the duration of unemployment for those in the Q1 2020 cohort (the deregistration period) was not longer, as assumed in *H2*, but was actually shorter. In addition, there was a slight increase in the intensity of taking up work in the first five months of unemployment (in *H3*, we assumed the opposite). Thus, the study did not fully confirm the negative impact of the pandemic on the situation of the unemployed. It appeared that in a difficult and unexpected economic situation, the unemployed were quicker to decide to accept a job offered by the office. The

threat of a worsening situation in the labour market, likely alongside fewer opportunities to work in the grey economy, influenced the acceleration of decisions among the unemployed.

Cortes and Forsythe [41] also indicate that the influence of the COVID-19 pandemic on the labour market is heterogeneous in the United States. This heterogeneity applies to various occupations and industries as well as demographic subgroups. The authors concluded that the pandemic has had the effect of exacerbating pre-existing inequalities. Lofton et al. [69] highlight the particularly difficult situation of mothers in the labour market during the pandemic (due to school closures). According to Groshen [70], the impact of the pandemic on the labour market in the U.S. was significant. The initial shock was very abrupt and deep by all historical standards. The author used two indicators, the national unemployment rate and the change in payroll jobs, in the study. The COVID-19 pandemic has had a particularly strong impact on the tourism sector. It has affected the countries of the Mediterranean area to the highest degree. In addition to the high number of infections and deaths, there have been significant economic losses in the region [71]. The impact of the COVID-19 pandemic on the labour market has encouraged many scientists to examine and quantify its consequences in this area. The literature mainly presents macroeconomic analyses. There is a lack of studies aimed at examining the impact on the labour market in the individual municipalities. In addition, Kotera and Schmittman [72] used macro and micro data to study the labour market. They concluded that the pandemic in Japan had a large negative impact on employment, labour force participation, earnings, and labour market mobility. Our research is also part of this trend, and it concerns the labour market of smaller areas of the country (regarding the specifics of business and demographic characteristics). It is the peculiarities of both the local and national labour markets that are important in the processes of response and adaptation in a pandemic situation [73,74]. Zieliński [75] analysed the impact of the pandemic on the labour market in the Visegrad Group (V4) countries, including the Polish labour market. He compared the years 2018–2019 to 2020–2021, and the results of his study coincide with our observations. He showed that the pandemic affected labour market imbalances relatively moderately. Importantly, it stopped the trend of decreasing unemployment rates observed in all V4 countries in 2018–2019. The highest unemployment rate in Poland in Q1 2021 corresponded to the lowest number of hours worked per week (usual weekly hours of work). Poland experienced a return to pre-pandemic unemployment rates in Q4 2021.

The speed at which jobs are taken up during a pandemic depends on the type of job. Research indicates that the greatest negative impact of a pandemic is on the catering industry and sales and customer service jobs. In contrast, jobs in warehousing and transport may increase as a result of the increase in e-commerce and the delivery of goods to customers [76]. The research shows that in Australia and Canada, the increase in the number of vacancies being posted online mentioning 'work from home' arrangements was especially strong [77].

Losing a job or not being able to obtain one are particularly acute situations during a crisis. The pandemic fuels unemployment, whose source is usually exogenous to the individual and can affect mental health [78]. The fear of a difficult situation may mobilise individuals to intensify their job search and to accept any kind of job.

Different findings from ours are presented by Hensvik et al. [79]. According to these authors, the COVID-19 pandemic particularly affected labour markets. There was a sharp increase in unemployment and a decline in job vacancies. Depending on how the intensity of job search changes after the shock, the supply side of the labour market may exacerbate or mitigate the effects of the shock on the demand for labour. The authors analysed how jobseekers in Sweden adjusted the intensity and direction of their search at the onset of the crisis. They found that job search intensity fell by 40% in March and April 2020 and returned to its previous level in July 2020. They explain the drop in search intensity by a decline in the number of vacancies and by fears of illness on the part of both employers and potential employees (the Swedish government's preventive measures were extremely mild). According to Sheldon [80], unique to the current crisis in Switzerland is the sharp upsurge in both

the incidence and duration of unemployment. These two variables have never increased so quickly in such a short period. Hensvik et al. [79], similarly to Bernstein et al. [81], indicate a change of direction with respect to job searches. Both studies point to the phenomenon of 'a flight to safety in labour market' occurring during a health crisis. Small firms or self-employment are less frequently chosen as places/forms of work. We also find that the increase in the intensity of the unemployed taking up work during the pandemic is a result of changes in the direction of the search for employment. Many companies are closing down or scaling back their operations, new entrepreneurial initiatives are not being created, and there is a lack of casual or informal work. This contributes to a greater propensity to accept jobs in the office.

6. Conclusions

Our study confirmed the findings of other researchers who found that the impact of the pandemic on the labour market had not been unequivocal and varied according to the economic situation of the country studied. This is also highlighted by the authors of The Sustainable Development Goals Report 2022. Developed economies are experiencing a more robust recovery. Of particular concern is the confluence of crises, dominated by COVID-19, climate change, and conflicts. Research conducted by Statistics Poland [82] shows a decline in labour demand in 2020 and a large increase in 2021. This shows that the initial uncertainty associated with the outbreak of the pandemic was contained fairly quickly. However, we must emphasise here that the Polish labour market in 2022 and beyond will be influenced by current political and economic events. How this will affect the Szczecin labour market will only become apparent in a few months' time. This will be a stimulus for us to conduct further research.

The limitation of our study was the use of data from only one large city, Szczecin. However, due to the state policy, regional analyses are more important than an overall analysis (concerning Poland as a whole). We must point out that the applied survival analysis methods require the use of individual data. Public statistics only provide aggregated data. Therefore, the added value of our study is the acquisition of such data and their use in the study of registered unemployment. On the other hand, another advantage of the methods we have chosen is the possibility of using the censored data.

The obtained empirical results may prove valuable for scientists interested in the influence of the pandemic on the labour market. These analyses are also important for political decision-makers involved in the efforts of mitigating the negative effects of the COVID-19 pandemic within national and regional economic systems. The study presented here could also be useful in the effort to refine the theoretical approach to the economic crisis caused by the spread of the virus. Our research showed that the registered unemployed took up work relatively quickly, but there are always people on the registers who often move into long-term unemployment. Political decision-makers can reduce the negative impact of COVID-19 on the unemployed by promoting more training and active labour market policies to facilitate their return to work at a decent job, which would be particularly beneficial for those who have been unemployed for a long-term. The study presented here could also be useful in the effort to refine the theoretical approach to the economic crisis caused by the spread of the virus.

After a significant increase at the start of the pandemic, unemployment is falling in many OECD countries [83]. However, unemployment is projected to be higher in most of them than before the crisis. However, in the context of this pandemic and the accompanying labour market policies, unemployment alone provides only a partial picture. In the early phases of the crisis, a large number of people withdrew from the labour market due to constraints on their job search and the increased burden of their household responsibilities. At the same time, many people who maintained employment experienced a reduction in working hours (job retention programmes). It is warned that in the future, many of the workers most affected by the pandemic may find it difficult to return to their previous jobs due to a lack of appropriate skills (e.g., due to new technologies in

production). Support in the form of upskilling and retraining is needed to ensure that the recovery is socially inclusive. An interesting solution is the introduction of a temporary increase in unemployment benefits in Sweden [79]. This is certainly a large help for the people in difficult situations, but it is a solution for wealthy countries. The full impact of the crisis on the labour market is not yet behind us [83]. There is, therefore, a need for continued labour market research. Medical sources point to the possibility of further waves of pandemics, although we expect these to be much smaller in scope due to the prevalence of vaccination and treatment experience. We will also observe changes that are driven by the experience of entrepreneurs, such as the increased prominence of e-commerce at the expense of traditional trade.

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References

1. The Sustainable Development Goals Report 2021. Available online: https://unstats.un.org/sdgs/report/2021/ (accessed on 30 May 2022).
2. Nundy, S.; Ghosh, A.; Mesloub, A.; Albaqawy, G.A.; Alnaim, M.M. Impact of COVID-19 pandemic on socio-economic, energy-environment and transport sector globally and sustainable development goal (SDG). *J. Clean. Prod.* **2021**, *312*, 127705. [CrossRef]
3. Eichhorst, W.; Marx, P.; Rinne, U. Manoeuvring Through the Crisis: Labour Market and Social Policies during the COVID-19 Pandemic. *Intereconomics* **2020**, *55*, 375–380. [CrossRef]
4. The Sustainable Development Goals Report 2022. Available online: https://unstats.un.org/sdgs/report/2022/ (accessed on 30 May 2022).
5. Fenner, R.; Cernev, T. The implications of the COVID-19 pandemic for delivering the Sustainable Development Goals. *Futures* **2021**, *128*, 102726. [CrossRef] [PubMed]
6. Begum, H.; Alam, A.S.A.F.; Leal Filho, W.; Awang, A.H.; Ghani, A.B.A. The COVID-19 Pandemic: Are There Any Impacts on Sustainability? *Sustainability* **2021**, *13*, 11956. [CrossRef]
7. Pavolová, H.; Čulková, K.; Šimková, Z. Influence of COVID-19 Pandemic on the Economy of Chosen EU Countries. *World* **2022**, *3*, 672–680. [CrossRef]
8. Abrhám, J.; Vošta, M. Impact of the COVID-19 Pandemic on EU Convergence. *J. Risk Financ. Manag.* **2022**, *15*, 384. [CrossRef]
9. Delardas, O.; Kechagias, K.S.; Pontikos, P.N.; Giannos, P. Socio-Economic Impacts and Challenges of the Coronavirus Pandemic (COVID-19): An Updated Review. *Sustainability* **2022**, *14*, 9699. [CrossRef]
10. Ghecham, M.A. The Impact of COVID-19 on Economic Growth of Countries: What Role Has Income Inequality in It? *Economies* **2022**, *10*, 158. [CrossRef]
11. Alibegovic, M.; Cavalli, L.; Lizzi, G.; Romani, I.; Vergalli, S. COVID-19 & SDGs: Does the Current Pandemic Have an Impact on the 17 Sustainable Development Goals? A Qualitative Analysis. *FEEM Brief*. 16 October 2020. Available online: https://www.feem.it/m/publications_pages/brief07-2020.pdf. (accessed on 20 June 2022).
12. Gavriluță, N.; Grecu, S.-P.; Chiriac, H.C. Sustainability and Employability in the Time of COVID-19. Youth, Education and Entrepreneurship in EU Countries. *Sustainability* **2022**, *14*, 1589. [CrossRef]
13. Lee, C.-T.; Hu, J.-L.; Kung, M.-H. Economic Resilience in the Early Stage of the COVID-19 Pandemic: An Across-Economy Comparison. *Sustainability* **2022**, *14*, 4609. [CrossRef]
14. Lee, S.; Schmidt-Klau, D.; Verick, S. The Labour Market Impacts of the COVID-19: A Global Perspective. *Ind. J. Labour Econ.* **2020**, *63*, 11–15. [CrossRef] [PubMed]

15. Nivakoski, S.; Mascherini, M. Gender Differences in the Impact of the COVID-19 Pandemic on Employment, Unpaid Work and Well-Being in the EU. *Inter. Econ.* **2021**, *56*, 254–260. [CrossRef] [PubMed]
16. Statistics Poland. *Selected Aspects of the Labour Market in Poland. Economic Activity of the Population before and during the COVID-19 Pandemic Period*; Statistics Poland: Warsaw, Poland, 2021.
17. Kufel, T. ARIMA-based forecasting of the dynamics of confirmed Covid-19 cases for selected European countries. *Equilib. Q. J. Econ. Econ. Policy* **2020**, *15*, 181–204. [CrossRef]
18. Aristodemou, K.; Buchhass, L.; Claringbould, D. The COVID-19 crisis in the EU: The resilience of healthcare systems, government responses and their socio-economic effects. *Eurasian Econ. Rev.* **2021**, *11*, 251–281. [CrossRef]
19. Ehnts, D.; Paetz, M. COVID-19 and its economic consequences for the Euro Area. *Eurasian Econ. Rev.* **2021**, *11*, 227–249. [CrossRef]
20. Islam, M.M.; Jannat, A.; Al Rafi, D.A.; Aruga, K. Potential Economic Impacts of the COVID-19 Pandemic on South Asian Economies: A Review. *World* **2020**, *1*, 283–299. [CrossRef]
21. Landmesser, J. The use of the dynamic time warping (DTW) method to describe the COVID-19 dynamics in Poland. *Oeconomia Copernic.* **2021**, *12*, 539–556. [CrossRef]
22. Hála, M.; Cvik, E.; MacGregor Pelikánová, R. Logistic Regression of Czech Luxury Fashion Purchasing Habits during the COVID-19 Pandemic—Old for Loyalty and Young for Sustainability? *Folia Oeconomica Stetin.* **2022**, *22*, 85–110. [CrossRef]
23. Machová, R.; Korcsmáros, E.; Marča, R.; Esseová, M. An International Analysis of Consumers' Consciousness during the COVID-19 Pandemic in Slovakia and Hungary. *Folia Oeconomica Stetin.* **2022**, *22*, 130–151. [CrossRef]
24. Magwedere, M.; Marozva, G. The Nexus between Bank Credit Risk and Liquidity: Does the COVID-19 Pandemic Matter? A Case of the Oligopolistic Banking Sector. *Folia Oeconomica Stetin.* **2022**, *22*, 152–171. [CrossRef]
25. Musa, H.; Rech, F.; Yan, C.; Musova, Z. The Deterioration of Financial Ratios during the COVID-19 Pandemic: Does Corporate Governance Matter? *Folia Oeconomica Stetin.* **2022**, *22*, 219–242. [CrossRef]
26. Liu, N.; Xu, Z.; Skare, M. The research on COVID-19 and economy from 2019 to 2020: Analysis from the perspective of bibliometrics. *Oeconomia Copernicana* **2021**, *12*, 217–268. [CrossRef]
27. Markowicz, I.; Rudawska, I. Struggling with COVID-19—A Framework for Assessing Health System Performance. *Sustainability* **2021**, *13*, 11146. [CrossRef]
28. Susu, S. The impact of the COVID-19 pandemic on the financial performance and price of the shares of the energy and fuel companies listed on the main segment of the Bucharest Stock Exchange. *USV Ann. Econ. Public Adm.* **2021**, *21*, 27–36.
29. Bieszk-Stolorz, B.; Markowicz, I. Decline in Share Prices of Energy and Fuel Companies on the Warsaw Stock Exchange as a Reaction to the COVID-19 Pandemic. *Energies* **2021**, *14*, 5412. [CrossRef]
30. Mikołajczak, P. What affects employment by NGOs? Counteraction to precarious employment in the Polish non-profit sector in the perspective of COVID-19 pandemic crises. *Oeconomia Copernic.* **2021**, *12*, 761–788. [CrossRef]
31. Svabova, L.; Tesarova, E.N.; Durica, M.; Strakova, L. Evaluation of the impacts of the COVID-19 pandemic on the development of the unemployment rate in Slovakia: Counterfactual before-after comparison. *Equilib. Q. J. Econ. Econ. Policy* **2021**, *16*, 261–284. [CrossRef]
32. Adamowicz, M. COVID-19 Pandemic as a Change Factor in the Labour Market in Poland. *Sustainability* **2022**, *14*, 9197. [CrossRef]
33. Hassan, S.M.; Riveros Gavilanes, J.M. First to React Is the Last to Forgive: Evidence from the Stock Market Impact of COVID 19. *J. Risk Financial Manag.* **2021**, *14*, 26. [CrossRef]
34. Bieszk-Stolorz, B.; Dmytrów, K. A survival analysis in the assessment of the influence of the SARS-CoV-2 pandemic on the probability and intensity of decline in the value of stock indices. *Eurasian Econ. Rev.* **2021**, *11*, 363–379. [CrossRef]
35. Pirgaip, B. Pan(dem)ic reactions in Turkish stock market: Evidence from share repurchases. *Eurasian Econ. Rev.* **2021**, *11*, 381–402. [CrossRef]
36. Nagaj, R.; Žuromskaitė, B. Tourism in the Era of COVID-19 and Its Impact on the Environment. *Energies* **2021**, *14*, 2000. [CrossRef]
37. Škare, M.; Riberio Soriano, D.; Porada-Rochoń, M. Impact of COVID-19 on the travel and tourism industry. *Technol. Forecast. Soc. Chang.* **2021**, *163*, 120469. [CrossRef] [PubMed]
38. Rakha, A.; Hettiarachchi, H.; Rady, D.; Gaber, M.M.; Rakha, E.; Abdelsamea, M.M. Predicting the Economic Impact of the COVID-19 Pandemic in the United Kingdom Using Time-Series Mining. *Economies* **2021**, *9*, 137. [CrossRef]
39. Barlow, J.; Vodenska, I. Socio-Economic Impact of the COVID-19 Pandemic in the U.S. *Entropy* **2021**, *23*, 673. [CrossRef]
40. Oncioiu, I.; Duca, I.; Postole, M.A.; Georgescu, G.C.; Gherghina, R.; Grecu, R.-A. Transforming the COVID-19 Threat into an Opportunity: The Pandemic as a Stage to the Sustainable Economy. *Sustainability* **2021**, *13*, 2088. [CrossRef]
41. Cortes, G.M.; Forsythe, E.C. *The Heterogeneous Labor Market Impacts of the COVID-19 Pandemic*; Upjohn Institute Working Paper 20–327; W.E. Upjohn Institute for Employment Research: Kalamazoo, MI, USA, 2020. [CrossRef]
42. Blustein, D.L.; Duffy, R.; Ferreira, J.A.; Cohen-Scali, V.; Cinamon, R.G.; Allan, B.A. Unemployment in the time of COVID-19: A research agenda. *J. Vocat. Behav.* **2020**, *119*, 103436. [CrossRef]
43. Antipova, A. Analysis of the COVID-19 impacts on employment and unemployment across the multi-dimensional social disadvantaged areas. *Soc. Sci. Humanit. Open* **2021**, *4*, 100224. [CrossRef]
44. Su, C.-W.; Dai, K.; Ullah, S.; Andlib, Z. COVID-19 pandemic and unemployment dynamics in European economies. *Econ. Res.-Ekon. Istraživanja* **2021**, *35*, 1752–1764. [CrossRef]
45. Botha, F.; De New, J.P.; De New, S.C.; Ribar, D.C.; Salamanca, N. Implications of COVID-19 labour market shocks for inequality in financial wellbeing. *J. Popul. Econ.* **2021**, *34*, 655–689. [CrossRef]

46. Mamgain, R.P. Understanding labour market disruptions and job losses amidst COVID-19. *J. Soc. Econ. Dev.* **2021**, *23*, 301–319. [CrossRef] [PubMed]
47. Edwards, R.; Essien, L.S.; Levinstein, M.D. U.S. labor market shows improvement in 2021, but the COVID-19 pandemic continues to weigh on the economy. In *Monthly Labor Review*; U.S. Bureau of Labor Statistics: Washington, DC, USA, June 2022. [CrossRef]
48. Gherghina, S.C.; Botezatu, M.A.; Simionescu, L.N. Exploring the Impact of Electronic Commerce on Employment Rate: Panel Data Evidence from European Union Countries. *J. Theor. Appl. Electron. Commer. Res.* **2021**, *16*, 3157–3183. [CrossRef]
49. Bieszk-Stolorz, B.; Dmytrów, K. Influence of Accession of the Visegrad Group Countries to the EU on the Situation in Their Labour Markets. *Sustainability* **2020**, *12*, 6694. [CrossRef]
50. Dmytrów, K.; Bieszk-Stolorz, B. Comparison of changes in the labour markets of post-communist countries with other EU member states. *Equilib. Q. J. Econ. Econ. Policy* **2021**, *16*, 741–764. [CrossRef]
51. Bąk, I.; Wawrzyniak, K.; Sobolewski, A. Classification of District Employment Agencies in Terms of Employment and Cost-Effectiveness Using Regression Trees. *Folia Oeconomica Stetin.* **2020**, *20*, 20–35. [CrossRef]
52. Dmytrów, K.; Bieszk-Stolorz, B. Mutual relationships between the unemployment rate and the unemployment duration in the Visegrad Group countries in years 2001–2017. *Equilib. Q. J. Econ. Econ. Policy* **2019**, *14*, 129–148. [CrossRef]
53. GUS. *Wpływ Epidemii COVID-19 na Wybrane Elementy Rynku Pracy w Polsce w I, II, III i IV Kwartale 2020 r. i w I kwartale 2021 r*; GUS: Warszawa, Poland, 2021.
54. Cajner, T.; Crane, L.D.; Decker, R.A.; Grigsby, J.; Hamins-Puertolas, A.; Hurst, E.; Kurz, C.; Yildirmaz, A. *The U.S. Labor Market during the Beginning of the Pandemic Recession*; NBER Working Paper Series; National Bureau of Economic Research: Cambridge, MA, USA, 2020; Volume 27159. Available online: http://www.nber.org/papers/w27159. (accessed on 20 September 2022).
55. Svabova, L.; Metzker, Z.; Pisula, T. Development of unemployment in Slovakia in the context of the COVID-19 pandemic. *Ekon. -Manaz. Spectr.* **2020**, *14*, 114–123. [CrossRef]
56. Foryś, I. The Cox Proportional Hazards Model in the Analysis of Property Transactions. *Folia Oeconomica Stetin.* **2010**, *8*, 71–81. [CrossRef]
57. Putek-Szeląg, E.; Gdakowicz, A. Application of Duration Analysis Methods in the Study of the Exit of a Real Estate Sale Offer from the Offer Database System. In *Data Analysis and Classification. SKAD 2020. Studies in Classification, Data Analysis, and Knowledge Organization*; Jajuga, K., Najman, K., Walesiak, M., Eds.; Springer: Cham, Switzerland, 2021. [CrossRef]
58. Markowicz, I. Duration Analysis of Firms—Cohort Tables and Hazard Function. *Int. J. Bus. Soc. Res.* **2015**, *5*, 36–47. [CrossRef]
59. Urbańczyk, D.M. Competing Risks Models for an Enterprises Duration on the Market. *Folia Oeconomica Stetin.* **2020**, *20*, 456–473. [CrossRef]
60. Markowicz, I.; Baran, P. Duration of Trade Relationships of Polish Enterprises on the Intra-Community Market: The Case of Vehicles and Automotive Parts Trade. *Sustainability* **2022**, *14*, 3599. [CrossRef]
61. Han, A.; Hausman, J.A. Flexible Parametric Estimation of Duration and Competing Risk Models. *J. Applied. Econom.* **1990**, *5*, 1–28. [CrossRef]
62. Birau, F.R.; Dănăcică, D.-E.; Spulbar, C.M. Social Exclusion and Labor Market Integration of People with Disabilities. A Case Study for Romania. *Sustainability* **2019**, *11*, 5014. [CrossRef]
63. Kleinbaum, D.G.; Klein, M. *Survival Analysis. A Self-Learning Text*, 3rd ed.; Springer: New York, NY, USA, 2012. [CrossRef]
64. Kaplan, E.L.; Meier, P. Nonparametric estimation from incomplete observations. *J. Am. Stat. Assoc.* **1958**, *53*, 457–481. [CrossRef]
65. Latta, R.B. A Monte Carlo study of some two-sample rank tests with censored data. *J. Am. Stat. Assoc.* **1981**, *76*, 713–719. [CrossRef]
66. Stevenson, M. *An Introduction to Survival Analysis*; EpiCentre, IVABS, Massey University: Palmerston North, New Zealand, 2009. Available online: http://www.massey.ac.nz/massey/fms/Colleges/College%20of%20Sciences/Epicenter/docs/ASVCS/Stevenson_survival_analysis_195_721.pdf (accessed on 15 June 2022).
67. Markowicz, I. Analysis of the risk of liquidation depending on the age of the company: A study of entities established in Szczecin in period 1990–2010. *Econometrics* **2019**, *23*, 49–62. [CrossRef]
68. Shin, K.; Park, G.; Choi, J.Y.; Choy, M. Factors Affecting the Survival of SMEs: A Study of Biotechnology Firms in South Korea. *Sustainability* **2017**, *9*, 108. [CrossRef]
69. Lofton, O.; Petrosky-Nadeau, N.; Seitelman, L. Parents in a Pandemic Labor Market. *Fed. Reserve Bank San Fr. Work. Pap.* **2021**, *4*. [CrossRef]
70. Groshen, E.L. COVID-19's impact on the U.S. labor market as of September 2020. *Bus. Econ.* **2020**, *55*, 213–228. [CrossRef]
71. Raimo, N.; Martínez-Córdoba, P.-J.; Benito, B.; Vitolla, F. The Impact of the COVID-19 Pandemic on the Labor Market: An Analysis of Supply and Demand in the Spanish Municipalities. *Sustainability* **2021**, *13*, 12996. [CrossRef]
72. Kotera, S.; Schmittman, J.M. The Japanese Labor Market during the COVID-19 Pandemic. *IMF Work. Paper*. 2022. WP/22/89. Available online: https://www.imf.org/-/media/Files/Publications/WP/2022/English/wpiea2022089-print-pdf.ashx (accessed on 30 May 2022).
73. Palomino, J.C.; Rodríguez, J.G.; Sebastián, R. Wage inequality and poverty effects of lockdown and social distancing in Europe. *Eur. Econ. Rev.* **2020**, *129*, 103564. [CrossRef] [PubMed]
74. Barrot, J.N.; Grassi, B.; Sauvagnat, J. Sectoral effects of social distancing. *AEA Pap. Proc.* **2021**, *111*, 277–281. [CrossRef]
75. Zieliński, M. The Effect of the COVID-19 Pandemic on the Labor Markets of the Visegrad Countries. *Sustainability* **2022**, *14*, 7386. [CrossRef]

76. McKinsey Global Institute, the Postpandemic Economy the Future of Work after COVID-19, Report 2021. Available online: https://www.mckinsey.com/mgi (accessed on 20 September 2022).
77. OECD. An Assessment of the Impact of COVID-19 on Job and Skills Demand Using Online Job Vacancy Data. 2021. Available online: http://www.oecd.org/coronavirus (accessed on 20 September 2022).
78. Posel, D.; Oyenubi, A.; Kollamparambil, U. Job loss and mental health during the COVID-19 lockdown: Evidence from South Africa. *PLoS ONE* **2021**, *16*, e0249352. [CrossRef] [PubMed]
79. Hensvik, L.; Le Barbanchon, T.; Rathelot, R. Job search during the COVID-19 crisis. *J. Public Econ.* **2021**, *194*, 104349. [CrossRef]
80. Sheldon, G. Unemployment in Switzerland in the wake of the COVID-19 pandemic: An intertemporal perspective. *Swiss J. Econ. Stat.* **2020**, *156*, 8. [CrossRef]
81. Bernstein, S.; Townsend, R.R.; Xu, T. *Flight to Safety: How Economic Downturns Affect Talent Flows to Startups*; Working Paper No. 27907; National Bureau of Economic Research: Cambridge, MA, USA, 2020. Available online: http://www.nber.org/papers/w27907 (accessed on 20 September 2022).
82. Statistics Poland. *The Demand for Labour in 2021*; Statistical Office in Bydgoszcz: Warszawa, Poland; Bydgoszcz, Poland, 2022.
83. OECD. *OECD Employment Outlook 2021: Navigating the COVID-19 Crisis and Recovery*; OECD Publishing: Paris, France, 2021. [CrossRef]

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Review

Working from Home, Telework, and Psychological Wellbeing? A Systematic Review

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Abstract: The practice of telework, remote work, and working from home has grown significantly across the pandemic era (2020+). These practices offer new ways of working but come with a lack of clarity as to the role it plays in supporting the wellbeing of staff. (1) Background: The purpose of this study is to examine the current literature on wellbeing outcomes and effects of telework; (2) Methods: This study adopts a systematic literature review from 2000–2022 using the PRISMA approach and thematic analysis guided by the United Nations Sustainable Development Goals (Wellbeing, Decent Work, Gender Equality, and Inclusive Production); (3) Results: It was evident that there is a lack of clarity on the actual effects of telework on employee wellbeing, but it appeared that it had a generally positive effect on the short-term wellbeing of staff, and created more flexible and proactive work design opportunities; (4) Conclusions: There is a need for more targeted research into work designs that support wellbeing and productivity of staff, and consider the environmental sustainability changes from reduced office and onsite work and increased working from home.

Keywords: remote work; telework; systematic literature review; work design; workforce planning

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1. Introduction

Telework and working from home have become necessary tools in the organization's arsenal for combatting the COVID-19 pandemic. The concept, while not a direct product of the global outbreak has moved from the periphery to the fore of work and organizing. Full time work before 2019 was typically situated in offices and workplaces onsite, with only 3.6 percent of U.S. workers and 5.4 percent of European workers required to work from home [1]. Gallup [2] finds that 37 percent of U.S. workers had engaged in some form of telecommuting within their roles, with 32 percent in 2006, and only 9 percent in 1995. In 2013, the CEO of Yahoo, Marissa Mayer, made it company policy for staff to work inside of the corporate office, and prior to 2020 this was a common position for organizations to adopt.

Indeed, studies on the nature of work, have primarily emphasized on-site work with after-hours answering of emails and international teleconferencing a secondary concern [3]. Yet, working from home is quite different than formal practices of arriving at a previously designated time, occupying a professional workspace to complete daily work, and a recommended end time for departure. Across forty in-depth interviews, teleworkers created physical, temporal, behavioral, and communicative boundaries to enable them to separate work and life [4]. Yet, the authors acknowledge that these boundaries may not be transferable to 'always on' workplaces. These boundaries orient toward regimented bureaucratic methods of organizing work [5], and offer considerable constraints to contemporary work. The resurgence of telework opportunities offers a prospective opportunity to re-evaluate restricted measures of organizing work into fixed 9-5 work hours.

This systematic review evaluates the impact of telework on worker wellbeing. This is recognizing that for workplaces—and individuals within them—to be sustainable, all workers should be supported to have and experience full and productive employment and

decent work. Decent work is Goal Eight of the United Nations Sustainable Development Goals enumerated in the historic *2030 Agenda for Sustainable Development* manifesto [6]. While worker wellbeing is only one facet of the Sustainable Development Goal, it does provide a key foundation for understanding how work effects workers. In better understanding how telework contributes to, or challenges, worker wellbeing, this review curates foundational knowledge for development of decent telework conditions. As a result, the research objective of this study is to identify the current role telework is having on worker wellbeing. To do so, the United Nations Sustainable Development Goals is used as a guiding framework to address the research objective.

1.1. COVID-19 Lockdown Working from Home

Many of the studies published on working from home during 2020–2022 have been based on understanding how COVID-19 has affected the wellbeing of workers. For example, Canales-Romero et al. [7] find that working from home during the pandemic did not generally contribute to negative wellbeing (although this does conflicts with much of the literature presented below). However, they did find that parents working from home who served in dual roles as 'assistant teachers' to their children did experience declining wellbeing. In this study, the emphasis was on the testing of relationships that have limited transferability to a non-COVID-19 context; working from home practices do not usually coincide with sustained home-based remote student learning of school-aged children. Instead, these are restricted to scenarios where parents choose to home school, or children have periods of school holidays, where they are not usually expected to join virtual classrooms from home.

Likewise, when reflecting on the COVID-19 stressors, it becomes clearer that working from home practices during lockdowns are materially different than working from home during or beyond the pandemic era. The development of the pandemic induced stress scale [8] assumed that living and working during lockdowns created unique stress to humans. This included the introduction of home confinement orders, economic, social, and professional loss, redesigning work practices with inadequate or uncertain resourcing, and heightened anxiety from scaled health information dissemination. This is confirmed in one study that examined how daily self-leadership enabled positive outcomes for daily basic need satisfaction during the pandemic. However, this relationship was moderated by daily rumination about COVID-19 [9]. That is, baseline thoughts about COVID-19 have a direct effect on how well individuals satisfy their own basic needs.

1.2. Problem Statement

There is currently inconsistent empirical evidence on how the practices of working from home and telework effect employee wellbeing. While some have attempted to resolve this, there is a need for a social and relational work design perspective on this topic. Prior to this review, there have been two reviews that have sought to respond to the relationship between telework and wellbeing. This review, however, offers a critical point of difference. The first review by Chirico et al. [10] examines 15 manuscripts on how working from home during lockdowns affected employee wellbeing published during 2020–2021. The Chirico et al. [10] review offers a useful view of how lockdown measures created conditions of declining wellbeing in employees, yet it was highly restrictive to the lockdown context. In distinguishing, this review is different from pandemic telework review, as it focuses carefully on how telework is measured, discussed, and evaluated outside of specific-pandemic lockdown scenarios. While some studies in the final sample are situated inside of the pandemic, those whose findings are related to lockdown-specific contexts were excluded.

The second review by Beckel and Fisher [1] provides short descriptions of fourteen antecedents, four mediators, six moderators, and fifteen outcome variables within a telework nomological network, grouped by updated categories originally proposed by Allen et al. [11]. Adopting a job demands-resources and macro-ergonomics systems ap-

proach, Becker and Fisher [1] examine how management-designed structures of work effect the wellbeing of employees situated in those workspaces. I acknowledge the key contribution that these scholars made to a broad-based understanding of telework structures, individual difference, and wellbeing from an occupational health perspective. In distinguishing the work of Beckel and Fisher [1] from this study, I adopt a proactive work design approach that focuses on understanding how employees and employers co-construct meaningful work environments within hybrid contexts. I focus on the telework outcome of the manager-subordinate co-construction.

2. Theoretical Framework: Proactive Work Design

In a 100-year review of work design research, there are five distinct historical developments identified [12]. Namely sociotechnical systems, job characteristics, job demands-control, job demand-resources, and role theory. Many of these adopt industrialist approaches to connection between work as a highly structured activity. Progression in telework and more flexible work design research have been studied in some of these contexts [1], however it seems less common that telework is examined through work designs more suited to the changing nature of work. As an outcome of this review [12], there is recognition that proactive work designs can support more positive outcomes and reduce negative outcomes in workplaces.

Grant and Parker [13] wrote on the changing nature of work and organizations because of a global transition towards a knowledge economy and away from industrial revolution notions of organizing. The study highlights proactive perspectives of work, where a higher degree of uncertainty creates a need for dynamic response. In their review, social support, outside interactions, interpersonal feedback, and social context were considered key foundations of work design theories. Interestingly, while Grant and Parker [13] focus on the work effects on individuals and organizing, Fuller et al. [14] evidence how employee proactive personality supports a response to the effect that structural and social challenges (e.g., hierarchical position, resource access) have on their felt responsibility for constructive change. That is, the extent to which people with a high proactive personality take psychological ownership of changes made. In the context of telework, employees with high proactive personalities may be more positive in responding and leading change.

While industrial and bureaucratic organizations adopt often rigid perspectives of work, where managers design jobs for employees to be placed inside of, and engage with limited agency in fulfilling those roles, it is not as common among learned employees. Bakkar et al. [9] propose that self-leadership and playful work designs enable psychological need fulfilment and role performance during the pandemic. Underlying these assumptions is self-determination, where the individual has agency to determine their work, and to achieve. In this regard, this study adopts a proactive perspective for work design, where work is built in a condition where employees can adapt their work patterns and behaviors to support their own self-determined pathway to performance. In hybrid work environments, this becomes more prominent, although there appears to be institutional resistance to self-designed methods of performing.

3. Materials and Methods

This study adopts a systematic review method to address the research question, using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Statement as guidance [15], and Braun and Clarke's [16] method of thematic analysis to define themes within the data. To ensure clarity, and that the findings in this paper reflect on telework/working from home practices, rather than outcomes that could be attributable to COVID-19 lockdowns, those studies whose primary reference point is within a lockdown are excluded. For example, where studies measure effects of government-mandates on wellbeing. Studies that were published during the pandemic, but specifically on telework and working from home and examined the wellbeing-effects of working from home were included.

3.1. Search Strategy

The search strategy for this study includes two phases. First, a database-driven search using Web of Science, Scopus, PsycInfo and PubMed were used. This search was limited to academic journals, English language, and date ranged from 1 January 2000 to 31 July 2022. The search phrase was:

Title (telework OR telecommut * OR work from home) AND *Title/abstract* (wellbeing OR well-being OR mental health OR mental ill-health).

Following the initial search, a second search using manual scanning of Google Scholar was used to identify any articles missed in the search (of the first 10 pages), with a final snowball search of reference lists for articles in the final sample. Articles identified in these stages were added at the screening stage (see Table 1 for summary).

Table 1. Search results.

Database	Search 1	Search 2
Scopus	104 results	
PsycInfo	61 results	
Web of Science	53 results	
PubMed	34 results	
Google Scholar		18 results
Reference review		4 results
Subtotal	252 results	22 results
Total		274 results

3.2. Selection Procedure and Quality Assessment

The PRISMA Statement (Figure 1 [15]) highlights the progression of 274 manuscripts identified for potential inclusion, using a review against the intention of the search strategy. That is, manuscripts must speak to telework (or the equivalent) and explicitly discuss worker wellbeing. PRISMA is commonly used in sustainability and organizational research [17]. Through a screening of title and abstracts, and a second full-text review, 43 and 70 manuscripts were excluded, respectively. The final sample was 58, and these are represented in the references with an asterisk. Importantly, considerable effort was made to remove studies that focused on the effects of COVID-19 lockdowns (n = 34), where the findings were not comparable to working from home contexts outside of the lockdown context. Many studies included, however, were situated within the broad pandemic landscape. The key point of difference was that these were studies not specifically on the lockdown effects, and they were not exploring relationships that were unique to the lockdown. While some conflation will exist (e.g., studies not describing when their data was collected), the aim was to only include studies that aimed to study working from home contexts.

3.3. Thematic Analysis

Adopting the method of thematic analysis [16], this author reviewed each manuscript multiple times during the screening process for data familiarization. Following, findings were extracted from each manuscript to support data coding and theme searching using the United Nations' Sustainable Development Goals (SDGs) as guidance [6]. Finally, each emergent theme was classified and defined, and the sample was re-assessed for inclusion to finalize each thematic representation in studies.

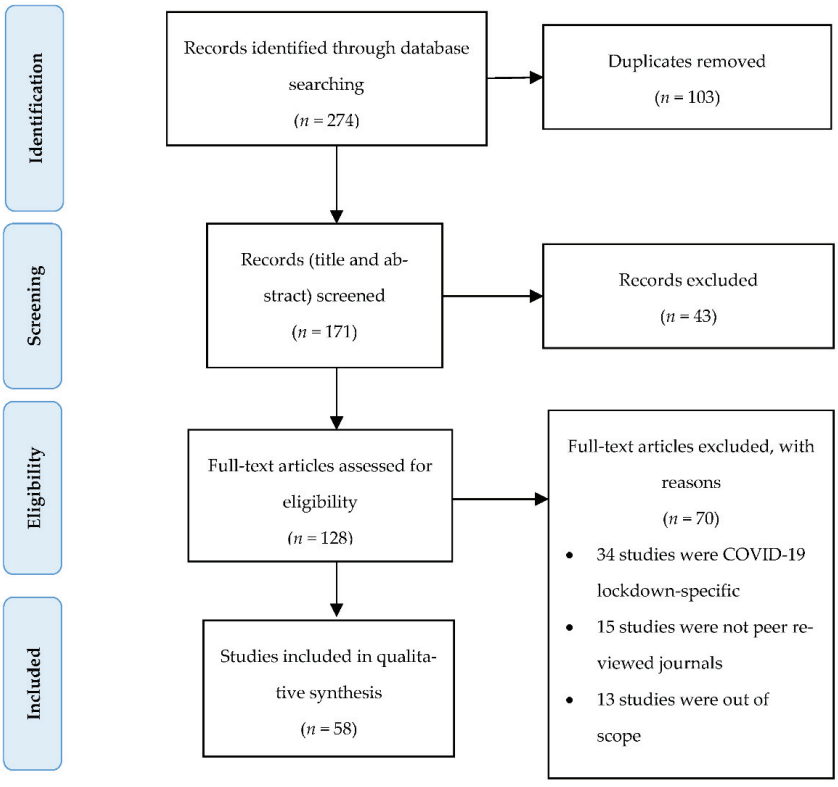

Figure 1. PRISMA Statement.

4. Results

The results of this study indicate a great deal of inconsistency among findings, with some studies reporting on conflicting relationships, and others having insignificant and significant findings on the same relationship. Greater work is clearly needed in high quality research that better controls for macro-level pandemic-differences (e.g., health information-based anxiety) in understanding how telework, in isolation, effects employee wellbeing. However, the literature appears to currently explore telework and onsite work differences from four sustainable development goal perspectives.

4.1. Contributing Factors for How Telework Effected Employee Wellbeing (SDG 8)

Goal 8 is to "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" [6]. Across the sample there were six broad contributing factors that explained differences in wellbeing outcomes across telework and traditional onsite work: individual differences, decent work perceptions, communication, work design, social support, and work time (see Table 2). Individual differences were generally studied, however, few studies explicitly examined how individual differences had effects on how telework was experienced. In one study, people with disability [18] experienced worse wellbeing because of telework. This is perhaps due to reduced social and physical mobility that can be experienced by some people with disability, where creating and sustaining meaningful relationships can be more difficult. In onsite environments, there are consistent relationship development opportunities (e.g., adjacent offices, shared lunch areas), whereas telework environments require planning to establish contact. Additionally, quality communication opportunities were important [19,20].

Table 2. How wellbeing was affected by telework.

Variable	Source	Predicted Direction
Individual differences		
Age	Arvola et al. [21]	Insignificant
Cultural power distance	Hoque and Bacon [18]	−
	Michinov et al. [22]	Unclear
Personality	Michinov et al. [22]	Insignificant
Previous experience	Erro-Garces et al. [23]	+
	Hoque and Bacon [18]	−
People with disability	Adamovic [24]	+
Individualism perspective	Adamovic [24]	−
Stay-at-home children	Rieth and Hagemann [25]	−
Workaholism	Magnavita et al. [26]	− (moderator)
Decent work perception		
Job satisfaction	Erro-Garces et al. [23]	+ (mediator)
Motivation	Vanderstukken et al. [27]	+
Work meaningfulness	Maillot et al. [28]	−
	Maillot et al. [28]	−
Perceived intensity	Michinov et al. [22]	Insignificant
	Shepherd-Banigan et al. [29]	Insignificant
Work-family conflict	Vander Elst et al. [30]	−
Work-family balance	Miglioretti et al. [31]	+
Emotional exhaustion	Vander Elst et al. [30]	−
Communication		
Online communication	Karatuna et al. [19]	+
	Kitagawa et al. [20]	+
Face-to-face communication	Karatuna et al. [19]	+
Work design		
Academic environment	Karatuna et al. [19]	+
Working conditions	Karatuna et al. [19]	+
Office distraction	Wohrmann and Ebner [32]	−
Dedicated home office	Fukumura et al. [33]	+
	Kitagawa et al. [20]	+
Flexibility	Fukumura et al. [33]	+
	Widar et al. [34]	+
	Shepherd-Banigan et al. [29]	Insignificant
Job resources	Miglioretti et al. [31]	+
Job demands	Miglioretti et al. [31]	Insignificant
	Eguchi et al. [35]	+ (moderator)
	Chu et al. [36]	Insignificant
Organizational support	Bosua et al. [37]	+
	Karatuna et al. [19]	+
Physical isolation	Wang et al. [38]	+
Participatory decision-making	Vander Elst et al. [30]	+
Autonomy	Vander Elst et al. [30]	+
Social support		
Co-worker relationships	Wohrmann and Ebner [32]	−
Social support at home	Prabowo et al. [39]	Insignificant
Quality interactions	Maillot et al. [28]	+
Social integration	Kim et al. [40]	+
Psychological isolation	Wang et al. [38]	−
Work social support	Vander Elst et al. [30]	+

Table 2. *Cont.*

Variable	Source	Predicted Direction
Work time		
Perceived time pressure	Wohrmann and Ebner [32]	+
After hours work	Magnavita et al. [26]	–
Weekend/holiday work	Song and Gao [41]	+
Extent/hours of telework	Heiden et al. [42]	Insignificant
	Vander Elst et al. [30]	Insignificant
Work time control	Wohrmann and Ebner [32]	+
Boundaryless work hours	Wohrmann and Ebner [32]	+
Work–life balance	Erro-Garces et al. [23]	+ (mediator)
	Chu et al. [36]	+
	Zarcher et al. [32]	Insignificant
Work timing	Maillot et al. [28]	–

In drawing on the proactive work design model, work design conditions were the most studied component regarding telework. For example, working conditions [19], dedicated home office spaces [20,33], flexibility [33,34], and organizational support [19,36] were seen as important contributors to decent work for employees engaging in telework practices. This makes contextual sense given that many studies focused on understanding what drivers effected wellbeing in workplaces where telework was merely a reflection of the same work and work practices occurring offsite. Likewise, general social supports from co-workers [30,32] and home family [39] were inconsistently studied and had varying results. However, when the focus was on the quality of interactions [28] and feelings of isolation [38], the sample presented a more coherent picture in line with the belongingness hypothesis. That is, it was more important for employees to have a few meaningful relationships with colleagues and family than the quantity of social relationships.

Interestingly, the area with the least congruence was arrangements of work-timing. Whereas control in work time arrangements seemed to support better wellbeing [28], the general extent of telework did not seem important [30,42]. Specific time arrangements were considered, and these had a contributory effect on the wellbeing of employees. As organizations progress towards more hybrid work arrangements, it seems greater emphasis is needed on the nature of work hours versus work results, and greater supports for developing capability for work and life task switching outside of fixed 9-5 hours of work.

4.2. Wellbeing-Based Outcomes of Telework (SDG 3)

Goal 3 is to "Ensure healthy lives and promote wellbeing for all at all ages" [6]. While Goal 3 focuses more on health (e.g., access to vaccines) over psychological wellbeing, it does consider promotion of positive mental wellbeing. Table 3 presents a list of wellbeing-based outcomes of telework. These include increases in positive outcomes (e.g., flow, work engagement), increases in negative outcomes (e.g., fatigue, detachment), declines in positive outcomes (e.g., sexual intercourse, emotional connections), and declines in negative outcomes (e.g., anxiety, distraction). More, however, is needed in considering and reflecting on the potential interaction effects that exist between these outcomes. This is particularly true in concepts where a measure effects telework, and in another study reports on the effect telework has on an outcome.

Table 3. Outcomes of telework that indicate changes in wellbeing.

Variable	Source
Increases due to telework	
Self-organisation	Paridon and Hupke [43]
Ergonomic stress	Paridon and Hubke [43] Schade et al. [44]
Work engagement	Miglioretti et al. [31] Delanaeiji and Verbruggen [45]
Flow	Schade et al. [44]
Affect	Schade et al. [44]
Detachment	Schade et al. [44]
Fatigue	Oakman et al. [46]
Financial burden	Oakman et al. [46]
Onsite loneliness	Zarcher et al. [47]
Weight gain	Ekpanyaskul and Padungtod [48]
Perceived work intensity	Ekpanyaskul and Padungtod [48]
Next day work engagement	Darouei and Pluut [49]
Decreases due to telework	
Sexual intercourse	Prabowo et al. [39]
Stress	Rieth and Hagemann [25] Adamovic [24] Bosua et al. [37] Delanoeije and Verbruggen [45] Song and Gao [41] (increase, rather than decrease)
Anxiety	Schifano et al. [50]
Technology challenges	Liddiard [51]
Emotional overload	Liddiard [51]
Confusion	Liddiard [51]
Emotional connections	Liddiard [51]
Distraction	Zarcher et al. [47]
Perceived workload -Metropolitan workers -Rural workers	Turja et al. [52] (insignificant for rural)
Time pressure	Darouei and Pluut [49]
Work-family conflict	Darouei and Pluut [49]
Depression symptoms	Shepherd-Banigan et al. [29]
Physical health	Oakman et al. [46]
Conflicting changes due to telework	
Exhaustion	Cheng and Zhang [53] (+) Darouei and Plutt [49] (−) Windeler et al. [54] (-in part-time telework)

Interestingly, there were some conflicting results relating to stress, with one study [41] indicating higher stress in telework, whereas four others [24,25,37,45] confirm lower stress. The study articulating higher stress [41] measured stress in 2010, 2012, and 2013, and is based on a phone survey recording the previous 24 h of activities, rather than a typical single time-point survey. Aside from this data being earlier (the studies confirming effects were published in 2020–2022), when working from home practices were less common, this study arguably provides more rigorous accounts of stress from telework practices. The difference in societal expectations and norms also may play a role. It would be reasonable to assume that in 2010–2013, telework was a less frequent work design with less resourcing established for access to the correct technology, work products, and human online connections.

Exhaustion also highlighted confused results, with positive [53], negative [49], and negative in part-time telework identified [54]. In these studies, their framing around emotional exhaustion was different. For example, one study [49] identifies morning exhaustion as an outcome of working from home, mediated by work-home conflict; whereas in another [53],

delayed emotional exhaustion was a product of extent of telework and detachment from work. These assumptions require more robust conceptualization and testing to understand how telework is actually effecting employee wellbeing, and under which conditions the best telework productivity and wellbeing outcomes are achieved.

4.3. Gender-Based Differences (SDG 5)

Goal 5 is to "Achieve gender equality and empower all women and girls". The literature provides some analysis on gendered differences of telework on employee wellbeing. While many of these studies do have conflicting commentary and relationships tested, some inferences can be drawn. Firstly, women tended to experience exacerbated effects of existing relationships. For example, in one study [55], women saw greater perceived advantage in telework, but also reported higher perceived disadvantage. Likewise, emotional exhaustion was considered higher in women [55], but relaxation levels were also higher in women. A key area that requires greater clarity includes stress [41], depression symptoms [29,56], and loneliness [22]. This understanding will help organizational strategists and managers develop work-based responses that may support greater gender equality. Interestingly, there were statistically significant wellbeing effects of commute time [56] and psychological distress in women [57], but not statistically significant in men. In this regard, while these studies offer a useful nomological map as to how women experience telework differently, they seem to lack the controls required to understand what differences are experienced based on gender individual differences as compared to environmental, cultural, and social differences that adversely effect people of diverse genders (Table 4).

Table 4. Gendered differences of telework wellbeing effects.

Variable	Source
Higher in women	
Perceived advantages Perceived disadvantages Perceived workload Emotional exhaustion Relaxation levels Workaholism	Ghislieri et al. [55]
Depression symptoms	Burn et al. [56] Shepherd-Banigan et al. [29]
Stress	Song and Gao [41]
Lower in women	
Loneliness	Michinov et al. [22]
Higher in women and not statistically significant in men	
Commute time	Kroesen [58]
Psychological distress	Matthews et al. [57]

4.4. How Wellbeing Was Changed by Intervention (SDG 9)

Goal 9 is to "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". Most studies in the final sample tended to conduct inferential studies that linked an outcome or antecedent concept to telework (compared to onsite work). Across the findings, a series of physical structural responses supported higher wellbeing and support (e.g., stand-up desks [59]). Likewise, some supports to enable quality relationships and social support (e.g., coaching [60]; and communication strategies [24]). Having an emotionally and physically proximate dog also did well to support wellbeing in participants [59]. Yoga supported perception changes of stress, but did not present evidence of actual changes in stress or anxiety. More studies are needed in considering how experimental studies can support effective redesign of workplaces, and proactive responses to a more dynamic and flexible work environment experienced when transitioning through and between telework and onsite work (Table 5).

Table 5. Intervention effects on wellbeing.

Intervention	Source	Summary
Communication and performance strategies	Adamovic [24]	Higher sense of belonging and wellbeing.
Exercise Face-to-face eye contact	Burn et al. [56]	Served as a protective factor for wellbeing declines.
Online behavior modification program	Falk et al. [59]	Higher affective wellbeing and performance, and lower fatigue severity.
Positive psychology coaching	Van Nieuwerburg et al. [60]	Higher wellbeing, reflection time, awareness, and lower negative affect.
Proximally and emotionally close dogs	Junça-Silva et al. [61]	Higher productivity and wellbeing.
Stand-up desks	Falk et al. [59]	Higher affective wellbeing and performance, and lower fatigue severity.
Wrist worn sensors prompting regular breaks	Zhang et al. [62]	Higher productivity and wellbeing.
Yoga	Wadhen and Cartwright [63]	Higher wellbeing and lower perceived stress, but no change in actual stress and anxiety.

Management practices were also studied to understand how managers and leaders support quality responses to changing work lives among teleworkers. These often involved manager interventions to support staff through work change. For example, supporting staff to develop appropriate boundaries between work and life [64] or proactive responses to home conflict [65]. There was general coherence on the role that micromanagement has on reducing employee wellbeing. In the studies, this was represented in the negative relationship between intrusive leadership and wellbeing [26]. It was also visible when examining the relationship that supervisor trust of employees [36,40] and managers focusing more on results over specific hours worked [40] had on supporting improved wellbeing (Table 6).

Table 6. Leader and manager effects on employee wellbeing.

Variable	Source	Predicted Direction
Boundary development	Rodrigues et al. [64]	+
Collaboration	Rodrigues et al. [64]	+
Conflict at home	Lanaj et al. [65]	+
Depletion		+
Intrusive leadership	Magnavita et al. [26]	−
Isolation	Rodrigues et al. [64]	−
Manager results-orientation	Kim et al. [40]	+
Supervisor trust	Chu et al. [36]	Insignificant
	Bosua et al. [37]	+
	Kim et al. [40]	+

5. Discussion

This study presented a review of the current known roles that telework has on wellbeing. While the field by age is not novel or new, in its volume of research and contemporary relevance, telework has only began to receive growing coverage in workforce planning and wellbeing research in recent years. In this study, the final sample ranged between 2006 and 2022, however, only around 14 percent of studies existed prior to 2020. Indeed, almost half the studies included were from 2022 YTD (46.5%). The emergent evidence provides useful context for scholars and practitioners, however, even with careful consideration during this review to remove studies that likely had pandemic effects included, most studies were

situated during the pandemic era. That is, some of the strength or weakness of relationships may be attributable to temporally specific rather than attributable to telework practices. In a critical assessment of the studies that were included, I now turn to consider concepts that were less present in the net of research on telework and working from home practices. I group these by work culture, environmental sustainability, and transitory states.

5.1. Work Culture Gaps

The studies included have begun to explore pockets of pathways by which workplaces, work designs, and people effect employee wellbeing outcomes. Additionally, this is important as scholars become clearer on what levers incentivize and hinder decent and meaningful work. Of critical importance is considering changes in the fundamental nature of work. One study wrote that when managers focus on results over specifics around hours contributed, wellbeing improves [38]. However, this could also adversely affect underserved workers or incentivize faster and lower quality work. What moderation might be needed to ensure the effect of flexible work on workers is sustainable over temporal and spatial locations.

Indeed, belongingness research has found more significant challenges to the way in which employees engage, stay, or leave workplaces. While job turnover could be considered a lagging indicator of belongingness and wellbeing [66], a better understanding of what happens to engagement, belonging, and wellbeing over periods of time is critical [67,68]. Leadership and followership co-creation practices [69] also seem to be largely absent from the telework literature. When people with specific titles (e.g., 'manager' and 'employee') come together in onsite work, the spatial conditions effect the way leadership is claimed and granted. How does the blended and hybrid spatial conditions effect how leaders and followers co-create relationships, and likewise contribute to outcomes of wellbeing and belonging?

In relation to equity and relational norms, in traditional onsite organizations, workers are afforded a degree of equivalent opportunity to network with managers, colleagues, and clients. That is, by virtue of being in the same proximate location (e.g., the work office), each employee can attempt to build relationships with most of their peers. Over time, as leader-member exchange theorists would describe [70,71], some of these relationships become psychologically close and others remain distant. For teleworkers, if they have less face-to-face interaction opportunities, will they experience heightened disconnection and social isolation from their colleagues? Likewise, equal opportunity to promotions or qualitative perceptions of their performance by managers may also be different.

5.2. Environmental Sustainability

Among the studies, many examined social and physical changes experienced by teleworkers in contrast to similar onsite workers. Yet, there were few studies that discussed the impact of decentralized work structures on environmental outcomes. This seems congruent with work on higher education during the pandemic, that indicated environmental sustainability was deprioritized in the place of continuity of work and learning. In one study, working from home was identified as reducing transport costs [72]. However, in pandemic studies that feature working from home, eating habits were seen to be healthier [73], yet it was not clear if out-of-home eating changed. Higher consumption of takeaway food from cafés and restaurants can have a contributory effect on landfill and single-use plastic consumption, when contrasted to home-based meal preparation.

In considering electricity consumption, COVID-19 mandates that effected work from home patterns saw increased power consumption at home by 13 percent [74]. It is however, unclear if the increased domestic electricity consumption features a decline in office and work environment levels by an equivalent level (i.e., less or more overall electricity consumption). There is more research needed with relation to the relative effects of social and environmental outcomes and differences in telework contexts, including controlling for pandemic-effects.

5.3. Effects beyond Transitory States

Change creates inertia, and change creates resistance and differences in affective experiences. For many of the studies in this sample, scholars produced pilot interventions of introducing telework conditions or measuring the differences between employees who were teleworking and those completing onsite work. Yet, in the latter, it was rarely clear if these teleworkers were only recently transitioned to this type of work or if studies were capturing genuine teleworkers in contrast to genuine onsite workers. Studies pertaining to telework moving forwards should provide clear parameters for the previous experience and temporal duration of telework experienced by those sampled.

To extend, during the pandemic, there are numerous studies on changing wellbeing because of lockdowns [75,76]. These changes are likely having an exogenous effect on employee wellbeing that is exacerbating the effects theorized as endogenous of telework. As the world moves through and beyond the pandemic, some of the assumptions highlighted within this research will need to be re-tested and better control for exogeneity in the telework and onsite work experience.

5.4. Practical Implications

This study focused on examining the current research on telework work conditions in contrast to onsite work. I was primarily concerned telewith establishing a clear understanding of the published literature on telework and employee psychological wellbeing to support future research [77–81]. However, this study has clear implications for practitioners experiencing, or implementing telework. First, telework is not comparable to onsite work. While it seems it contributes to better employee wellbeing outcomes, the reasons why this is the case are more mixed and often conflicting. This means that focusing on creating an environment that works for the specific industry and individual needs is important, and the variability in relationships tested in the sample studies may be reflective of the complexity of employees and specific work practices. Second, telework removes physical boundaries that separate work (in the office/onsite) and life (not in the office/offsite), and this requires a resetting practice for workers. Working from home, productivity, and employee health remain linked [82–86]. While managers could support employees to build effective boundaries, there may be a case for progression towards results-based evaluation rather than performative hours-based work; particularly in knowledge workers.

Third, identifying strategies to build connection and social cohesion between onsite, telework, and hybrid staff is critical for ensuring that work modality does not affect long-term performance, wellbeing, engagement, or belongingness among staff. This could include practices such as mandated onsite days, although this likely offers a disadvantage those who are required to transition to onsite on some days without social and physical systems (e.g., childcare and parking permits) in place. Higher education have been studying students transitioning between modalities for a while [86–90], and could be drawn on in the context of working from home. Indeed, these staff may also find it difficult to reintegrate with the social bonds developed by permanently onsite staff also [91]. It may be more effective to choose neutral easy-access locations for regular blended social and professional meetings and check-ins. Local parks may offer an interesting contribution. In the Australian small business context, attending a public barbeque in the park for a lunch meeting could offer a useful opportunity for developing meaningful connections. Being physically co-located (e.g., shared or adjacent offices) may support social bonding, but without sustained opportunities to connect, this may be more complex.

6. Conclusions

This study examined the relationship that telework and working from home practices had on employee wellbeing. Through a systematic review, leveraging PRISMA and thematic analysis, I evaluated 58 studies on this relationship using the United Nations' Sustainable Development Goals as guidance. While the evidence was not always clear, it did seem to highlight that opportunities for telework seemed to generally improve the

wellbeing of employees. However, this was not a linear relationship with extent of telework not always supporting heightened wellbeing. The data indicated that telework was different for some staff, and that telework could be considered decent work in parallel or substitution of onsite work. The research on telework however was often conflicting, and likely a product of conflation between lockdown-effects from the COVID-19 pandemic and genuine telework. While effort was made to control for these in the sample, the majority of studies were published between 2020–2022. This is an important limitation to the work. There are incredible opportunities for telework to create more meaningful, flexible, and productive work environments where employees can belong across spatial contexts. However, it requires dedicated and considered management and leadership to support staff to transition and stabilize such a change.

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References

1. Beckel, J.; Fisher, G. Telework and worker health and well-being: A review and recommendations for research and practice. *Int. J. Environ. Res. Public Health* **2022**, *19*, 3879. [CrossRef] [PubMed]
2. Gallup. *Work and Education Poll*; Gallup Institute: Washington, DC, USA, 2016.
3. Belkin, L.; Becker, W.; Conroy, S. The invisible leash: The impact of organizational expectations for email monitoring after-hours on employee resources, well-being, and turnover intentions. *Group Organ. Manag.* **2020**, *45*, 709–740. [CrossRef]
4. Basile, K.A.; Beauregard, T.A. Strategies for successful telework: How effective employees manage work/home boundaries. *Strateg. HR Rev.* **2016**, *15*, 106–111. [CrossRef]
5. Potter, R.E.; Zadow, A.; Dollard, M.; Pignata, S.; Lushington, K. Digital communication, health & wellbeing in universities: A double-edged sword. *J. High. Educ. Policy Manag.* **2022**, *44*, 72–89.
6. United Nations. *2030 Agenda for Sustainable Development*; United Nations: New York, NY, USA, 2015; Available online: https://sdgs.un.org/2030agenda (accessed on 10 August 2022).
7. Canales-Romero, D.; Hachfeld, A. Juggling School and Work From Home: Results From a Survey on German Families With School-Aged Children During the Early COVID-19 Lockdown. *Front. Psychol.* **2021**, *Advanced Online Publication*. [CrossRef]
8. Srivastava, R.; Gupta, S.; Sanjeev, M.A. Comprehending and measuring pandemic induced stress among professionals due to lockdown and work from home. *J. Public Aff.* **2021**, *Advanced Online Publication*. [CrossRef]
9. Bakker, A.; Breevaart, K.; Scharp, Y.; de Vries, J. Daily self-leadership and playful work design: Proactive approaches of work in times of crisis. *J. Appl. Behav. Sci.* **2021**, *Advanced Online Publication*. [CrossRef]
10. Chirico, F.; Zaffina, S.; Di Prinzio, R.R.; Giorgi, G.; Ferrari, G.; Capitanelli, I.; Ilesanmi, O. Working from home in the context of COVID-19: A systematic review of physical and mental health effects of teleworkers. *J. Health Soc. Sci.* **2021**, *6*, 319–332.
11. Allen, T.; Golden, T.; Shockley, K. How effective is telecommuting? Assessing the status of our scientific findings. *Psychol. Sci. Public Interest* **2015**, *16*, 40–68. [CrossRef]
12. Parker, S.K.; Morgeson, F.P.; Johns, G. One hundred years of work design research: Looking back and looking forward. *J. Appl. Psychol.* **2017**, *102*, 403. [CrossRef]
13. Grant, A.; Parker, S. 7 redesigning work design theories: The rise of relational and proactive perspectives. *Acad. Manag. Ann.* **2009**, *3*, 317–375. [CrossRef]
14. Fuller, J.B.; Marler, L.E.; Hester, K. Promoting felt responsibility for constructive change and proactive behavior: Exploring aspects of an elaborated model of work design. *J. Organ. Behav.* **2006**, *27*, 1089–1120. [CrossRef]
15. Moher, D.; Liberati, A.; Tetzlaff, J.; Altman, D.; PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *Ann. Intern. Med.* **2009**, *151*, 264–269. [CrossRef] [PubMed]
16. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]
17. Crawford, J.; Cifuentes-Faura, J. Sustainability in higher education during the COVID-19 pandemic: A systematic review. *Sustainability* **2022**, *14*, 1879. [CrossRef]
18. Hoque, K.; Bacon, N. Working from home and disabled people's employment outcomes. *Br. J. Ind. Relat.* **2022**, *60*, 32–56. [CrossRef]
19. Karatuna, I.; Jönsson, S.; Muhonen, T. Job Demands, Resources, and Future Considerations: Academics' Experiences of Working From Home During the Coronavirus Disease 2019 (COVID-19) Pandemic. *Front. Psychol.* **2022**, *13*, 8640. [CrossRef] [PubMed]
20. Kitagawa, R.; Kuroda, S.; Okudaira, H.; Owan, H. Working from home and productivity under the COVID-19 pandemic: Using survey data of four manufacturing firms. *PLoS ONE* **2021**, *16*, e0261761. [CrossRef]

21. Arvola, R.; Tint, P.; Kristjuhan, U.; Siirak, V. Impact of telework on the perceived work environment of older workers. *Sci. Ann. Econ. Bus.* **2017**, *64*, 199–214. [CrossRef]
22. Michinov, E.; Ruiller, C.; Chedotel, F.; Dodeler, V.; Michinov, N. Work-From-Home During COVID-19 Lockdown: When Employees' Well-Being and Creativity Depend on Their Psychological Profiles. *Front. Psychol.* **2022**, *13*, 1280. [CrossRef]
23. Erro-Garcés, A.; Urien, B.; Čyras, G.; Janušauskienė, V.M. Telework in Baltic Countries during the Pandemic: Effects on Wellbeing, Job Satisfaction, and Work-Life Balance. *Sustainability* **2022**, *14*, 5778. [CrossRef]
24. Adamovic, M. How does employee cultural background influence the effects of telework on job stress? The roles of power distance, individualism, and beliefs about telework. *Int. J. Inf. Manag.* **2022**, *62*, 102437. [CrossRef]
25. Rieth, M.; Hagemann, V. The Impact of Telework and Closure of Educational and Childcare Facilities on Working People during COVID-19. *Z. Fur Arb.-Und Organ.* **2021**, *65*, 202–214. [CrossRef]
26. Magnavita, N.; Tripepi, G.; Chiorri, C. Telecommuting, off-time work, and intrusive leadership in workers' well-being. *Int. J. Environ. Res. Public Health* **2021**, *18*, 3330. [CrossRef]
27. Vanderstukken, A.; Nikolova, I.; de Jong, J.P.; Ramioul, M. Exploring types of telecommuters: A latent class analysis approach. *Eur. J. Work. Organ. Psychol.* **2022**, *31*, 245–259. [CrossRef]
28. Maillot, A.S.; Meyer, T.; Prunier-Poulmaire, S.; Vayre, E. A Qualitative and Longitudinal Study on the Impact of Telework in Times of COVID-19. *Sustainability* **2022**, *14*, 8731. [CrossRef]
29. Shepherd-Banigan, M.; Bell, J.F.; Basu, A.; Booth-LaForce, C.; Harris, J.R. Workplace Stress and Working from Home Influence Depressive Symptoms Among Employed Women with Young Children. *Int. J. Behav. Med.* **2016**, *23*, 102–111. [CrossRef]
30. Vander Elst, T.; Verhoogen, R.; Sercu, M.; Van Den Broeck, A.; Baillien, E.; Godderis, L. Not Extent of Telecommuting, but Job Characteristics as Proximal Predictors of Work-Related Well-Being. *J. Occup. Environ. Med.* **2017**, *59*, e180–e186. [CrossRef]
31. Miglioretti, M.; Gragnano, A.; Margheritti, S.; Picco, E. Not all telework is valuable. *Rev. De Psicol. Del Trab. Y De Las Organ.* **2021**, *37*, 43770. [CrossRef]
32. Wöhrmann, A.M.; Ebner, C. Understanding the bright side and the dark side of telework: An empirical analysis of working conditions and psychosomatic health complaints. *New Technol. Work. Employ.* **2021**, *36*, 348–370. [CrossRef]
33. Fukumura, Y.E.; Schott, J.M.; Lucas, G.M.; Becerik-Gerber, B.; Roll, S.C. Negotiating Time and Space When Working From Home: Experiences During COVID-19. *Otjr Occup. Particip. Health* **2021**, *41*, 223–231. [CrossRef]
34. Widar, L.; Heiden, M.; Boman, E.; Wiitavaara, B. How Is Telework Experienced in Academia? *Sustainability* **2022**, *14*, 5745. [CrossRef]
35. Eguchi, H.; Inoue, A.; Hino, A.; Tsuji, M.; Tateishi, S.; Ikegami, K.; Nagata, T.; Matsugaki, R.; Fujino, Y. Effect of Working from Home on the Association between Job Demands and Psychological Distress. *Int. J. Environ. Res. Public Health* **2022**, *19*, 6287. [CrossRef] [PubMed]
36. Chu, A.; Chan, T.; So, M. Learning from work-from-home issues during the COVID-19 pandemic: Balance speaks louder than words. *PLoS ONE* **2022**, *17*, e0261969. [CrossRef]
37. Bosua, R.; Kurnia, S.; Gloet, M.; Mendoza, A. Telework impact on productivity and well-being: An Australian study. In *Social Inclusion and Usability of ICT-Enabled Services*; Routledge: New York, NY, USA, 2017; pp. 187–208. [CrossRef]
38. Wang, W.; Albert, L.; Sun, Q. Employee isolation and telecommuter organizational commitment. *Empl. Relat.* **2020**, *42*, 609–625. [CrossRef]
39. Prabowo, K.; Ellenzy, G.; Wijaya, M.C.; Kloping, Y. Impact of Work from Home Policy during the COVID-19 Pandemic on Mental Health and Reproductive Health of Women in Indonesia. *Int. J. Sex. Health* **2022**, *34*, 17–26. [CrossRef]
40. Kim, T.; Mullins, L.B.; Yoon, T. Supervision of Telework: A Key to Organizational Performance. *Am. Rev. Public Adm.* **2021**, *51*, 263–277. [CrossRef]
41. Song, Y.; Gao, J. Does Telework Stress Employees Out? A Study on Working at Home and Subjective Well-Being for Wage/Salary Workers. *J. Happiness Stud.* **2020**, *21*, 2649–2668. [CrossRef]
42. Heiden, M.; Widar, L.; Wiitavaara, B.; Boman, E. Telework in academia: Associations with health and well-being among staff. *High. Educ.* **2021**, *81*, 707–722. [CrossRef]
43. Paridon, H.; Hupke, M. Psychosocial Impact of Mobile Telework: Results from an Online Survey. *Eur. J. Psychol.* **2009**, *5*, 1–20. [CrossRef]
44. Schade, H.; Digutsch, J.; Kleinsorge, T.; Fan, Y. Having to Work from Home: Basic Needs, Well-Being, and Motivation. *Int. J. Environ. Res. Public Health* **2021**, *18*, 5149. [CrossRef]
45. Delanoeije, J.; Verbruggen, M. Between-person and within-person effects of telework: A quasi-field experiment. *Eur. J. Work. Organ. Psychol.* **2020**, *29*, 795–808. [CrossRef]
46. Oakman, J.; Kinsman, N.; Graham, M.; Stuckey, R.; Weale, V. Strategies to manage working from home during the pandemic: The employee experience. *Ind. Health* **2022**, *60*, 319–333. [CrossRef]
47. Zarcher, A.; Galliker, S.; Jacobshagen, N.; Lascher Mathieu, P.; Eller, A.; Elfering, A. Increased Working From Home in Vocational Counseling Psychologists During COVID-19: Associated Change in Productivity and Job Satisfaction. *Front. Psychol.* **2021**, *12*, 1–12. [CrossRef]
48. Ekpanyaskul, C.; Padungtod, C. Occupational Health Problems and Lifestyle Changes Among Novice Working-From-Home Workers Amid the COVID-19 Pandemic. *Saf. Health Work.* **2021**, *12*, 384–389. [CrossRef] [PubMed]

49. Darouei, M.; Pluut, H. Work from home today for a better tomorrow! How working from home influences work-family conflict and employees' start of the next workday. *Stress Health* **2021**, *37*, 986–999. [CrossRef] [PubMed]
50. Schifano, S.; Clark, A.E.; Greiff, S.; Vögele, C.; d'Ambrosio, C. Well-being and working from home during COVID-19. *Inf. Technol. People* **2021**, *ahead-of-print*. [CrossRef]
51. Liddiard, K. A qualitative study exploring the experiences of multi-disciplinary staffs in a medium secure service when working from home and virtually during the COVID-19 pandemic. *J. Forensic Pract.* **2022**, *24*, 287–297. [CrossRef]
52. Turja, T.; Krutova, O.; Melin, H. Telework and perceived workload: Learnings prior to the COVID-19 upheaval. *Hum. Syst. Manag.* **2022**, *41*, 251–255. [CrossRef]
53. Cheng, J.; Zhang, C. The Depleting and Buffering Effects of Telecommuting on Wellbeing: Evidence From China During COVID-19. *Front. Psychol.* **2022**, 13. [CrossRef]
54. Windeler, J.B.; Chudoba, K.M.; Sundrup, R.Z. Getting away from them all: Managing exhaustion from social interaction with telework. *J. Organ. Behav.* **2017**, *38*, 977–995. [CrossRef]
55. Ghislieri, C.; Sanseverino, D.; Addabbo, T.; Bochicchio, V.; Musumeci, R.; Picardi, I.; Tomio, P.; Guidetti, G.; Converso, D. The Show Must Go On: A Snapshot of Italian Academic Working Life during Mandatory Work from Home through the Results of a National Survey. *Soc. Sci.-Basel* **2022**, *11*, 111. [CrossRef]
56. Burn, E.; Tattarini, G.; Williams, I.; Lombi, L.; Gale, N.K. Women's Experience of Depressive Symptoms While Working From Home During the COVID-19 Pandemic: Evidence From an International Web Survey. *Front. Sociol.* **2022**, *7*. [CrossRef] [PubMed]
57. Matthews, T.A.; Chen, L.; Omidakhsh, N.; Zhang, D.; Han, X.; Chen, Z.; Shi, L.; Li, Y.; Wen, M.; Li, H.; et al. Gender difference in working from home and psychological distress-A national survey of U.S. employees during the COVID-19 pandemic. *Ind. Health* **2022**, *60*, 334–344. [CrossRef]
58. Kroesen, M. Working from home during the corona-crisis is associated with higher subjective well-being for women with long (pre-corona) commutes. *Transp. Res. Part A Policy Pract.* **2022**, *156*, 14–23. [CrossRef]
59. Falk, G.E.; Mailey, E.L.; Okut, H.; Rosenkranz, S.K.; Rosenkranz, R.R.; Montney, J.L.; Ablah, E. Effects of Sedentary Behavior Interventions on Mental Well-Being and Work Performance While Working from Home during the COVID-19 Pandemic: A Pilot Randomized Controlled Trial. *Int. J. Environ. Res. Public Health* **2022**, *19*, 6401. [CrossRef]
60. van Nieuwerburgh, C.; Barr, M.; Fouracres, A.J.S.; Moin, T.; Brown, C.; Holden, C.; Lucey, C.; Thomas, P. Experience of positive psychology coaching while working from home during the COVID-19 pandemic: An Interpretative Phenomenological Analysis. *Coach. Int. J. Theory Res. Pract.* **2021**. [CrossRef]
61. Junça-Silva, A.; Almeida, M.; Gomes, C. The Role of Dogs in the Relationship between Telework and Performance via Affect: A Moderated Moderated Mediation Analysis. *Animals* **2022**, *12*, 1727. [CrossRef]
62. Zhang, Y.; Chen, Z.; Tian, H.; Kido, K.; Ono, N.; Chen, W.; Tamura, T.; Altaf-Ul-Amin, M.D.; Kanaya, S.; Huang, M. A Real-Time Portable IoT System for Telework Tracking. *Front. Digit. Health* **2021**, *3*, 1–11. [CrossRef]
63. Wadhen, V.; Cartwright, T. Feasibility and outcome of an online streamed yoga intervention on stress and wellbeing of people working from home during COVID-19. *Work* **2021**, *69*, 331–349. [CrossRef]
64. Rodrigues, E.A.; Rampasso, I.S.; Pavan Serafim, M.; Filho, W.L.; Anholon, R. Difficulties experienced by managers in the coordination of teams working from home: An exploratory study considering the COVID-19 pandemic. *Inf. Technol. People* **2022**, *ahead-of-print*. [CrossRef]
65. Lanaj, K.; Gabriel, A.; Chawla, N. The self-sacrificial nature of leader identity: Understanding the costs and benefits at work and home. *J. Appl. Psychol.* **2021**, *106*, 345–363. [CrossRef] [PubMed]
66. Waldman, D.A.; Carter, M.Z.; Hom, P.W. A multilevel investigation of leadership and turnover behavior. *J. Manag.* **2015**, *41*, 1724–1744. [CrossRef]
67. Crawford, J. Defining Post-Pandemic Work and Organizations: The Need for Team Belongingness and Trust. In *Leadership—New Insights*; InTech Open: London, UK, 2022.
68. Knox, M.W.; Crawford, J.; Kelder, J.A.; Carr, A.R.; Hawkins, C.J. Evaluating leadership, wellbeing, engagement, and belonging across units in higher education: A quantitative pilot study. *J. Appl. Teach. Learn.* **2020**, *3*, 108–117.
69. Uhl-Bien, M.; Riggio, R.; Lowe, K.; Carsten, M. Followership theory: A review and research agenda. *Leadersh. Q.* **2014**, *25*, 83–104. [CrossRef]
70. Kim, T.Y.; Liden, R.C.; Liu, Z.; Wu, B. The interplay of leader–member exchange and peer mentoring in teams on team performance via team potency. *J. Organ. Behav.* **2022**, *43*, 932–945. [CrossRef]
71. Zhao, H.; Liu, W.; Li, J.; Yu, X. Leader–member exchange, organizational identification, and knowledge hiding: T he moderating role of relative leader–member exchange. *J. Organ. Behav.* **2019**, *40*, 834–848.
72. Beck, M.; Hensher, D. Working from home in Australia in 2020: Positives, negatives and the potential for future benefits to transport and society. *Transp. Res. Part A Policy Pract.* **2022**, *158*, 271–284.
73. Sato, K.; Kobayashi, S.; Yamaguchi, M.; Sakata, R.; Sasaki, Y.; Murayama, C.; Kondo, N. Working from home and dietary changes during the COVID-19 pandemic: A longitudinal study of health app (CALO mama) users. *Appetite* **2021**, *165*, 105323.
74. Ku, A.L.; Qiu, Y.L.; Lou, J.; Nock, D.; Xing, B. Changes in hourly electricity consumption under COVID mandates: A glance to future hourly residential power consumption pattern with remote work in Arizona. *Appl. Energy* **2022**, *310*, 118539.
75. Evans, S.; Alkan, E.; Bhangoo, J.K.; Tenenbaum, H.; Ng-Knight, T. Effects of the COVID-19 lockdown on mental health, wellbeing, sleep, and alcohol use in a UK student sample. *Psychiatry Res.* **2021**, *298*, 113819. [CrossRef]

76. Every-Palmer, S.; Jenkins, M.; Gendall, P.; Hoek, J.; Beaglehole, B.; Bell, C.; Stanley, J. Psychological distress, anxiety, family violence, suicidality, and wellbeing in New Zealand during the COVID-19 lockdown: A cross-sectional study. *PLoS ONE* **2020**, *15*, e0241658. [CrossRef] [PubMed]
77. Kumaresan, A.; Suganthirababu, P.; Srinivasan, V.; Chandhini, Y.; Divyalaxmi, P.; Alagesan, J.; Vishnuram, S.; Ramana, K.; Prathap, L. Prevalence of burnout syndrome among Work-From-Home IT professionals during the COVID-19 pandemic. *Work.-A J. Prev. Assess. Rehabil.* **2022**, *71*, 379–384. [CrossRef] [PubMed]
78. Sutarto, A.; Wardaningsih, S.; Putri, W. Work from home: Indonesian employees' mental well-being and productivity during the COVID-19 pandemic. *Int. J. Workplace Health Manag.* **2021**, *14*, 386–408. [CrossRef]
79. Standen, P.; Daniels, K.; Lamond, D. The home as a workplace: Work-family interaction and psychological well-being in telework. *J. Occupational Health Psych* **1999**, *4*, 368–381. [CrossRef]
80. Di Fusco, S.; Spinelli, A.; Castello, L.; Mocini, E.; Gulizia, M.; Oliva, F.; Gabrielli, D.; Imperoli, G.; Colivicchi, F. Impact of working from home on cardiovascular health: An emerging issue with the COVID-19 pandemic. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1882. [CrossRef]
81. Lunde, L.K.; Fløvik, L.; Christensen, J.O.; Johannessen, H.A.; Finne, L.B.; Jørgensen, I.L.; Vleeshouwers, J. The relationship between telework from home and employee health: A systematic review. *BMC Public Health* **2022**, *22*, 1–14. [CrossRef]
82. Vaddadi, B.; Ringenson, T.; Sjöman, M.; Hesselgren, M.; Kramers, A. Do they work? Exploring possible potentials of neighbourhood Telecommuting centres in supporting sustainable travel. *Travel Behav. Soc.* **2022**, *29*, 34–41. [CrossRef]
83. Mayer, B.; Boston, M. Residential built environment and working from home: A New Zealand perspective during COVID-19. *Cities* **2022**, *129*, 103844. [CrossRef]
84. Hafermalz, E.; Riemer, K. Productive and connected while working from home: What client-facing remote workers can learn from telenurses about "belonging through technology". *Eur. J. Inf. Syst.* **2021**, *30*, 89–99. [CrossRef]
85. Hylmö, A. Telecommuting and the contestability of choice: Employee Strategies to Legitimize Personal Decisions to Work in a Preferred Location. *Manag. Commun. Q.* **2006**, *19*, 541–569. [CrossRef]
86. Anderson, A.J.; Kaplan, S.A.; Vega, R.P. The impact of telework on emotional experience: When, and for whom, does telework improve daily affective well-being? *Eur. J. Work. Organ. Psychol.* **2015**, *24*, 882–897. [CrossRef]
87. Phelps, C.; Moro, C. Using live interactive polling to enable hands-on learning for both face-to-face and online students within hybrid-delivered courses. *J. Univ. Teach. Learn. Pract.* **2022**, *19*, 8.
88. Hews, R.; McNamara, J.; Nay, Z. Prioritising lifeload over learning load: Understanding post-pandemic student engagement. *J. Univ. Teach. Learn. Pract.* **2022**, *19*, 128–146. [CrossRef]
89. Phan, T.T.T.; Vu, C.T.; Doan, P.T.T.; Luong, D.H.; Bui, T.P.; Le, T.H.; Nguyen, D.H. Two decades of studies on learning management system in higher education: A bibliometric analysis with Scopus database 2000–2020. *J. Univ. Teach. Learn. Pract.* **2022**, *19*, 9.
90. Moore, J.L.; Dickson-Deane, C.; Galyen, K. e-Learning, online learning, and distance learning environments: Are they the same? *Internet High. Educ.* **2011**, *14*, 129–135. [CrossRef]
91. Osterman, K.F. Students' need for belonging in the school community. *Rev. Educ. Res.* **2000**, *70*, 323–367. [CrossRef]

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The Effect of Cognitive Load on Learning Memory of Online Learning Accounting Students in the Philippines

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Abstract: Before COVID-19, universities in the Philippines sparingly used online learning instructional methods. Online learning is now widely known, and universities are increasingly keen to adopt it as a mainstream instructional method. Accounting is a popular discipline of study undertaken by students, but its online adoption is less well known. This study investigated university accounting students' perceptions of the cognitive load of learning and how it influences their effect on learning memory at a university in the Philippines. During the COVID-19 period, after introducing online learning, 482 university undergraduate accounting students provided their perceptions using a five-point Likert scale survey questionnaire. The study measured teaching quality, learning content quality, and learning management system (LMS) quality, representing the cognitive load of learning. It measured electronic learning (e-learning) quality, learner satisfaction, and behavioral intentions to adopt online learning, continually representing the learning memory framework. The data analyzed using a structural equation model showed that students managing their cognitive load positively influenced their short-term learning. Learning content, teaching, and LMS quality positively influenced e-learning quality and student satisfaction. Student satisfaction positively influenced, but e-learning quality did not influence, students' continued willingness for online learning. The findings were largely consistent across the second- and third-year enrolments. Findings from the first-year students showed that teaching quality did not influence student satisfaction and e-learning quality. This is the first study to test the influence of the cognitive load of learning on the learning memory of accounting students in an online learning environment.

Keywords: accounting; cognitive learning theory; human memory; Philippines; online learning; quality education; reduced inequalities; sustainable development goals

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1. Introduction

If a single thread could interconnect all 17 United Nations Sustainable Development Goals (SDGs), it would be SDG 4 Quality Education for all. Education is a silver line that can transform oppression into emancipation and deprivation into abundance (Power, 2015) [1]. Higher education occupies a special place because it is where the best minds congregate to generate sustainable ideas and address social inequalities. In view of this, higher education must reach out to as many people as possible who wish to receive an education (Kromydas, 2017) [2].

There were three motivations for undertaking this study. First, online educational delivery can introduce variability in the quality of education (Chen et al., 2020) [3]. Traditional universities are likely to consider online learning less productive, especially if they have not previously adopted it (Means, 2009) [4]. Second, the digital divide can drive the recipients of education, and it is especially relevant to developing countries such as the Philippines,

where social inequality is a deciding barrier to undertaking education (Dhawan., 2020) [5]. Online education can help reduce social inequality. However, developing countries such as the Philippines face special challenges in the adoption of online learning. These include unstable Internet connectivity, inadequate learning resources available for online learners, electrical power interruptions, and limited teacher scaffolds. Online students can encounter responsibilities at home that conflict with their learning efforts and a poor learning environment (Rotas & Cahapay, 2020) [6]. Third, online learning has both positive and negative aspects for students and universities; however, it is unknown where Philippine universities stand.

On the positive axiom, online learning is excellent for self-directed students and encourages lifelong learning. Travel time to universities is eliminated, and students and teachers can save time and resources. Virtual interaction games can be introduced more seamlessly into online learning environments (Mukhtar et al., 2020; Skulmowski & Xu, 2022) [7,8]. On the negative axiom, it is much harder to read students' nonverbal cues to determine whether they understand the learning material being taught. Students can develop a shorter attention span because of more distractions in their chosen learning environment. There are also challenges to upholding academic integrity because students are virtually monitored and not physically observed (Barrot et al., 2021; Mukhtar et al., 2020) [7,9].

The positive aspects of online educational delivery can increase student motivation and engagement, whereas the negative aspects can decrease it. However, these factors can influence student cognitive load differently, which is a measure of ease or difficulty in learning imposed by teaching quality, learning content quality, and learning management system (LMS) quality. Taking advantage of the online learning environment and effectively balancing student cognitive load is crucial yet ill-understood (Skulmowski & Xu, 2022) [8]. The Philippines has a large number of young people, with a median age of 25 years. They are at the height of receiving quality education to become productive citizens (Worldometer, 2023) [10].

This study aims to fill this research gap by understanding how university accounting students in the Philippines perceive teaching quality, learning content quality, and LMS quality, and their effects on short-term learning memory measured as electronic learning (e-learning) quality and student satisfaction. Additionally, LMS quality and student satisfaction can influence students' propensity to engage in online learning and increase long-term learning memory, which is a crucial parameter for universities to continue online education. The study chose the Philippines as a research location because it shares common characteristics of the online learning environments of developing countries where the digital divide has disadvantaged people accessing information and learning through hardware and software (Rotas & Caha-pay, 2020) [6].

Studies have contributed to understanding and highlighting online delivery in tertiary education. This study contributes to the ill-understood area in this domain by focusing on students' perceptions of online learning in accounting education. Learning accounting subjects requires building complex memory patterns known as schemas (Abeysekera & Jebeile, 2019; Blaney et al., 2016) [11,12]. Previous research conducted at a university in the Middle East has shown that accounting students are better supported by participation and collaboration in traditional learning than in online learning environments (Shabeeb et al., 2022) [13]. The study findings differ due to national societal and cultural settings and how online learning was designed and implemented. To develop a deeper understanding, this study focuses on undergraduate accounting students at a university in the Philippines. This study established student perceptions and satisfaction levels that can help understand the behavioral intentions of students undertaking continuing studies under online delivery. This study was conducted during the COVID-19 2020–2021 academic year in the Philippines and addressed the following eight questions.

(1) To what extent does teaching quality influence e-learning quality?

(2) To what extent does teaching quality influence student satisfaction?

(3) To what extent does learning content quality influence e-learning quality?
(4) To what extent does learning content quality influence student satisfaction?
(5) To what extent does LMS quality influence e-learning quality?
(6) To what extent does LMS quality influence student satisfaction?
(7) To what extent does e-learning quality influence continuing online learning adoption?
(8) To what extent does student satisfaction influence continuing online learning adoption?

The Philippine Republic Act No. 11469, also known as the "Bayanihan to Heal as One Act", was responsible for the response of the Philippine government to COVID-19. The Commission on Higher Education (CHED) adopted and promulgated Resolution No. 412–2020 of the Act that outlined the Guidelines on Flexible Learning (FL) to be implemented by the Higher Education Institutions (HEIs) (CHED Memo No. 4, 2020) [14]. The memorandum in the CHED defined online learning as a pedagogical approach that allows flexibility of time, place, and audience, including, but not solely focused on, the use of technology. The university in this study opened its academic year in August 2020 despite the ongoing pandemic crisis. In pursuing academic excellence, it provides online education to all its students, including those in the accountancy degree. The online instruction was conducted using the learning management system (LMS) Canvas and was used by the faculty staff and students.

The next section discusses the literature on student online learning to show the importance of fulfilling the research aims. Section 3 presents theoretical frameworks—cognitive learning theory and learning memory framework—and states the hypotheses tested using structural equation modeling. Section 4 presents the methodology for data collection using a five-point Likert scale survey questionnaire. Section 5 presents the findings and discusses their implications for higher education. The final section presents the concluding remarks with implications for policymakers, theory, methodology, limitations that bound result interpretation, and future research propositions.

2. Review of the Literature

Online learning has a sporadic history that took root in widespread adoption during COVID-19. During the early adoption periods, the focus was on whether students accepted the environment as a learning environment. Instrument scales were developed to measure the usefulness and ease of use of hardware (Davis, 1989) [15]. Students who have undertaken online learning perceived their strengths and weaknesses. Strengths include a sense of independence in choosing their study time and style and being at ease in their comfort whilst learning. Students feel lonely and unsupported when they learn without physical peers. Successful online learning requires self-discipline and a firm commitment to learning (Song et al., 2004) [16].

The availability and readiness of the online learning environment influenced positive feedback (Almahasees et al., 2021) [17]. These included computer hardware, software, and connectivity (wired and wireless Internet), not just hardware a few decades ago (Davis, 1989) [15]. Students were less motivated and interacted less during online learning (Almahasees et al., 2021) [17]. A study revealed that only one-third of the students had a positive opinion of online learning, while the other two-thirds had negative or undecided opinions. A total of 69.4% of students who used online learning complained about technical difficulties. Teachers did not use the full features of a learning platform, leading to negative student views. A total of 60.5% of students reported cognitive difficulty in processing information for learning (Coman et al., 2020) [18].

The cognitive difficulties arose from instructional methods adopted by teachers where students found more theoretical than practical learning content, and infrastructure inflexibility was associated with the LMS. Students admitted that they share responsibility for developing favorable perceptions, as their ill-preparedness with using the LMS and not balancing their studies with family and work life have contributed to adverse perceptions (Dhawan, 2020) [5].

Research has proposed that overcoming student cognitive difficulties in online learning could facilitate students to perceive online learning positively and receive a satisfactory experience. The proposed techniques included providing frequent breaks to students, combined with other learning methods, such as the flip classroom approach, to shorten lectures and increase interactions. It also proposed that the government improve Internet speed and access (Mukhtar et al., 2020) [7]. Although studies have not commented on the LMS, its infrastructure functionality can influence student perception and satisfaction with online learning and help them perceive it as a helpful learning platform. It must also be easy to use with the least amount of effort. A study evaluating the LMS used by medical staff found that 77.1% of staff perceived it as helpful to their learning and 76.5% found it easy to use (Zalat et al., 2021) [19]. These factors increased LMS's perceived usefulness and ease of use, which can increase students' online learning perception and learning satisfaction.

Table 1 summarizes the research interconnected by citations. These publications show that the early focus of online learning was on hardware (Davis, 1989) [15], and its importance has now re-emerged (Zalat et al., 2021) [19]. The emergence was in the context of what software is possible for online learning, such as Zoom, Microsoft Teams, and WhatsApp platforms (Almahasees et al., 2021; Almahasees et al., 2020) [17,20]. These platforms have increased the possibilities of degree offerings and teaching methods (Pokhrel & Chhetri, 2021) [21], which has broadened the online education outlook (Zhang et al., 2022) [22].

The quality of online learning is at the forefront (Ehlers & Pawlowski, 2006) [23], evaluating advantages and disadvantages (Mukhtar et al., 2020) [7]. Research is actively evaluating the perceptions of faculty staff (Al-Salman & Haider, 2020; Zalat et al., 2021) [19,24] and students (Coman et al., 2020) [25], with a special focus on adolescents (Elashry et al., 2021) [26] and university students (Asif et al., 2022) [27].

Studies have identified specific ways to refine their investigations of online learning effectiveness (Fox et al., 2023; Elalouf et al., 2022) [28,29], acknowledging that engagement, perception, and satisfaction are separate constructs leading to different implications in pedagogy (Coman et al., 2020; Dubey, 2023; Sumilong, 2022) [25,30,31]. Research has investigated the logistical support required (Alammary, 2022; Assadi & Kashkosh, 2022) [32,33] with government interventions to improve online education to improve supporting infrastructure (Daher et al., 2023) [34].

Online learning can be offered in synchronous, asynchronous, and hybrid modes. The increasingly available tools to prepare learning content and delivery of content have enabled students to learn with faculty staff teaching them at scheduled times. However, the synchronous learning mode can become inconvenient for students who cannot fit into scheduled times, such as working students. The asynchronous mode can accommodate a wider range of students because learning materials are pre-recorded to access students' convenience for learning. Research has shown that control-oriented students are more engaged in the synchronous mode, and autonomous-oriented students are more engaged in the asynchronous mode (Giesbers et al., 2014) [35]. A study conducted during the COVID-19 period showed that students were more satisfied with asynchronous learning than with synchronous learning. The authors proposed that teaching institutions use LMS infrastructure that students can use and continuously update learning materials for effective online learning [36]. These studies have highlighted the importance of investigating student perception and satisfaction in developing countries that began introducing online learning on a large scale, such as the Philippines.

Table 1. A subset of relevant literature.

	Authors	Research Investigation of Online Learning
1	Davis (1989) [15]	Ease of Use and Acceptance of Information Technology
2	Ehlers and Pawlowski (2006) [23]	Quality of online learning. Quality is more highly perceived than face-to-face learning
3	Dhawan (2020) [5]	Importance of Online Learning as a Learning Platform
4	Mukhtar et al. (2020) [7]	Advantages, limitations, and recommendations
5	Almahasees et al. (2020) [20]	Facebook as a Learning Platform
6	Al-Salman and Haider (2020) [24]	Staff perceptions of Online Learning
7	Coman et al. (2020) [25]	Student perspectives on Online Learning
8	Almahasees et al. (2021) [17]	Usefulness of Zoom, Microsoft Teams, offering online interactive classes, and WhatsApp as online platforms
9	Pokhrel and Chhetri (2021) [21]	Must innovate and implement alternative learning platforms, such as online learning
10	Elashry et al. (2021) [26]	Adolescent Perceptions and Academic Stress
11	Zalat et al. (2021) [19]	Staff Acceptance of Online Learning as a tool
12	Alammary (2022) [32]	Toolkit to support blended learning degrees
13	Daher et al. (2023) [34]	Government intervention and leadership to promote online learning among students and teachers
14	Assadi and Kashkosh (2022) [33]	Strategies used by teacher trainers to address the technological, pedagogical, social, and emotional challenges of student–teacher interactions
15	Asif et al. (2022) [27]	University students' perceptions
16	Elalouf et al. (2022) [29]	Student perception of learning structured query language through online and face-to-face learning
17	Sumilong (2022) [31]	Students' self-expression, participation, and discourse
18	Zhang et al. (2022) [22]	A metaverse for education that includes online learning for blended, competence-based, and inclusive education
19	Fox et al. (2023) [28]	Efficacy of online learning for degree studies: Mental health recovery for carers
20	Dubey (2023) [30]	Factors behind student engagement in online learning
21	Giesbers et al. (2014) [35]	Student Engagement with synchronous and asynchronous online learning
22	Dargahi et al. (2023) [36]	Student satisfaction with synchronous and asynchronous online learning

3. Theoretical Framework and Hypothesis Development

3.1. Theoretical Framework

Survival-oriented learning to build primary knowledge is an important genetically driven aspect of learning, but it is not considered here (Sweller et al., 2011, pp. 3–14) [37]. Providing new knowledge, preparing students for the workforce, and making ideal contributions to society are the focus of higher education institutions to which this study has drawn attention (Chan, 2016) [38]. Student learning requires the use of cognitive resources that interact with instructional and learning resources to attain learning efficiencies. According to cognitive learning theory (CLT), learning efficiencies can be attained through two methods of efficiently managing cognitive loads. The intrinsic cognitive load arises from the intrinsic nature of the instructional material, which must be decreased. The extrinsic cognitive load that arises from how learning materials are presented to students must be decreased. Germane processing is the students' effort to store knowledge in short-term and long-term memory by developing memory patterns known as schema, and pedagogy facilitates building and increasing schema (Jiang & Kalyuga, 2020; Sweller et al., 2019) [39,40].

The teaching quality of faculty staff represents the intrinsic cognitive load aspect as they can take the lead in making harder learning content easier for students. The LMS quality in an online learning platform represents the extraneous cognitive load aspect as a usable LMS can assist students in learning. The learner's effort to process learning content and automate it into memory patterns becomes schema representations. A high learning content quality can ease the amount of students' learning content to process, which can support the germane load to learn.

The Human Memory System Framework shows that appropriately assorting schema occurs through the sensory system and should be sufficiently receptive to the students' receptive system to draw attention to learning. After passing the sensory system, students build schema or patterns (or configurations) of memory and hold them in the working memory store, which is a short-term memory reserve. The highest learning efficiency occurs when short-term memory is transformed into long-term memory with lasting schemas (Atkinson & Shiffrin, 1968) [41]. The amount of information and the amount the learner knows impacts memory retention (Miller, 1956) [42]. There are two parties in the learning contract: pedagogies managing intrinsic and extraneous cognitive load and learners managing germane processing. The amount of information can become a variance in learning, and reducing the variance by providing information that the learner can accommodate can assist in memory building. The human memory system is unified in encoding, storing, and retrieving; however, there is a qualitative difference in retrieving between short- and long-term memory. Neurologically, the anterior frontal cortex plays a role in retrieving long-term episodes by judging remembrances (Nee et al., 2008) [43]. Short-term or working memory is only an episodic buffer. Although intimately linked with long-term memory, short-term memory does not simply represent an activation of long-term memory, but rather a gateway to it (Baddeley, 2000) [44].

As shown in Figure 1, this study combined the cognitive load theory and human memory system framework to build a theoretical model. The model became the benchmark for testing the data collected from students regarding online learning perceptions. This study investigated whether managing cognitive load causally influences learners' memory retention in an online learning environment.

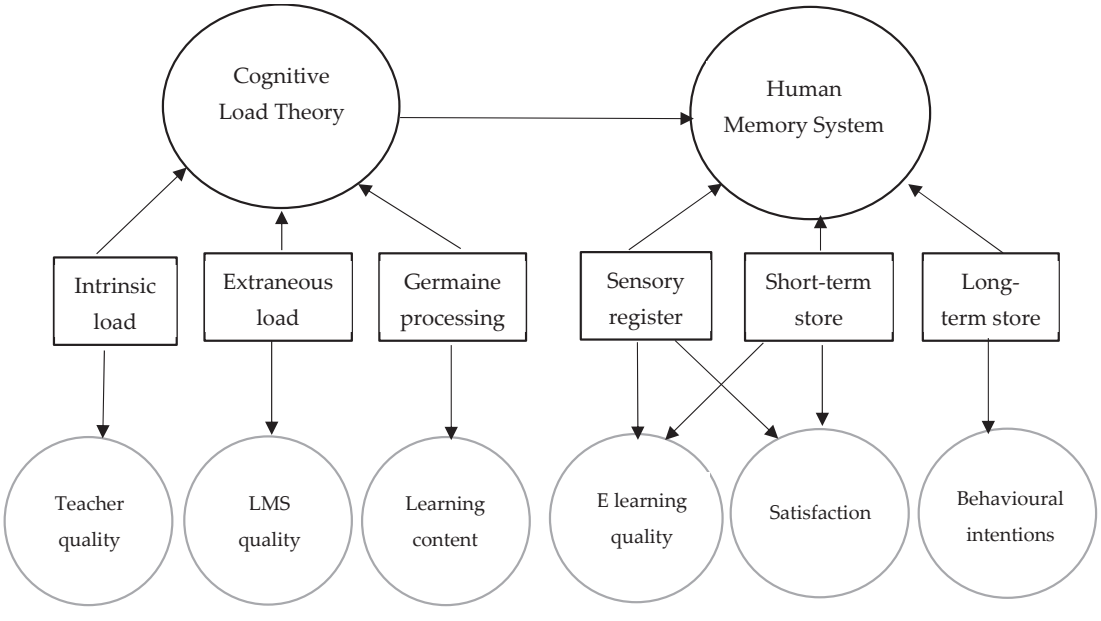

Figure 1. Theoretical framework.

This study translated the cognitive load theory and human memory system framework theoretical dimensions to develop a theoretical model. In that, it identified the teaching quality to represent the intrinsic cognitive load, the LMS quality to represent the extraneous cognitive load, and the learning content quality to represent the germane load. The sensory register and short-term learning stored in the working memory were measured using objectively based e-learning quality and subjectively based student satisfaction. The long-term store of memory was measured using student behavioral intentions to adopt online learning for their continuing studies.

Online teaching using digital technology offers many benefits over traditional face-to-face teaching models. It can offer virtual reality closer to what is happening in workplaces, allowing interactions to increase learning and gain near-practical experience while learning online. Interactive quizzes and assessments can provide real-time personalized feedback. However, LMS design factors can increase extraneous cognitive load. These two cognitive loads, intrinsic and extraneous, can influence the germane processing load in learning. For example, too much immersion in a single online task can deplete learners' germane processing, decreasing overall learning efficiency (Frederiksen et al., 2020) [45].

The five design factors used in online learning are as follows: (1) interactive learning media (interaction leads to remembering and understanding the learning content); (2) immersion (believable digital environment that makes one forget the real environment); (3) realism (realistic and schematic visualizations); (4) disfluency (avoiding non-readable fonts); and (5) emotional (affective aspects of learning) design, which commonly aim to decrease extraneous load on learners so that they can easily use different forms of germane processing (such as verbal, mathematical, or procedural processing) to increase learning efficiency. Student learning can then be formally assessed by considering the germane processing aspects used by students for learning (Skulmowski & Xu, 2022) [8].

Figure 2 shows the conceptual framework in which the tested data fit the hypothesized model (Theresiawati et al., 2020) [46]. Three exogenous constructs exist: teacher quality, LMS quality, and learning content quality. The exogenous constructs represent the CLT. The theoretical framework noted that these three constructs influence e-learning quality and learner satisfaction. E-learning quality is whether it meets learners' objective expectations. Satisfaction refers to learners' feelings arising from comparing their perceptions with expectations and measuring subjective expectations. This study argues that these learning efficiencies, by improving cognitive load, can lead to improved working memory. However, the ultimate learning efficiency occurs in the e-learning quality, and student satisfaction contributes to building students' long-term learning memory by developing learning schemas (patterns). The study argued that such long-term learning efficiencies lead to behavioral intentions encouraging students to continue using online learning (Theresiawati et al., 2020) [46].

Teaching quality comprises four dimensions: (1) Assurance is a guarantee that faculty staff have knowledge and understanding of the learning materials provided to guide students to obtain a sense of confidence in their learning. Faculty staff should be fair and objective in assessing students' learning achievements and capabilities. (2) Responsiveness refers to the faculty staff's willingness to help and respond quickly and efficiently to the needs of students by answering their questions and assisting them in problem-solving activities. (3) Reliability refers to the consistency of lecturers in providing materials to the curriculum set by the study. (4) Empathy includes faculty staff's concern for students and their encouragement and motivation to do their best (Udo et al., 2011; Uppal et al., 2018) [47,48]. Usability indicators measure LMS quality. Usability represents the physical facilities of the LMS, including various learning activities, ease of use and accessibility of the e-learning user interface, and ease of management by students (Udo et al., 2011; Uppal et al., 2018) [47,48]. Learning content quality refers to the availability of materials and services directly related to student learning outcomes (Uppal et al., 2018; Cao et al., 2005) [1,48].

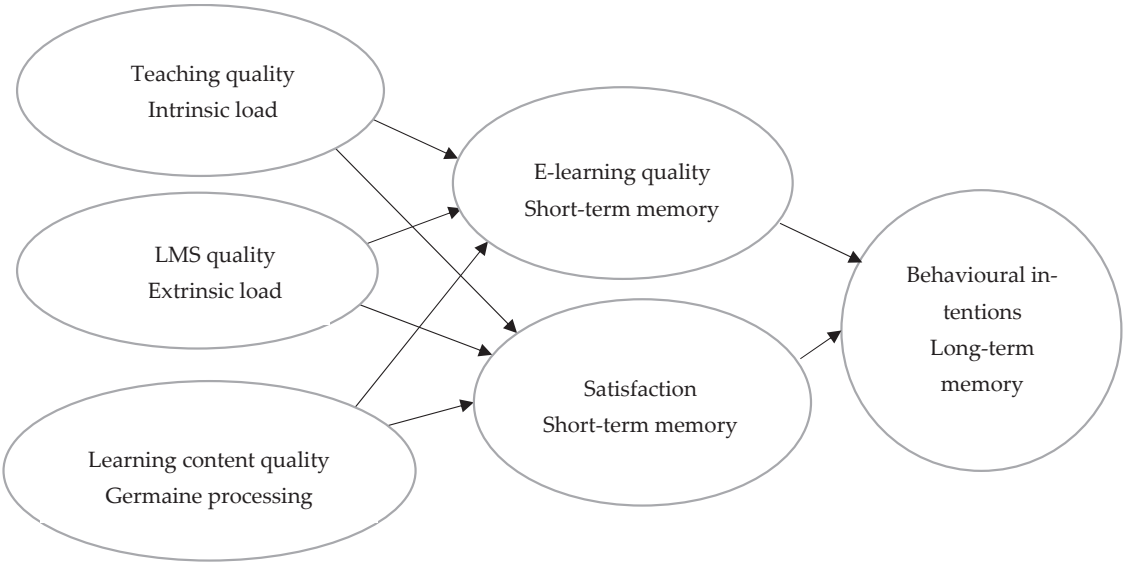

Figure 2. Conceptual model.

E-learning quality is about the availability of instructions to use e-learning aspects that are continually updated and are clear and adequately described. Satisfaction refers to student satisfaction with the decision to use an e-learning system and environment. Behavioral intention describes the intention of users to continue using online learning (Udo et al., 2011; Uppal et al., 2018) [47,48].

3.2. Hypotheses

From the above discussion, the following hypotheses were resolved to test the theoretical model.

3.2.1. Teaching Quality

Although teachers are not at the forefront of teaching as in face-to-face classroom environments, their importance in students' learning quality and satisfaction remains the same through the assurance, responsiveness, reliability, and empathy provided to students with cognitive, mental, and emotional support to positively influence e-learning quality and student satisfaction. A high teaching quality can decrease the intrinsic cognitive load on students' learning and positively influence e-learning quality and student satisfaction with online learning. Therefore, the following two hypotheses are proposed.

Hypothesis H1a: Teacher quality is positively correlated with e-learning quality.

Hypothesis H1b: Teacher quality is positively correlated with student satisfaction.

3.2.2. LMS Quality

An up-to-date, easy-to-use LMS can facilitate student learning by decreasing their extraneous cognitive load, thereby increasing e-learning quality and student satisfaction. Hence, the following two hypotheses are proposed.

Hypothesis H2a: LMS quality is positively correlated with e-learning quality.

Hypothesis H2b: LMS quality is positively correlated with student satisfaction.

3.2.3. Learning Content Quality

Learning content quality represents the ease of processing learning content for student learning. Hence, the following two hypotheses are proposed.

Hypothesis H3a: Learning content quality is positively correlated with e-learning quality.

Hypothesis H3b: Learning content quality is positively correlated with student satisfaction.

3.2.4. E-Learning Quality

E-learning quality can increase students' short-term storage (working memory). E-learning quality positively influences long-term memory storage, leading to students wanting to use online learning.

Hypothesis H4: E-learning quality is positively correlated with behavioral intentions.

3.2.5. Student Satisfaction

Student satisfaction can increase students' short-term storage (working memory). Student satisfaction can positively influence long-term memory storage, leading to students wanting to use online learning.

Hypothesis H5: Student satisfaction is positively correlated with behavioral intentions.

4. Methodology

4.1. Participants and Sampling

As part of a larger study in a business school, the participants of this study were undergraduate students enrolled in the accountancy degree at a university in the Philippines, with 482 participants in the 2020–2021 academic year: 80 students in the first year (16.6%), 195 students in the second year (40.4%), and 207 students in the third year (43%) of enrolment. Of the 482 students, 392 (81%) were female and 90 (19%) were male.

This was the first time that the University introduced online learning to students and used synchronized learning to resemble face-to-face learning environments. The teaching was conducted live stream, and students were required to attend online classes, have spontaneous and immediate interactions, and build an online learning community (Daher et al., 2023; Giesbers et al., 2014) [35,36].

4.2. Survey Instrument

This study used a survey instrument used in Indonesia (Theresiawati et al. (2020) [46]. As a neighboring country to the Philippines, the Indonesian setting had more societal–cultural similarities (Hudjashov et al., 2017) [49]. However, before using the survey questions, they were pre-tested for content and face validity by four academic staff members in the Philippines for the Philippines university setting.

All questions were presented on a 5-point Likert scale, except for those that collected demographic data from the respondents. The questionnaire has seven (7) parts, namely: (Part 1) Teaching quality construct measured using assurance, empathy, responsiveness, and reliability; (Part 2) Learning Management Systems (LMS) quality construct measured for its usability; (Part 3) Learning content quality was measured for features presented in it such as videos, audios, and animation, as a single construct; (Part 4) E-learning quality measured for its usage for updated and clear instructions contained, as a single construct; (Part 5) Satisfaction comprised students experience, decision to enroll in online learning, and was measured as a single construct; and, (Part 6) Behavioral intention measured for recommending it to others, continue using it, and as a single construct. Part 7 of the questionnaire obtained students' personal information about gender, study location, and enrolment year and degree type.

Although the instrument has been validated in Indonesia, the study conducted validity and reliability tests to obtain the validity and reliability of the collected data before conducting theoretical model testing using structural equation modeling (SEM). SEM requires valid and reliably represented constructs as a pre-condition. Table 2 shows the preparedness of the data for structural equation modeling. The study tested preparedness by factor analysis of indicators to determine whether they represent underlying constructs in the hypothesized model.

Table 2. Validity and reliability measurements of the constructs.

Construct	Number of Indicators	KMO Test	Bartlett Test	Cronbach Alpha
Teaching Quality				
Assurance (AS)	4	0.80	668(6) ***	0.82
Empathy (EM)	4	0.82	921(6) ***	0.87
Reliability (RS)	3	0.72	577(3) ***	0.83
Responsiveness (RE)	3	0.72	565(3) ***	0.83
LMS Quality—Usability (US)	4	0.82	1002(6) ***	0.88
Learning Content (LC) Quality	3	0.81	1011(6) ***	0.87
E-learning quality	3	0.75	771(3) ***	0.88
Satisfaction	3	0.72	860(3) ***	0.88
Behavioral intentions	3	0.70	679(3) ***	0.84

*** indicates statistical significance at 1%.

The Kaiser–Meyer–Olkin (KMO) test shows the adequacy of indicators for factor analysis. The indicators must have less common variance and more unique variances to qualify for factor analysis. This shows that each indicator distinctly contributes to the underlying construct. A KMO output of more than 0.8 indicates an excellent contribution and a KMO output of over 0.7 indicates a good contribution. All indicators met the KMO output benchmark for constructs (Shkeer & Awang, 2019) [50].

The Bartlett sphericity test determined whether the correlation among indicators was unrelated and unsuited for factor analysis. This is known as the search for identity matrix, and if the indicators are related, they become suitable for factor analysis. As shown in the table, the statistically significant values computed for indicators with the chi-square test (and degree of freedom) showed that the indicators are suitable for factor analysis (Chatzopoulos et al., 2022; Rossoni et al., 2016) [51,52].

A construct becomes valid only if it is reliable. Validity is not a pre-condition for reliability, but reliability is a pre-condition for validity. The variance shared by indicators (or covariance) for that construct measured the reliability of the underlying construct. This means that indicators are interconnected or correlated with each other. Cronbach's alpha measures reliability based on these underlying principles. A low Cronbach alpha value can occur because of the low interconnectedness of indicators, a low number of indicators representing the construct, or the heterogeneity of the construct. An acceptable alpha value is 0.7. All reported values were greater than 0.7 (Tavakol & Dennick, 2011) [53].

4.3. Data Collection

Google Forms are widely used to collect survey data, which this study used. The questionnaire was uploaded through Google Forms, and the link was sent to the respondents via a messenger group through the help and efforts of the faculty. In collecting data, the study took steps to decrease social desirability bias where students could give favorable answers to appease the faculty staff and the university. Accounting students have higher moral codes, which could discourage them from acting unethically (Nguyen

&, Dellaportas, 2021) [54]. The survey did not collect personally identifiable information where otherwise they could engage in providing more favorable answers than their actual perceptions (Grimm, 2010) [55]. The data gathered were summarized in Excel or CSV files for more accessible data analysis. The total number of respondents officially enrolled was obtained from the university registrar.

The questionnaire comprised the cover letter first, explaining the purpose and importance of the research. The researchers requested written permission from the respondents regarding the data to be gathered in the study. The university approved the ethics consent, and assent letters were shared with the respondents. All responses from the respondents were kept strictly confidential. Before implementing the research protocol, the researchers sought the respondents' approval regarding the research objective, including the importance of their participation in the study. The data obtained in the online survey form were appropriately protected and archived upon completion of the study.

4.4. Data Analysis

The study used SPSS Version 29 to organize and analyze the data. The software conducted the descriptive analysis, KMO and Bartlett Sphercity of Test, and Cronbach Alpha computations. SPSS Amos Version 28 was used to conduct structural equation modeling (SEM) by feeding in research data from SPSS Version 29.

As eight hypotheses are being tested, there are arguments that increased testing of hypotheses with null hypotheses set at 0.05% statistical significance can lead to the parameters estimated to be accepted as meeting the null hypothesis, which is a Type 1 error; in fact, it must be rejected. Bonferroni correction is proposed to remedy this by decreasing the statistical significance in proportion to the number of hypotheses tested (Cribbie, 2007) [56]. There are several reasons for keeping the statistical significance intact. First, research studies in SEM presume that Type 1 error does not increase, although multiple hypotheses are tested as in SEM. Second, the Bonferroni test sets 0.05% statistical significance for all hypotheses in the SEM model, considering each hypothesis tested is a family of those hypotheses. It sets the significance level at an extremely low level, where inferences can defy common sense. For instance, eight hypotheses are tested, and significance is set at 0.05/8 = 0.00625%. Third, the Bonferroni test decreases Type 1 error, meaning it increases Type 2 error, leading to accepting a result as true or correct, when it is not (Perneger, 1998) [57]. Hence, this study proceeds with conventional significance levels at the hypothesis level: 0.1% as weak, 0.05% as moderate, and 0.01% as strong.

5. Results and Discussion

5.1. Main Analysis

Figure 3 shows the graphical SEM output. The SEM achieved the minimum requirements and was statistically significant at 0.01%, with Chi-square = 1624.44 and a degree of freedom = 426 (i.e., 527 number of distinct sample moments − 101 number of distinct parameters to be estimated). Although the model fit, CMIN shows a statistical discrepancy between the SEM model and the underlying data structure because PCMIN/DF = 3.8 at 0.01% significance. An inflated PCMIN/DF is possible with a larger sample size of more than 250 observations. A value below three is excellent, and a value below five indicates that the hypothesized model can explain the data of this study (Marsh & Hocevar, 1985) [58].

The model fit to data was investigated using fit indices. The Comparative Fit Index Statistic (CFI) was 0.9, the Tucker–Lewis Index (TLI) was closer to 0.9 (0.9), and the Normed Fit Index was 0.9, showing a good fit as they were closer to 1. The root mean square error approximation (RMSEA) was 0.08, which is closer to zero, indicating that the square root of population misfit per degree of freedom was small (Hayashi et al., 2010, pp. 202–234) [59].

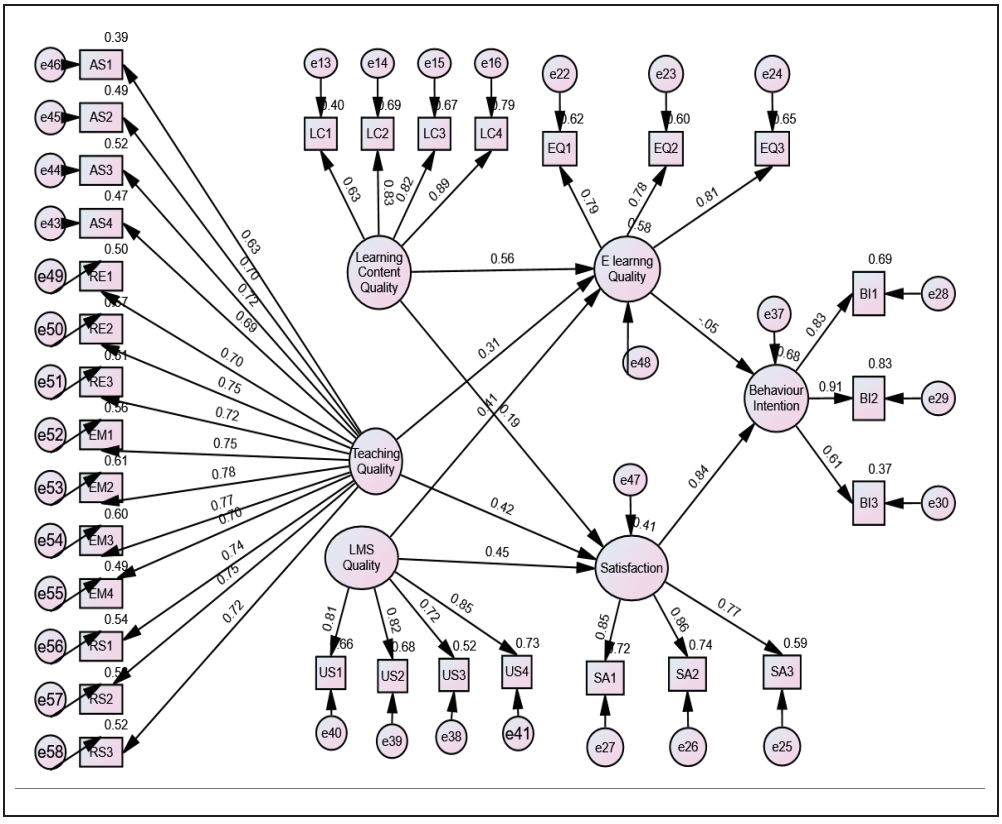

Figure 3. Structural Equation Model output with standardized regression coefficients.

Table 3 shows the coefficient values for each indicator. Structural equation analysis conducted using maximum likelihood estimates showed that all relationships are statistically and positively significant, except for the negative relationship between e-learning quality and behavioral intention.

The average variance extracted (AVE) was calculated manually by squaring each indicator for a given construct and computing the average value of the squared values added together because AMOS does not have the automated functionality to compute AVE. AVE indicates the amount of variance captured by the construct, rather than due to measurement errors resulting from the maximum likelihood estimates method conducted for the structural equation modeling computation. The AVE for Teaching Quality was 0.54, and the AVE for Learning Content Quality was 0.65. The AVE for e-learning quality was 0.65, satisfaction was 0.69, behavior indicator was 0.63, and LMS quality was 0.64. They were above 0.5, which showed acceptable convergent validity (Fornell & Larcker, 1981) [60]. The normality assessment of variables showed that kurtosis values were less than 5, with only variables reporting 1.4 and 1.1, and the remaining variables having values less than 1, which was confirmed using the maximum likelihood technique for data analysis in the model (Bentler, 2005) [61].

Figure 3 and Table 3 show the indicators well informed the measurement of the Teaching Quality with regression estimates of more than 0.5. However, teaching quality was influenced by 0.11 on e-learning quality and 0.45 on student satisfaction. The University adopted online learning for accounting students for the first time, and the low regression coefficients indicate the capacity to improve teaching quality in the future to contribute

to improving e-learning quality and student satisfaction. Previous research has proposed using pictures, diagrams, and other visual aids to decrease the intrinsic cognitive load in accounting learning. Learning with multiple representations of content, such as visual (animations and pictures), auditory, and textual, can assist in decreasing the intrinsic cognitive load that is otherwise embedded in learning accounting subjects (Sithole et al., 2017) [60].

Table 3. Standardized coefficients for the full sample.

Constructs and Indicators			Estimate
ELQ	<---	LCQ	0.564 ***
Satisfaction	<---	LMSQ	0.445 ***
ELQ	<---	LMSQ	0.41 ***
Satisfaction	<---	LCQ	0.185 ***
ELQ	<---	TQ	0.308 ***
Satisfaction	<---	TQ	0.417 ***
BI	<---	ELQ	−0.05
BI	<---	Satisfaction	0.842 ***
LC1	<---	LCQ	0.634 ***
LC2	<---	LCQ	0.83 ***
LC3	<---	LCQ	0.819 ***
LC4	<---	LCQ	0.887 ***
EQ1	<---	ELQ	0.787 ***
EQ2	<---	ELQ	0.775 ***
EQ3	<---	ELQ	0.807 ***
SA3	<---	Satisfaction	0.766 ***
SA2	<---	Satisfaction	0.86 ***
SA1	<---	Satisfaction	0.85 ***
BI1	<---	BI	0.83 ***
BI2	<---	BI	0.91 ***
BI3	<---	BI	0.612 ***
US3	<---	LMSQ	0.72 ***
US2	<---	LMSQ	0.822 ***
US1	<---	LMSQ	0.81 ***
US4	<---	LMSQ	0.852 ***
AS4	<---	TQ	0.688 ***
AS3	<---	TQ	0.723 ***
AS2	<---	TQ	0.701 ***
AS1	<---	TQ	0.627 ***
RE1	<---	TQ	0.705 ***
RE2	<---	TQ	0.753 ***
RE3	<---	TQ	0.717 ***
EM1	<---	TQ	0.749 ***
EM2	<---	TQ	0.781 ***
EM3	<---	TQ	0.773 ***
RS3	<---	TQ	0.722 ***
RS1	<---	TQ	0.737 ***
RS2	<---	TQ	0.746 ***
EM4	<---	TQ	0.702 ***

*** indicates statistical significance at 1%.

The learning content quality indicators represented their construct well, with standardized coefficients over 0.5. Learning Content Quality had a positive influence on E-Learning Quality by 0.56. However, its influence on student satisfaction was 0.19. Learning content was objectively appropriate to improve e-learning quality, but the subjective evaluation of students was that it did not satisfy them well. Multiple factors lead to student satisfaction. They include behavioral, cognitive, and emotional aspects. Satisfaction results from online interaction, student acceptance of learning content efficacy, and student engagement with learning can all be influenced by the social-cultural aspects of a country (Nia et al., 2023) [62].

With standardized coefficients over 0.5, the indicators represented the LMS quality construct well. LMS quality had a low positive influence of 0.11 on e-learning quality and a moderate positive influence of 0.45 on student satisfaction. The results indicate that LMS quality can be improved by making it more usable to students. Usability can be enhanced through access, ease of use provided to students, and whether the system has sufficient features to increase student engagement and interaction (Nasir et al., 2021) [63].

With the standardized coefficients over 0.5, the indicators represented the behavioral intention well. Student satisfaction was strongly influenced with a 0.84 standardized coefficient toward their adoption of online learning on an ongoing basis. Well-designed online learning lessons and strengthened digital infrastructure are two key aspects that can contribute to improving students' behavioral intentions (Xu & Xue, 2023) [64].

5.2. Additional Analysis by Years of Study

Faculty staff at the introductory level of accounting in the first year of student enrolment face several challenges. The first year has large student enrolments, and students join the accounting degree with different motivations. It is the first year where students study at the university for the first time, where they find a large volume of learning to be completed in a short time (Jones & Fields, 2001) [65]. Students perceive that introductory accounting degrees are more difficult than other degrees (Opdecam & Everaert, 2012) [66].

Table 4 shows the additional analysis conducted to investigate whether there were any differences in student perceptions regarding the influence of cognitive load on learning memory by student enrolment year. Year one comprised 80 students, year two comprised 195 students, and year three comprised 207 students. A sample size greater than 100 with no missing data is sufficient for confirmatory factor analysis (Ding et al., 1995) [67]. Hence, the enrolment year 1 output is reported with a reservation for interpretation.

Table 4. Standardized coefficients by enrolment year.

Construct		Construct	Yr1 Estimate	Yr2 Estimate	Yr3 Estimate
ELQ	<---	LCQ	0.653 ***	0.573 ***	0.486 ***
Satisfaction	<---	LMSQ	0.465 ***	0.39 ***	0.494 ***
ELQ	<---	LMSQ	0.216 **	0.454 ***	0.482 **
Satisfaction	<---	LCQ	0.276 ***	0.14 *	0.189 ***
ELQ	<---	TQ	0.338	0.227 ***	0.253 ***
Satisfaction	<---	TQ	0.126	0.413 ***	0.41 ***
BI	<---	ELQ	−0.105	−0.022	−0.028
BI	<---	Satisfaction	0.891 ***	0.84 ***	0.825 ***
LC1	<---	LCQ	0.566 ***	0.628 ***	0.625 ***
LC2	<---	LCQ	0.823 ***	0.79 ***	0.831 ***
LC3	<---	LCQ	0.917 ***	0.79 ***	0.785 ***
LC4	<---	LCQ	0.925 ***	0.836 ***	0.89 ***
EQ1	<---	ELQ	0.716 ***	0.868 ***	0.75 ***
EQ2	<---	ELQ	0.856 ***	0.771 ***	0.73 ***
EQ3	<---	ELQ	0.86 ***	0.803 ***	0.774 ***
SA3	<---	Satisfaction	0.7 ***	0.772 ***	0.778 ***
SA2	<---	Satisfaction	0.881 ***	0.835 ***	0.859 ***
SA1	<---	Satisfaction	0.877 ***	0.793 ***	0.866 ***
BI1	<---	BI	0.857 ***	0.783 ***	0.869 ***
BI2	<---	BI	0.946 ***	0.921 ***	0.888 ***

Table 4. *Cont.*

Construct		Construct	Yr1 Estimate	Yr2 Estimate	Yr3 Estimate
BI3	<---	BI	0.687 ***	0.547 ***	0.611 ***
US3	<---	LMSQ	0.629 ***	0.769 ***	0.692 ***
US2	<---	LMSQ	0.878 ***	0.814 ***	0.787 ***
US1	<---	LMSQ	0.884 ***	0.794 ***	0.777 ***
US4	<---	LMSQ	0.931 ***	0.814 ***	0.849 ***
AS4	<---	TQ	0.677 ***	0.725 ***	0.575 ***
AS3	<---	TQ	0.785 ***	0.665 ***	0.697 ***
AS2	<---	TQ	0.68 ***	0.729 ***	0.609 ***
AS1	<---	TQ	0.548 ***	0.584 ***	0.537 ***
RE1	<---	TQ	0.673 ***	0.622 ***	0.69 ***
RE2	<---	TQ	0.761 ***	0.683 ***	0.733 ***
RE3	<---	TQ	0.68 ***	0.66 ***	0.685 ***
EM1	<---	TQ	0.632 ***	0.748 ***	0.705 ***
EM2	<---	TQ	0.768 ***	0.799 ***	0.701 ***
EM3	<---	TQ	0.708 ***	0.752 ***	0.702 ***
RS3	<---	TQ	0.687 ***	0.685 ***	0.734 ***
RS1	<---	TQ	0.791 ***	0.68 ***	0.749 ***
RS2	<---	TQ	0.708 ***	0.728 ***	0.71 ***
EM4	<---	TQ	0.7 ***	0.651 ***	0.672 ***

*** indicates statistical significance at 1%, ** indicates statistical significance at 5%, and * indicates statistical significance at 10%.

The models for enrolment years 1, 2, and 3 achieved the minimum requirements and were statistically significant at 0.01% and a degree of freedom = 426 (i.e., 527 number of distinct sample moments − 101 number of distinct parameters to be estimated). The Chi-square value was 742.91 for enrolment year 1, 912.09 for enrolment year 2, and 1034.39 for enrolment year 3. The model fit measured by CMIN/DF for year 1 was 2.3, year 2 was 2.1, and year 3 was 2.4, which showed an excellent fit of data with the hypothesized model with values being less than 3 [56]. The kurtosis values of indicators and constructs were less than five for the enrolment years 1, 2, and 3 samples, confirming normality and suitability to use the maximum likelihood technique [61].

The estimated values shown in Table 4 showed similar patterns across the years. However, in enrolment year 1, the ELQ and TQ relationship and the TQ and student satisfaction relationship were not statistically significant. Accounting terminology is typically introduced in the first year, which can increase student's cognitive load due to intrinsic load. Given these data relate to the first implementation of online learning, the teaching faculty staff were yet to perfect the teaching techniques to decrease extraneous cognitive load for first-year students (Sithole et al., 2017) [68]. Presenting accounting with texts and diagrams along with numbers has been shown to increase student learning by decreasing extraneous cognitive load (Seedwell & Abeysekera, 2017, chapter 1) [69].

In all three study years, E-Learning Quality had no statistical influence on behavioral intentions to adopt continuing online learning. Learning Content Quality had a weak statistically positive influence on learner satisfaction in the enrolment cohort. The BI and ELQ relationship was not statistically significant for all three years. All other relationships were statistically and positively significant at 1%.

6. Conclusions

In relation to CLT, the findings showed that H1a (teacher quality influence on e-learning quality) and H1b (teacher quality influence on student satisfaction) were supported. H2a (LMS quality on e-learning quality) and H2b (LMS quality on student satisfaction) were supported. H3a (learning content quality on e-learning quality) and H3b (learning content quality on student satisfaction) were supported.

In relation to the Human Memory System, H4 (e-learning quality on students' behavioral intentions) was not supported. H5 (student satisfaction on students' behavioral intentions) was supported. The previous Section discussed the implications for universities arising from the findings of the study. In conclusion, this study has highlighted the implications of the findings. These include public policy, theoretical, and methodological implications. In addition, this Section notes the study's limitations and future research propositions.

6.1. Public Policy Implications

The Philippines comprises over 100 million people, with a substantially younger population. It would be a huge benefit for the Philippines to make them more productive with knowledge and skills to increase gross domestic product. Online education has opened up possibilities to reach a wider population to share knowledge and skills, and universities can play a leading role in reaching the rural poor. There is a strong positive correlation between education and poverty reduction in the Philippines. However, online education requires national infrastructure support with accessible Internet and cheaper computer hardware and software. COVID-19 highlighted the digital divide, with only 14% of students in poor households having access to a computer or tablet and 16% having access to the Internet (Republic of the Philippines, 2023) [70]. The Philippine government must consider narrowing the digital divide and promoting online education, especially degrees such as accounting offered by universities that can lead to skill-based employment. The Philippine government can partner with universities, the private sector, and bilateral and multilateral agencies to achieve quality education (SDG 4) of sustainable development with informed social values such as increasing human dignity, equity, and efficiency. A clear policy analysis with a specific problem statement, such as increasing access to university education for the rural poor, an explicit policy analysis framework as to the strategies and how to operationalize them to bridge the gap to reach set targets, and a bibliographic evidence-based understanding of how to reach the targets can enable the Philippine government and its partners to create expected values by effectively expending resources (Vining & Weimer, 2005) [71].

6.2. Theoretical Implications

The COVID-19 period of online teaching provided important lessons for the university to reflect upon in order to continue online education and assist a greater student population with university education. Such offerings can decrease inequality (SDG 10) and improve quality education (SDG 4) toward sustainable development in the Philippines. The findings show that the university must reflect on how to decrease the intrinsic load in learning accounting. LMS quality can be improved to decrease extrinsic cognitive load and improve e-learning quality and student satisfaction. These can help increase students' working memory in learning, which can help to store their learning in short-term memory. The findings showed that student satisfaction strongly contributes to retaining their learning in the long-term memory. The results also showed that improving e-learning quality can substantially improve students' long-term memory. The findings show that managing student cognitive load improves the student memory framework, with positive statistical coefficients.

6.3. Methodological Implications

The indicators used in the study to represent teaching quality, LMS quality, and learning content quality showed that they strongly represent the chosen constructs, as evidenced by high standardized coefficients. The questions related to them in the questionnaire can serve as indicators to test student cognitive load. The indicators used to measure e-learning quality, student satisfaction, and behavioral intentions strongly represent these constructs. They can methodologically serve to represent student memory system measurements during learning.

6.4. Limitations

Most participants in the study were females, which bounded the findings. Although previous findings showed no clear preference for a single gender toward online learning, research evidence supports that female students are more perseverant, engaging, and self-regulated than male students. Male students use more learning strategies and have better technical skills (Yu, 2021) [72]. Other demographic factors such as student age, student prior knowledge about accounting, and personal and professional characteristics of the lecturer can influence the findings.

Second, the research was conducted at a single university in the Philippines that introduced online learning for the first time. The novelty of the pedagogical approach can influence the findings. Online teaching and learning have specific pedagogical knowledge contents and contexts related to designing and organizing better learning experiences. Online learning also requires creating digital environments that are different from face-to-face classroom learning environments. The study was conducted during the COVID-19 period; students had no choice but to study online, and situational factors may have influenced their perceptions. Perfecting these requires time and resources (Rapanta et al., 2020) [73].

Third, this study investigated the online learning of accounting undergraduate students. The limited available evidence shows that the level of digital exposure can influence the propensity for online learning. In such situations, blended learning can provide additional support (Simonds & Brocks, 2014) [74]. Educational disciplines can be categorized as hard-pure, hard-applied, soft-pure, and soft-applied, and research has found notable differences in the usage of digital tools among these discipline categories (Smith et al., 2008) [75].

6.5. Future Research

COVID-19 provided important lessons for introducing and continuing online learning for universities. First, future research can overcome the limitations encountered in this study to make further contributions to online learning. The limitations suggest that a future study should investigate the effects of student age, prior accounting knowledge, teacher characteristics, and their effects on students' short- and long-term learning memory.

Second, given that online education is known and widely practiced, students' perceptions may have changed since the COVID-19 period. A replicate study can compare results to determine what changes have taken place in relation to students' perceptions of the cognitive load of online learning and its effect on learning memory. This study investigated the synchronous learning setting. However, asynchronous learning settings where students can learn at their own pace through pre-recorded learning content can provide flexibility and include learners who cannot commit to specific learning times. A hybrid setting where pre-recorded learning content is offered followed by scheduled meetings for discussions with academic teaching staff can complement learners (Dargahi et al., 2023; Giesbers et al., 2014) [35,36]. A future study could compare synchronous, asynchronous, and hybrid learning settings to investigate the effect of cognitive learning on student learning memory.

Third, the findings showed that in the main model, teaching quality positively but moderately influenced e-learning quality and student satisfaction. As pointed out by the Cognitive Load Theory, inappropriate instructional formats can increase extraneous

cognitive load, making it harder for students to learn. This includes fewer faculty members' preparedness to teach online (Saha et al., 2021) [76]. A future study should investigate the effectiveness of teaching materials used in online teaching to increase e-learning quality and student satisfaction.

Fourth, the findings showed that e-learning quality had no statistically significant influence on encouraging students to embrace online learning. A contributing factor could have been the difficulty of teaching practical syllabuses such as accounting and the lack of direct contact students have with the faculty staff (Stecuła & Wolniak, 2022) [77]. A future study can investigate the effects of work-integrated learning on student learning memory systems.

Fifth, in this study, the learning outcome descriptor was short- and long-term memory. However, there are various descriptors related to learning outcomes. Degree qualifications, university-generic learning expectations, and funders' educational expectations can influence learning outcome descriptors (Gudeva et al., 2011) [78]. A future study could investigate the influence of student cognitive load on chosen learning outcome descriptors in online learning.

Sixth, the 1987 Philippine Constitution states that it will protect and promote quality education for all citizens at all levels and will take the necessary steps to achieve this. However, since its independence in 1946, the Philippines has faced formidable challenges in executing its agenda effectively. The economic disparity between the haves and have-nots is a major issue with widespread poverty, which keeps 16.7 million people below the poverty line. The government initiated the Pantawid Pamilyang Pilipino Programme (4Ps), which provides cash transfers to poor families and helps them with education expenses such as school supplies, uniforms, and transportation costs (Republic of the Philippines, 2023) [64]. Its effectiveness on citizens receiving a university education is not well established. Future research can investigate the effectiveness of the 4P program in supporting SDG 4 of quality education.

Seventh, Filipinos spend more than nine hours a day online; 59.7% of screen time is on the phone, and 40.3% of time is on computers (Datareportal, 2023) [79]. Smartphones open up the possibility of reaching out to a greater population to take up university education such as undertaking accounting degree studies. ChatGPT can complement this with easily accessible knowledge, which has reset what is known, can be known, and is beyond knowledge. It has revised the benchmarks of pedagogy to ensure integrity in student learning (Abeysekera, 2024) [80]. These tools can help decrease educational institution costs and costs of student learning, increase education quality, and reduce social inequality. A future study can investigate using mobile phone applications as an LMS platform with knowledge along with the learning potentials offered by ChatGPT knowledge as an additional factor, and the effect of cognitive load on student learning memory.

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References

1. Power, C. The Power of Education. In *The Power of Education. Education in the Asia-Pacific Region: Issues, Concerns and Prospects*; Springer: Singapore, 2015; Volume 27. [CrossRef]
2. Kromydas, T. Rethinking higher education and its relationship with social inequalities: Past knowledge, present state and future potential. *Palgrave Commun.* **2017**, *3*, 1. [CrossRef]
3. Chen, T.; Peng, L.; Yin, X.; Rong, J.; Yang, J.; Cong, G. Analysis of User Satisfaction with Online Education Platforms in China during the COVID-19 Pandemic. *Healthcare* **2020**, *8*, 200. [CrossRef]
4. Means, B.; Toyama, Y.; Murphy, R.; Bakia, M.; Jones, K. Evaluation of Evidence-Based Practices in On-Line Learning: A Meta-Analysis and Review of Online Learning Studies. 2009. Available online: http://repository.alt.ac.uk/id/eprint/629 (accessed on 15 January 2024).
5. Dhawan, S. Online Learning: A Panacea in the Time of COVID-19 Crisis. *J. Educ. Technol. Syst.* **2020**, *49*, 5–22. [CrossRef]
6. Rotas, E.E.; Cahapay, M.B. Difficulties in Remote Learning: Voices of Philippine University Students in the Wake of COVID-19 Crisis. *Asian J. Distance Educ.* **2020**, *15*, 147–158.
7. Mukhtar, K.; Javed, K.; Arooj, M.; Sethi, A. Advantages, Limitations and Recommendations for online learning during COVID-19 pandemic era. *Pak. J. Med. Sci.* **2020**, *36*, S27. [CrossRef] [PubMed]
8. Skulmowski, A.; Xu, K.M. Understanding Cognitive Load in Digital and Online Learning: A New Perspective on Extraneous Cognitive Load. *Educ. Psychol Rev.* **2022**, *34*, 171–196. [CrossRef]
9. Barrot, J.S.; Llenares, I.I.; del Rosario, L.S. Students' online learning challenges during the pandemic and how they cope with them: The case of the Philippines. *Educ. Inf. Technol.* **2021**, *26*, 7321–7338. [CrossRef] [PubMed]
10. Worldometer. Phillppines Population. 2023. Available online: https://www.worldometers.info/world-population/philippines-population/ (accessed on 11 January 2024).
11. Abeysekera, I.; Jebeile, S. Why Learners Found Transfer Pricing Difficult? Implications for Directors. *J. Asian Financ. Econ. Bus.* **2019**, *6*, 9–19. [CrossRef]
12. Blayney, P.; Kalyuga, S.; Sweller, J. The impact of complexity on the expertise reversal effect: Experimental evidence from testing accounting students. *Educ. Psychol.* **2016**, *36*, 1868–1885. [CrossRef]
13. Shabeeb, M.A.; Sobaih, A.E.E.; Elshaer, I.A. Examining Learning Experience and Satisfaction of Accounting Students in Higher Education before and amid COVID-19. *Int. J. Environ. Res. Public Health* **2022**, *19*, 16164. [CrossRef]
14. CHED Memo. No. 4. 2020. Available online: https://ched.gov.ph/wp-content/uploads/CMO-No.-4-s.-2020-Guidelines-on-the-Implementation-of-Flexible-Learning.pdf (accessed on 13 January 2024).
15. Davis, F.D. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Q.* **1989**, *13*, 319–340. [CrossRef]
16. Song, L.; Singleton, E.S.; Hill, J.R.; Koh, M.H. Improving online learning: Student perceptions of useful and challenging characteristics. *Internet High. Educ.* **2004**, *7*, 59–70. [CrossRef]
17. Almahasees, Z.; Mohsen, K.; Amin, M.O. Faculty's and Students'perceptions of Online Learning during COVID-19. *Front. Educ.* **2021**, *6*, 638470. [CrossRef]
18. Cronin, J.J.; Taylor, S.A. Measuring Service Quality: A Reexamination and Extension. *J. Mark.* **1992**, *56*, 55–68. [CrossRef]
19. Zalat, M.M.; Hamed, M.S.; Bolbol, S.A. The experiences, challenges, and acceptance of e-learning as a tool for teaching during the COVID-19 pandemic among university medical staff. *PLoS ONE* **2021**, *16*, e0248758. [CrossRef]
20. Almahasees, Z.; Jaccomard, H. Facebook translation service (FTS) usage among jordanians during COVID-19 lockdown. *Adv. Sci. Technol. Eng. Syst.* **2020**, *5*, 514–519. [CrossRef]
21. Pokhrel, S.; Chhetri, R. A Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning. *High. Educ. Future* **2021**, *8*, 133–141. [CrossRef]
22. Zhang, H.; Wu, C.; Zhang, Z.; Lin, H.; Zhang, Z.; Sun, Y.; Mueller, J.; Manmatha, R.; Li, M.; Meta, A.S.; et al. Snap, Amazon, ByteDance, & SenseTime. *ResNeSt Split.-Atten. Netw.* **2022**. Available online: https://openaccess.thecvf.com/content/CVPR2022W/ECV/papers/Zhang_ResNeSt_Split-Attention_Networks_CVPRW_2022_paper.pdf (accessed on 13 January 2024).
23. Ehlers, U.D.; Pawlowski, J.M. Quality in European e-learning: An introduction. In *Handbook on Quality and Standardisation in E-Learning*; Springer: Berlin/Heidelberg, Germany, 2006. [CrossRef]
24. Al-Salman, S.; Haider, A.S. Jordanian University Students' Views on Emergency Online Learning During COVID-19. *Online Learn.* **2021**, *25*, 286–302. [CrossRef]
25. Coman, C.; Țîru, L.G.; Meseșan-Schmitz, L.; Stanciu, C.; Bularca, M.C. Online Teaching and Learning in Higher Education during the Coronavirus Pandemic: Students' Perspective. *Sustainability* **2020**, *12*, 10367. [CrossRef]
26. Elashry, R.S.; Brittler, M.C.; Saber, E.-H.; Ahmed, F.A. Adolescents' Perceptions and Academic Stress towards Online Learning during COVID-19 Pandemic. *Assiut Sci. Nurs. J.* **2021**, *9*, 68–81. [CrossRef]
27. Asif, M.; Khan, M.A.; Habib, S. Students' Perception towards New Face of Education during This Unprecedented Phase of COVID-19 Outbreak: An Empirical Study of Higher Educational Institutions in Saudi Arabia. *Eur. J. Investig. Health Psychol. Educ.* **2022**, *12*, 835–853. [CrossRef]
28. Fox, J.; Griffith, J.; Smith, A.M. Exploring the Efficacy of an Online Training Programme to Introduce Mental Health Recovery to Carers. *Community Ment Health J.* **2023**, *59*, 1193–1207. [CrossRef]

29. Elalouf, A.; Edelman, A.; Sever, D.; Cohen, S.; Ovadia, R.; Agami, O.; Shayhet, Y. Students' Perception and Performance Regarding Structured Query Language Through Online and Face-to-Face Learning. *Front. Educ.* **2022**, *7*, 935997. [CrossRef]
30. Dubey, P.; Pradhan, R.L.; Sahu, K.K. Underlying factors of student engagement to E-learning. *J. Res. Innov. Teach. Learn.* **2023**, *16*, 17–36. [CrossRef]
31. Sumilong, M.J. Learner Reticence at the Time of the Pandemic: Examining Filipino Students'Communication Behaviors in Remote Learning. *Br. J. Teach. Educ. Pedagog.* **2022**, *1*, 1–13. [CrossRef]
32. Alammary, A.S. How to decide the proportion of online to face-to-face components of a blended course? A Delphi Study. *SAGE Open* **2022**, *12*, 21582440221138448. [CrossRef]
33. Assadi, N.; Kashkosh, E. Training Teachers' Perspectives on Teacher Training and Distance Learning During the COVID-19 Pandemic. *J. Educ. Soc. Res.* **2022**, *12*, 40–55. [CrossRef]
34. Daher, W.; Shayeb, S.; Jaber, R.; Dawood, I.; Abo Mokh, A.; Saqer, K.; Bsharat, M.; Rabbaa, M. Task design for online learning: The case of middle school mathematics and science teachers. *Front. Educ.* **2023**, *8*, 1161112. [CrossRef]
35. Giesbers, B.; Rienties, B.; Tempelaar, D.; Gijselaers, W. A dynamic analysis of the interplay between asynchronous and synchronous communication in online learning: The impact of motivation. *J. Comput. Assist. Learn.* **2014**, *30*, 30–50. [CrossRef]
36. Dardahi, H.; Kooshkebaghi, M.; Mireshghollah, M. Learner satisfaction with synchronous and asynchronous virtual learning systems during the COVID-19 pandemic in Tehran university of medical sciences: A comparative analysis. *BMC Med. Educ.* **2023**, *23*, 886. [CrossRef]
37. Sweller, J.; Ayers, P.; Kalyuga, S. *Cognitive Load Theory*; Springer: New York, NY, USA, 2011.
38. Chan, R.Y. Understanding the Purpose of Higher Education: An Analysis of the Economic and Social Benefits for Completing a College Degree. *IEPPA* **2016**, *6*, 1–40. Available online: https://scholar.harvard.edu/files/roychan/files/chan_r._y._2016._understanding_the_purpose_aim_function_of_higher_education._jeppa_65_1-40.pdf (accessed on 15 January 2024).
39. Jiang, D.; Kalyuga, S. Confirmatory factor analysis of cognitive load ratings supports a two-factor model. *Tutor. Quant. Methods Psychol.* **2020**, *16*, 216–225. [CrossRef]
40. Sweller, J.; van Merriënboer, J.J.; Paas, F. Cognitive architecture and instructional design: 20 years later. *Educ. Psychol. Rev.* **2019**, *31*, 261–292. [CrossRef]
41. Atkinson, R.C.; Shiffrin, R.M. Human Memory: A Proposed System and its Control Processes. *Psychol. Learn. Motiv.* **1968**, *2*, 89–195. [CrossRef]
42. Miller, G.A. The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychol. Rev.* **1956**, *63*, 81–97. [CrossRef] [PubMed]
43. Nee, D.E.; Berman, M.G.; Moore, K.S.; Jonides, J. Neuroscientific Evidence About the Distinction Between Short- and Long-Term Memory. *Curr. Dir. Psychol. Sci.* **2008**, *17*, 102–106. [CrossRef] [PubMed]
44. Baddeley, A. The episodic buffer: A new component of working memory? *Trends Cogn. Sci.* **2000**, *4*, 417–423. [CrossRef]
45. Frederiksen, J.G.; Sørensen, S.M.D.; Konge, L.; Svendsen, M.B.S.; Nobel-Jørgensen, M.; Bjerrum, F.; Andersen, S.A.W. Cognitive load and performance in immersive virtual reality versus conventional virtual reality simulation training of laparoscopic surgery: A randomized trial. *Surg. Endosc.* **2020**, *34*, 1244–1252. [CrossRef] [PubMed]
46. Theresiawati, S.H.B.; Hidayanto, A.N.; Abidin, Z. Variables Affecting E-Learning Services Quality in Indonesian Higher Education: Students' Perspectives. *J. Inf. Technol. Educ. Res.* **2020**, *19*, 259–286. [CrossRef]
47. Udo, G.J.; Bagchi, K.K.; Kirs, P.J. Using SERVQUAL to assess the quality of e-learning experience. *Comput. Hum. Behav.* **2011**, *27*, 1272–1283. [CrossRef]
48. Uppal, M.A.; Ali, S.; Gulliver, S.R. Factors determining e-learning service quality. *Br. J. Educ. Technol.* **2018**, *49*, 412–426. [CrossRef]
49. Hudjashov, G.; Karafet, T.M.; Lawson, D.J.; Downey, S.; Savina, O.; Sudoyo, H.; Lansing, J.S.; Hammer, M.F.; Cox, M.P. Complex Patterns of Admixture across the Indonesian Archipelago. *Mol. Biol. Evol.* **2017**, *34*, 2439–2452. [CrossRef]
50. Shkeer, A.S.; Awang, Z. Exploring the Items for Measuring the Marketing Information System Construct: An Exploratory Factor Analysis. *Int. Rev. Manag. Mark.* **2019**, *9*, 87–97. [CrossRef]
51. Chatzopoulos, A.; Kalogiannakis, M.; Papadakis, S.; Papoutsidakis, M. A Novel, Modular Robot for Educational Robotics Developed Using Action Research Evaluated on Technology Acceptance Model. *Educ. Sci.* **2022**, *12*, 274. [CrossRef]
52. Rossoni, L.; Engelbert, R.; Bellegard, N.L. Normal science and its tools: Reviewing the effects of exploratory factor analysis in management. *Rev. Adm.* **2016**, *51*, 198–211. [CrossRef]
53. Tavakol, M.; Dennick, R. Making sense of Cronbach's alpha. *Int. J. Med. Educ.* **2011**, *2*, 53–55. [CrossRef]
54. Nguyen, A.L.; Dellaportas, S. Accounting Ethics Education Research: A Historical Review of the Literature. In *Accounting Ethics Education Teaching Virtues and Values*; Routledge: New York, NY, USA, 2021; Volume 3, pp. 44–80. [CrossRef]
55. Grimm, P. Social desirability bias. In *Wiley International Encyclopedia of Marketing*; Sheth, J.N., Malhotra, N.K., Eds.; Wiley Sons and Limited: Hoboken, NJ, USA, 2010. [CrossRef]
56. Cribbie, R.A. Multiplicity control in structural equation modelling. *Struct. Equ. Model. A Multidiscip. J.* **2007**, *14*, 98–112. [CrossRef]
57. Perneger, T.V. What's Wrong with Bonferroni Adjustments. *BMJ Br. Med. J.* **1998**, *316*, 1236–1238. [CrossRef]
58. Marsh, H.W.; Hocevar, D. Application of confirmatory factor analysis to the study of self-concept: First- and higher order factor models and their invariance across groups. *Psychol. Bull.* **1985**, *97*, 562–582. [CrossRef]
59. Hayashi, K.; Bentler, P.M.; Yuan, K.-H. Structural Equation Modeling. In *Essential Statistical Methods for Medical Statistics, Handbook of Statistics*; Elsevier: Amsterdam, The Netherlands, 2011; Volume 27, pp. 202–234. [CrossRef]

60. Fornell, C.; Larcker, D.F. Evaluating structural equation models with unobservable variables and measurement error. *J. Mark. Res.* **1981**, *18*, 39–50. [CrossRef]
61. Bentler, P.M. *Structural Equations Program Manual*; EQS 6; Multivariate Software: Encino, CA, USA, 2006.
62. Nia, H.S.; Marôco, J.; She, L.; Fomani, F.K.; Rahmatpour, P.; Ilic, I.S.; Ibrahim, M.M.; Ibrahim, F.M.; Narula, S.; Esposito, G.; et al. Student satisfaction and academic efficacy during online learning with the mediating effect of student engagement: A multi-country study. *PLoS ONE* **2023**, *18*, e0285315. [CrossRef]
63. Nasir, F.D.M.; Hussain, M.A.M.; Mohamed, H.; Mokhtar, M.; Karim, N.A. Student Satisfaction in Using a Learning Management System (LMS) for Blended Learning Courses for Tertiary Education. *Asian J. Univ. Educ.* **2021**, *17*, 442–454. [CrossRef]
64. Xu, T.; Xue, L. Satisfaction with online education among students, faculty, and parents before and after the COVID-19 outbreak: Evidence from a meta-analysis. *Front. Psychol.* **2023**, *14*, 1128034. [CrossRef]
65. Jones, J.P.; Fields, K.T. The role of supplemental instruction in the first accounting course. *Issues Account. Educ.* **2001**, *16*, 531–547. [CrossRef]
66. Opdecam, E.; Everaet, P. Improving student satisfaction in a first-year undergraduate accounting course by team learning. *Issues Account. Educ.* **2011**, *27*, 53–82. [CrossRef]
67. Ding, L.; Velicer, W.F.; Harlow, L. Effects of Estimation Methods, Number of Indicators Per Factor, and Improper Solutions on Structural Equation Modeling Fit Indices. *Struct. Equ. Model. A Multidiciplinary J.* **1995**, *2*, 119–143. [CrossRef]
68. Sithole, S.; Chandler, P.; Abeysekera, I.; Paas, F. Benefits of Guided Self-Management of Attention on Learning Accounting. *J. Educ. Psychol.* **2017**, *109*, 220–232. [CrossRef]
69. Sithole, S.T.M.; Abeysekera, I. *Accounting Education: Cognitive Load Theory Perspective*; Routledge: New York, NY, USA, 2017.
70. Republic of the Philippines. Educational Challenges in the Philippines. Philippine Institute for Development Studies. 2023. Available online: https://pids.gov.ph/details/news/in-the-news/educational-challenges-in-the-philip-pines#:~:text=The%201987%20Philippine%20Constitution%20states,such%20education%20accessible%20to%20all.%E2%80%9D (accessed on 15 January 2024).
71. Vining, A.R.; Weimer, D.L. The P-Case. In *Thinking Like a Policy Analyst*; Geva-May, I., Ed.; Palgrave Macmillan: New York, NY, USA, 2005; pp. 153–170. [CrossRef]
72. Yu, Z. The effects of gender, educational level, and personality on online learning outcomes during the COVID-19 pandemic. *Int. J. Educ. Technol. High. Educ.* **2021**, *18*, 14. [CrossRef]
73. Rapanta, C.; Botturi, L.; Goodyear, P.l.; Guardia, L.; Koole, M. Online University Teaching During and After the COVID-19 Crisis: Refocusing Teacher Presence and Learning Activity. *Postdigit. Sci. Educ.* **2020**, *2*, 923–945. [CrossRef]
74. Simonds, T.A.; Brocks, B.L. Relationship between Age, Experience, and Student Preference for Types of Learning Activities in Online Courses. 2014. Available online: https://files.eric.ed.gov/fulltext/EJ1020106.pdf (accessed on 15 January 2024).
75. Smith, G.; Heindel, A.J.; Torres-Ayala, A.T. E-learning commodity or community: Disciplinary differences between online courses. *Internet High. Educ.* **2008**, *11*, 152–159. [CrossRef]
76. Saha, S.M.; Pranty, S.A.; Rana, M.J.; Islam, M.J.; Hossain, M.E. Teaching during a pandemic: Do university teachers prefer online teaching? *Heliyon* **2021**, *8*, e08663. [CrossRef] [PubMed]
77. Stecuła, K.; Wolniak, R. Advantages and Disadvantages of E-Learning Innovations during COVID-19 Pandemic in Higher Education in Poland. *J. Open Innov. Technol. Mark. Complex.* **2022**, *8*, 159. [CrossRef]
78. Gudeva, L.K.; Dimova, V.; Daskalovska, N.; Trajkova, F. Designing Descriptors of Learning Outcomes for Higher Education Qualification. *Procedia—Soc. Behav. Sci.* **2011**, *46*, 1306–1311. [CrossRef]
79. Datareportal. Digital 2023: Global Overview Report. 2023. Available online: https://datareportal.com/reports/digital-2023-global-overview-report (accessed on 15 January 2024).
80. Abeysekera, I. ChatGPT and academia on accounting assessments. *J. Open Innov. Technol. Mark. Complex.* **2024**, *10*, 100213. [CrossRef]

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Satisfaction Level of Engineering Students in Face-to-Face and Online Modalities under COVID-19—Case: School of Engineering of the University of León, Spain

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Abstract: University education in times of COVID-19 was forced to seek alternative teaching/learning methods to the traditional ones, having to abruptly migrate to the online modality, changes that have repercussions on student satisfaction. That is why this study aims to compare the level of student satisfaction in face-to-face and "forced" online modalities under COVID-19. A quantitative, cross-sectional methodology was applied to two groups of students: Under a face-to-face modality (n = 116) and under an online modality (n = 120), to which a questionnaire was applied under a Likert scale, with four dimensions: Course design structure, content, resources, and instructor. Non-parametric statistics, specifically the Mann–Whitney U-test, were used to compare the groups. The results showed that there are significant differences in the level of satisfaction of students in the face-to-face and online "forced" modalities (p = 0.01984 < 0.05), and the dimensions of the level of satisfaction that presented significant differences were course design structure (p = 0.04523 < 0.05) and content (p = 0.00841 < 0.05). The research shows that students in the face-to-face modality express a higher level of satisfaction, which is reflected in the dimension design structure of the course, specifically in its workload indicator, as well as in the dimension content, in its indicators, overlapping with other courses and materials.

Keywords: university education; satisfaction; formal learning; online learning; COVID-19; quantitative analysis

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1. Introduction

The social changes brought about by COVID-19 began to be felt globally in the first months of 2020. The morbidity and mortality rates associated with the virus and the official declaration of a pandemic transformed the reality known until then into a "new normality", as it has been called. Many cities were paralyzed, with mobility, economic, educational, and recreational activities being almost non-existent. These actions sought to control the number of contagions. Measures were even taken in a forced manner, despite the fact that the trajectory of the virus and the speed of transmission did not prevent contagion [1,2]. Governments around the world found it necessary to subject the population to restrictions, quarantines, prolonged confinement, curfews, and the closure of inter-and intra-country borders, and because of this, many aspects of daily life have been forgotten. Spain did not escape this reality, and on 14 March 2020, the Spanish government decreed a state of alarm, with confinement measures that were tightened on 29 March, measures that paralyzed 'non-essential' activity and, consequently, a large part of the country's economy [3].

Most governments were forced to close educational institutions indefinitely to prevent the spread of COVID-19 [4]. Therefore, in order to give continuity to the teaching/learning

processes, UNESCO [5] recommended the use of information and communication technologies (ICT) as the main tool for the development of educational activities at all levels. In this sense, the Spanish government established containment measures in the educational field, suspending all educational activities at all levels of education, including university education. In addition, it established that during the suspension period, educational activities should be carried out under distance and online modalities [3].

Thus, at the end of June 2020, approximately one billion students witnessed and were affected by the closure of their schools, colleges, and universities due to the coronavirus outbreak [6], which led to a change in the teaching/learning processes from the face-to-face modality to the application of online teaching/learning. To ensure the continuity of educational activities, a variety of technological tools were used for the interaction of teachers and students [7], among which instant messaging such as Telegram, WhatsApp, and platforms for meetings stand out, in addition to emails that were traditionally used for the exchange of information. However, the transition from face-to-face to virtual classes implied the adaptation of courses, as well as significant changes in methodologies, the use of new strategies and resources, and a complete reprogramming in an accelerated manner. All this was added to the lack of training of some teachers in the preparation of teaching resources and the application of distance or "online" education, as well as difficulties in the use of digital technology, which for many was unknown. Consequently, a great challenge was generated for educators at all levels of Spanish universities, and also for students, when the confinement was imposed in the country in the middle of the second semester.

At the center of these changes in the teaching/learning process are teachers and students, with their intrinsic processes, such as satisfaction and the ways in which they report having acquired knowledge. The degree of satisfaction of students with the education they receive is constantly referred to as a key element in the assessment of the quality of education [8]. This indicates that it is the students who can best value the education they receive, even when they have a partial view of the teaching/learning process.

For this reason, the purpose of this research conducted at the School of Engineering of the University of León is, precisely, to carry out a comparative study of the level of satisfaction of students in the face-to-face and online modalities.

1.1. Teaching/Learning Modalities

In the face of the emergency derived from the COVID-19 pandemic, in general, Spanish universities experienced a rapid evolution in the teaching/learning process, moving from a traditional classroom environment to one that blends traditional and online learning. Moreover, the availability and wide distribution of low-cost devices such as smartphones, computers, and tablets, along with the varied applications available for free such as YouTube, Facebook, WhatsApp, Google Meet, etc., have changed people's lifestyles, their way of communicating with others, and habits in education [9].

In principle, the presential modality is developed as a face-to-face teaching/learning process in which it is the teacher who transmits knowledge to the students, exchanging concepts and opinions with the students in direct contact. They unify some of the basic characteristics required in the face-to-face modality, such as having knowledge, being the repository of information, the ability to analyze and process information in an orderly manner, and being an instrument of communication [10]. It is necessary to emphasize that, nowadays, the face-to-face modality has incorporated the use of ICT in the teaching/learning process, using resources and carrying out activities in which both the teacher and the student make use of technology.

Globally, structural changes were not far away, and institutions were not only dedicated to developing tools but also to motivating and facilitating a comprehensive understanding of the subjects of interest in order to avoid or reduce dropouts and solve any difficulties that students might have. In Pakistan, for example, the Higher Education Commission (HEC) and Higher Education Department (HED) mandated that all public and private educational institutes should offer online teaching and learning activities un-

til the COVID-19 contagion curve could be flattened [7]. Furthermore, the Universidad Francisco de Vitoria (UFV) in Madrid was able to expedite the switch to emergency remote learning, maintaining regular classes with minimal interruptions or rescheduling, apart from addressing flex-based requirements during the coronavirus quarantine [6]. In Spain, a study involving students at the School of Telecommunications Engineering at the Polytechnic University of Madrid described the changes experienced due to the pandemic condition (COVID-19), exploring the potential impact of educational decisions, such as (1) synchronization in online communication, (2) the number of students, and (3) digital technologies used, on the academic results of students participating in 43 undergraduate courses compared to the results of the last two academic years to establish possible differences in the performance of students enrolled in courses taught with emergency remote teaching and traditional face-to-face courses, finding no significant differences [11].

In this sense, teachers had to make an abrupt transition from face-to-face teaching to online teaching, understood as the teaching/learning process, where the teacher and students participate in a digital environment using ICT, which allows them, through the use of the Internet, to develop a synchronous or asynchronous connection through laptops, smartphones, and tablets.

In this sense, "we will face new teaching-learning models in which technologies will not have a complementary role but a determining role, and where online teaching will be seen with different eyes by students and teachers" [11,12]. This leads to a change in the structure of university education and the way of teaching, and all of this is a consequence of the COVID-19 pandemic. Although the concept of online learning is not new, especially after the popularity and success of Massive Open Online Courses (MOOCs), such as Coursera, EdX, and Udemy, among others, they have never before been used as a primary means of teaching. Teachers had to face four major challenges of online education, such as demonstrating their pedagogical skills in an online classroom, addressing their management role, establishing relationships with students, and providing technical support [13].

1.2. Context of Education in Spain and at the University of León

In Spain, university education traditionally takes place in the face-to-face modality, and only 15% of undergraduate students are enrolled in public or private universities that offer distance education. Distance education, in addition to being supported by the development of technological platforms and devices, is consolidated in the design and planning of training routes or online educational experiences [14]. The declaration of the state of alarm in Spain, together with the enforcement of the total confinement decreed by the national authorities (RD 463/2020) in an attempt to control the spread of the virus, forced Spanish educational institutions to adopt the online modality as a matter of urgency [15,16].

The University of León is a public institution located in the city of León, Spain. It has nine faculties, three schools, an attached private center, a language center, and an ICT center, in which several undergraduate and graduate degrees are taught. Specifically, in the School of Engineering, prior to the pandemic situation, teaching/learning activities were based on (1) theoretical lectures and practical classes, (2) practices using ICT in a computer classroom, and (3) support through available resources that were shared on the institution's Moodle platform. Attendance was mandatory for most of the activities, so it could be considered a full face-to-face education.

All this changed with the pandemic, migrating, at first, exclusively to the online modality through the university's own platform, which became supersaturated due to the strong demand, and Google Meet was also used. In addition to live classes, video tutorials, recorded classes, practices, and complementary readings, among others, were used. In addition, a design was employed for the application of online exams, and the professors developed protocols to minimize plagiarism. Despite the apparent success of the situation and the achievements obtained, it is necessary to validate or monitor the teaching/learning process, especially if we take into consideration the disruption in the

activities and the abrupt change in this process, also taking into consideration the nature of the undergraduate and graduate courses taught at the School of Engineering. Specifically, the environment of this research comprises the careers of Electrical Engineering, Industrial Electronics and Automation Engineering, Mechanical Engineering, Energy Engineering, Mining Engineering, and Aerospace Engineering at the undergraduate level, and postgraduate degrees at the master's level in Mining Engineering and Energy Resources and Industrial Engineering.

1.3. Student Satisfaction

Student satisfaction with the teaching/learning process depends on their expectations, and these vary according to the type of course. Satisfaction, in some cases, refers to the needs that, as individuals, are experienced by the organization's personnel; in others, to the adequate response to the expectations, interests, needs, and demands of the recipients [17]. In the particular case of the educational field, the addressees are the students, and their satisfaction is related to the way in which the educational process and the institution itself attend to the expectations, interests, and needs of this particular group [7]. Student satisfaction is a fundamental element in the evaluation of the educational process and reflects the efficiency of this process in relation to the interaction with the teacher, their satisfaction with the contents and resources, as well as with the structure of the course.

1.4. Research Problem

UNESCO [5] recommends the use of online learning programs and open educational applications during the closure of educational institutions caused by COVID-19, for teachers to use them in the teaching/learning process and limit the disruption of education. For this reason, educational institutions, including universities, opt for online classes [18]. In contrast to the face-to-face modality, teachers are researching ways in which the online modality can produce better academic results and achievements.

In that sense, comparative studies have been conducted to explore whether face-to-face or traditional teaching methods are more productive or whether online learning is better [19,20]. These studies reflect those students performing much better in the online modality than in the face-to-face modality. Henriksen [21] highlighted the problems faced by educators when moving from face-to-face to the online modality. In addition, both teachers and students face multiple obstacles to online learning, such as Internet access and unfamiliarity with the platforms used for the teaching/learning process, among others [22].

On the other hand, some researchers have emphasized the need to study the satisfaction level of students under the online mode [23–25]. However, little literature is available on the factors affecting students' satisfaction levels in online classes during the COVID-19 pandemic [26].

Now, the primary interest of this research is the level of student enjoyment, specifically contrasting face-to-face and online modalities. Under this perspective, and because of the above, this research provides an answer to the following question:

Are there significant differences in the level of student satisfaction in the face-to-face and online "forced" modality under COVID-19?

In order to answer this question, the researchers set the following research objective:

To compare the level of student satisfaction in face-to-face and "forced" online modalities under COVID-19.

All of the above leads to concretizing the objective of the research by establishing the study hypothesis.

Hypothesis 1 (H1). *The level of satisfaction of students in the face-to-face modality differs significantly from that of students in the "forced" online modality.*

2. Materials and Methods

We understand the method as the systematic process to be followed to collect and process the information necessary to answer the questions of a given study. This research was developed through quantitative research, and since the purpose of the study was to compare the level of satisfaction of two groups of students, a cross-sectional analytical study approach was used, because its research focus is a specific moment in time, and it allows hypothesis testing. In addition, the questions posed imply a numerical measurement and statistical analysis [27].

2.1. Research Context and Participants

The research was carried out at the University of Leon. Specifically in the School of Engineering, in the careers of Electrical Engineering, Industrial Electronics and Automation Engineering, Mechanical Engineering, Energy Engineering, Mining Engineering, Aerospace Engineering at the undergraduate level, and postgraduate at the master's level in Mining Engineering and Energy Resources and Industrial Engineering.

Nine courses were considered for the research approach: (a) Fluid Mechanical Engineering; (b) Cold Engineering; (c) Industrial and Building Systems; (d) Acoustics and Vibrations; (e) Geology; (f) Graphic Expression II; (g) Nuclear Energy; (h) Mineral Processing; and (i) Management of Mineral and Metallurgical Plants of the aforementioned degrees. A non-probabilistic intentional sampling was applied, and two samples of students were selected for the two modalities; in the face-to-face modality, the sample was composed of 116 students (group 1) and that of the online modality was composed of 120 students (group 2).

2.2. Instrument

The instrument used corresponds to an adaptation of the questionnaire proposed and validated by Pastor [28]. This questionnaire consists of 14 questions under a Likert-type scale of 5 values (1. Totally disagree, 2. Disagree, 3. Indifferent, 4. Agree, 5. Totally agree) and includes 4 dimensions with their respective indicators, as shown in the variables map (Table 1).

Table 1. Satisfaction level and its dimensions.

Variable	Dimension	Indicators	Item
Level of satisfaction	Course design structure	Workload	1
		Content of the subject	2
		Previous courses	3
	Content	Overlap with other courses	4
		Materials	5
		Teaching resources	6
	Resources	Access to bibliography	7
		Class distribution	8
	Instructor	Explanation of the subject	9
		Audiovisual resources and media	11
		Knowledge of the subject	10
		Motivates the class	12
		Communication	13
		Teacher accessibility	14

Figure 1 shows the percentage distribution of the items according to the dimensions of the instrument.

Figure 1. Distribution of the items according to the dimensions.

For the application of the instrument, the students gave informed consent after being duly notified of the objectives of the study and the confidentiality of the study, which is under strict compliance with the ethical norms of the Research Committee and the Helsinki Declaration of 1975.

For the reliability of the instrument, the internal consistency analysis was applied by means of Cronbach's Alpha [29] performed using the IBM SPSS 25 statistical program, which resulted in $\alpha = 0.92$, reliability considered "excellent" according to that established by George and Mallery [30], which validates that the instrument measures the dimensions to be measured with a high degree of certainty.

2.3. Data Analysis

Non-parametric statistics were used, specifically, the Mann–Whitney U test since the student satisfaction level variable has an ordinal scale. The Mann–Whitney U test allows testing for differences between independent groups with scales varying [31]. This test allowed us to know if there are significant differences in the level of student satisfaction in the face-to-face and "forced" online modalities under COVID-19, and a significance level of 0.05 was established. The data were analyzed using IBM SPSS 25.

3. Results

3.1. Analysis of Student Satisfaction Level

First, the Mann–Whitney U test was applied to compare the level of student satisfaction in the "forced" face-to-face and online modalities under COVID-19. We posed the following hypotheses:

Hypothesis 2 (H2). *There are no significant differences in the level of student satisfaction in face-to-face and "forced" online modalities.*

Hypothesis 3 (H3). *There are significant differences in the level of student satisfaction in the "forced" face-to-face and online modalities.*

According to the results presented in Table 2, the rejection of the null hypothesis (H0) is confirmed, since the probability of the error is below the established significance level

$p = 0.019847 < 0.05$. Therefore, it can be confirmed that there are statistically significant differences in the level of satisfaction of both groups of students. When observing the value of the average range, it can be pointed out that there is a higher level of satisfaction in the group of students of the face-to-face modality with respect to the "forced" online one.

Table 2. Mann–Whitney U test statistics for student satisfaction level.

Groups	N	Average Range	Sum of Ranges
Presential	116	129.02	14,966.50
Online	120	108.33	12,999.50
Test statistics			
Mann-Whitney U test		5739.50	
Z		−2.329	
Asymptotic sig. (bilateral) (p)		0.019847	
$p < 0.05$ rejection of the null hypothesis			

3.2. Analysis of the Level of Satisfaction According to the Dimensions: Course Design Structure, Content, Resources, and Instructor

The results show (Table 3) that for the dimensions of resources and the instructor, the null hypothesis is accepted. No statistically significant differences are observed in the resources dimension since the probability of error is above the established significance level $p = 0.08234 > 0.05$. Something similar occurs with the instructor dimension, with a probability of error above the established significance level $p = 0.061732 > 0.05$.

Table 3. Mann-Whitney U-test statistics for the dimensions of student satisfaction level.

Dimension	Group	N	Average Range	Sum of Ranges
Course design structure	Presential	116	127.47	14,787.00
	Online	120	109.83	13,179.00
	Test statistics			
	Mann-Whitney U test		5919.00	
	Z		−2.003	
	Asymptotic sig. (bilateral) (p)		0.045203	
Content	Group	N	Average range	Sum of ranges
	Presential	116	130.30	15,115.00
	Online	120	107.09	12,851.00
	Test statistics			
	Mann-Whitney U test		5591.00	
	Z		−2.635	
	Asymptotic sig. (bilateral) (p)		0.008411	
Resources	Group	N	Average range	Sum of ranges
	Presential		126.36	14,657.50
	Online		110.90	13,308.50
	Test statistics			
	Mann-Whitney U test		6048.50	
	Z		−1.749	
	Asymptotic sig. (bilateral) (p)		0.08234	
Instructor	Group	N	Average range	Sum of ranges
	Presential		126.86	14,716.00
	Online		110.42	13,250.00
	Test statistics			
	Mann-Whitney U test		5990.00	
	Z		13,250.00	
	Asymptotic sig. (bilateral) (p)		0.061732	
$p < 0.05$ rejection of the null hypothesis				

Regarding the dimensions course design structure and content, the results indicate the rejection of the null hypothesis. Statistically significant differences were found in the

level of student satisfaction in the face-to-face and online groups, which is reflected in the significance values for each dimension.

For the course content structure dimension, a probability of error below the established significance level $p = 0.04523 < 0.05$ was observed. This indicates that there are statistically significant differences between the medians of the groups, and it can be pointed out that there is a higher level of satisfaction in the group of students of the face-to-face modality with respect to the "forced" online modality, obtaining an average range value of 127.47 higher than that of the online modality of 109.83. These significant differences are specifically reflected in the behavior of the workload indicator (Table 4) where the face-to-face modality presents a median of 4, higher than the median of the online modality, indicating the level of satisfaction of the students of the online modality is higher.

Table 4. Median of indicators according to dimension.

Dimension	Indicators	Presential	Online
Course design structure	Workload	4	3
	Content of the subject	4	4
	Previous courses	4	4
Content	Overlap with other courses	5	4
	Materials	4	3.5
	Teaching resources	4	4
Resources	Access to bibliography	4	4
	Class distribution	4	4
	Explanation of the subject	4	4
	Knowledge of the subject	4	4
Instructor	Audiovisual resources and media	5	5
	Motivates the class	4	4
	Communication	4	4
	Teacher accessibility	5	5

Something similar occurs with the content dimension, where a probability of error below the established significance level $p = 0.008411 < 0.05$ was observed (Table 3). This indicates that there are statistically significant differences between the medians of the groups, obtaining a higher level of satisfaction with the dimension in the group of students of the face-to-face modality, obtaining an average range value of 130.3, higher than the online modality range of 107.09. These significant differences are specifically reflected in the behavior of the indicators overlapping with other courses and materials (Table 4) where the students of the face-to-face modality express a higher level of satisfaction. In the case of the course preference indicator, it presents a median of 5, higher than the median of the online modality. Similar behavior is observed in the materials indicator, where the face-to-face modality obtained a median of 4, higher than the median of the online modality.

The confinement decreed by the Spanish government on 15 March 2020 coincided with the start of the second university semester and came as a real shock, both for students and the teaching work of professors, who had to adapt in record time to the new circumstances dictated by the pandemic.

The impact on teaching was uneven and was marked by a number of factors, including the technological competence of the teaching staff, the nature of the subjects involved, access to mobile devices connected to the internet, and the university's communications infrastructure. Fortunately, the last two factors did not play a major role. The University of León is equipped with a very modern fiber optic intranet and, for years, teachers and students have had access to it from the outside to run different administrative and teaching

tools. On the other hand, access to mobile devices and high-bandwidth internet by students is widespread (97% of students). In addition, the Rector's Office set up a system for lending computers with eSim cards for those students who have difficulties accessing them at home.

The more experimental subjects, with more practical content, were the most difficult to teach during confinement. Worthy of mention is the case of the Graphic Expression II subjects included in this study. The thematic block on the representation of mechanical assemblies was undoubtedly the most problematic when teaching the classes by videoconference, as the students did not have material access to the mechanisms, which was a burden on their understanding. The teachers made a great effort to finalize the programming of a mobile application, based on Augmented Reality, and adapt it to the new pandemic circumstances so that the students could work on the competences on mechanisms included in the syllabus of the subject. The use of the app was an important aid and has been highly valued by the students, as well as having a positive influence on learning [32]. This academic year, 2022–2023, is the third year that the app is being used, and the experience has been awarded the Prize for Innovation in Teaching 2022, awarded unanimously by the Social Council of the University of León.

4. Conclusions

Virtual education was adopted as a solution to the disruptive situation that arose due to the COVID-19 pandemic and, although it has been a successful solution in many cases, it should be evaluated in order to make the corresponding adjustments to ensure a quality teaching/learning process, and also motivate participants to continue training under this new concept.

This is reflected in the results obtained in this research, where when comparing the level of satisfaction of the students in the face-to-face and "forced" online modalities, it can be affirmed that the students of the face-to-face modality, in general, express a higher level of satisfaction. This indicates that the teaching/learning modality matters as much as other factors that can influence the teaching/learning process. The level of student satisfaction should be used to suggest a number of positions for effective online learning [33].

In view of the fact that the teaching/learning process is conditioned by the level of digital competencies of both teachers and students, it is necessary to train university teachers to design structures, contents, and resources that are applicable to online teaching. In this case, the University of León must take up the challenge to definitively face the changes and be prepared for the implementation of a hybrid or exclusively online model if necessary.

Virtual education was the response to the continuity of teaching/learning processes in the face of the pandemic in the world, and while students are able to identify the usefulness of digital tools and learning platforms, the face-to-face experience is considered more satisfactory [34].

Providing students with a course content structure for the development of an adequate teaching/learning process is important for educational quality. The choice of course content structure has implications for the work of teachers and students. In that sense, the results of this study indicate that students under the online modality were less satisfied with the structure of the course content compared to students under the face-to-face modality. This is due to the fact that they consider that in the online modality, the amount of work is excessive, even though they are keeping up with it, and they also consider that the professor did not adequately adapt the course for the online modality. This work overload may be caused by (1) the concern of teachers to complete the course on time, (2) the content of the programs not being adjusted to the online modality, as they remain static, (3) the lack of experience of teachers and students in the online teaching/learning process, and (4) the multiplicity of learning platforms faced by students [35]. In particular, the structure of online course content requires great flexibility and accessibility in terms of the workload, course content, and linkages with previous courses, in order to favor the teaching/learning

process. In this regard, some of the reasons behind differences between face-to-face and online classes could be due to the fact that the characteristics of the assignments, the content, and specificity of the course, the students' characteristics, the students' motivation, and the instructor's characteristics were not taken into account [36,37].

The COVID-19 crisis has forced the use of new technologies and hasty preparation on the part of teachers, which leads to planning not previously thought out for teaching courses in the online modality. Online teaching not only consists of digitizing contents, replacing the hour of face-to-face class in the classroom with another hour of virtual class, but also the appropriate teaching materials and resources for the class must be considered. In this sense, the results indicate that the students expressed a low level of satisfaction in reference to the teaching materials and resources used in the online modality with respect to the face-to-face one. They indicated that in the virtual classes, the notes and support material, as well as the videos and teaching resources, were scarce and very poor, and the classes became very tedious and demotivating. Mediation, the accompaniment provided by the tutor, and the interaction with other participants lose their effect if the materials used do not respond to the characteristics of the virtual environment. It is these materials that determine the interest and progress of the participants [38]. Online education can be an equally effective teaching format when the online course is designed using the appropriate materials, resources, and pedagogy [39].

This low level of satisfaction with the materials and resources could indicate that there is a need to review the contents and resources used to impart knowledge, which requires greater attention when it comes to distance education because one should not lose sight of the fact that all activities designed virtually should efficiently stimulate the construction of knowledge [38].

On the other hand, with regard to resources and instructor dimensions, even when students of both types of modalities were equally satisfied, it should be emphasized that they expressed a lack of motivation on the part of the professor, classes that were not very dynamic and attractive, failures in communication, and the response of the professor when students try to communicate their doubts and concerns. It is difficult to overcome the traditional pedagogy of lecture classes and adapt to contemporary ideas of a model rich in interactions using online technology [40].

This leads to the importance of carrying out concrete actions to review and update curricula and degree profiles, updating programs for teachers, the standardization of teaching/learning methodologies, and the organization of teachers. In view of the fact that the process is conditioned by the level of digital competencies of both teachers and students, it is necessary to train university teachers to design structures, content, and resources that are applicable to online teaching. In this case, universities must take up the challenge to definitively face the changes and be prepared for the implementation of a hybrid or exclusively online model if necessary.

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References

1. Qazi, A.; Qazi, J.; Naseer, K.; Zeeshan, M.; Qazi, S.; Abayomi-Alli, O.; Said, I.; Darwich, M.; Talpur, B.; Hardaker, G.; et al. Adoption of distance learning to continue the academic year amid COVID-19 lockdown. *Child. Youth Serv. Rev.* **2021**, *126*, 106038. [CrossRef] [PubMed]
2. Dwivedi, Y.; Hughes, L.; Coombs, C.; Constantiou, J.; Duan, Y.; Edwards, J.; Gupta, B.; Lal, B.; Misra, S.; Prashant, P.; et al. Impact of COVID-19 pandemic on information management research and practice: Transforming education, work and life. *Int. J. Inf. Manag.* **2020**, *55*, 102211. [CrossRef]
3. Real Decreto 463/2020, de 14 de marzo, por el que se declara el estado de alarma para la gestión de la situación de crisis sanitaria ocasionada por el COVID-19. *Boletín Oficial del Estado*, 67, 14 March 2020. Available online: https://www.boe.es/buscar/doc.php?id=BOE-A-2020-3692(accessed on 15 September 2021).
4. Ducoing, P. *Una expresión de la desigualdad en educación básica durante la emergencia sanitaria: El caso de una alumna. Educación y pandemia: Una visión académica*; Cardiel, H.C., Ed.; Universidad Nacional Autónoma de México, Instituto de Investigación sobre la Universidad y la Educación: Ciudad de México, Mexico, 2020; pp. 55–64.
5. UNESCO-IESALC. El coronavirus COVID-19 y la educación superior: Impacto y Recomendaciones. 2020. Available online: https://www.iesalc.unesco.org/2020/04/02/el-coronavirus-covid-19-y-la-educacion-superior-impacto-y-recomendaciones/ (accessed on 15 September 2021).
6. Ripoll, V.; Godino-Ojera, M.; Calzada, J. Teaching chemical engineering to biotechnology students in the time of COVID-19: Assessment of the adaptation to digitalization. *Educ. Chem. Eng.* **2021**, *34*, 94–405. [CrossRef]
7. Rafique, G.M.; Mahmood, K.; Warraich, N.F.; Rehman, S. Readiness for Online Learning during COVID-19 pandemic: A survey of Pakistani LIS students. *J. Acad. Librariansh.* **2021**, *47*, 102346. [CrossRef]
8. Gento, S.; Vivas, M. El SEUE: Instrumento para conocer la satisfacción de los estudiantes universitarios con su educación. *Acción Pedagógica* **2003**, *12*, 16–27.
9. Pal, D.; Vanijja, V. Perceived usability evaluation of Microsoft Teams as online learning platform during COVID-19 using system usability scale and technology acceptance model in India. *Child. Youth Serv. Rev.* **2020**, *119*, 105535. [CrossRef] [PubMed]
10. Rama, C. El nuevo paradigma de educación y el papel de las industrias culturales. *Ciencia, Docencia y Tecnología* **2004**, *XV*, 113–123. Available online: https://www.redalyc.org/articulo.oa?id=14502801 (accessed on 15 September 2021).
11. Iglesias-Pradas, S.; Hernández-García, A.; Chaparro-Peláez, J.; Prieto, J. Emergency remote teaching and students' academic performance in higher education during the COVID-19 pandemic: A case study. *Comput. Hum. Behav.* **2021**, *119*, 106713. [CrossRef]
12. Torrecillas, C. El reto de la Docencia Online para la Universidades Públicas Españolas ante la Pandemia del COVID-19. ICEI Papers COVID-19; Complutense de Estudios Internacionales: Madrid, Spain, 2020; Volume 16, pp. 2–4.
13. Phillipsen, B.; Tondeur, J.; Pareja Roblin, N.; Vanslambrouck, S.; Zhu, C. Improving teacher professional development for online and blended learning: A systematic meta-aggregative review. *Educ. Technol. Res. Dev.* **2019**, *67*, 1145–1174. [CrossRef]
14. Zubillaga, A.; Gortazar, L. *Covid-19 y Educación: Problemas, Respuestas y Escenarios*; Fundación COTEC para la Innovación: Madrid, Spain, 2020.
15. Ariño, A.; Martínez, M.; Llopis, R.; Pons, E.; Prades, A. Via Universitària: Accés, condicions d'aprenentatge, expectatives i retorns dels estudis universitaris (2017–2019). Resultats principals, conclusions i propostes Política Universitària; Castellón. 2019, p. 4. Available online: https://www.vives.org/book/via-universitaria-acces-condicions-aprenentatge-expectatives-estudis-universitaris-2/ (accessed on 17 September 2021).
16. Hodges, C.B.; Moore, S.; Lockee, B.; Trust, T.; Bond, A. The difference between emergency remote teaching and online learning. *Educ. Rev.* **2020**. Available online: http://hdl.handle.net/10919/104648 (accessed on 17 September 2021).
17. Pérez, R. *La calidad de la educación. In Hacia una Educación de Calidad*; Pérez, R., López, F., Peralta, M.D., Municio, P., Eds.; Gestión, instrumentos y evaluación: Narcea, Spain, 2000; pp. 13–44.
18. Shehzadi, S.; Nisar, Q.; Hussain, M.; Basheer, M.; Hameed, W.; Chaudhry, N. The role of digital learning toward students' satisfaction and university brand image at educational institutes of Pakistan: A post-effect of COVID-19. *Asian Educ. Dev. Stud.* **2021**, *10*, 276–294. [CrossRef]
19. González-Gómez, D.; Jeong, J.; Rodríguez, D.; Cañada-Cañada, F. Performance and perception in the flipped learning model: An initial approach to evaluate the effectiveness of a new teaching methodology in a general science classroom. *J. Sci. Educ. Technol.* **2016**, *25*, 450–459. [CrossRef]
20. Lockman, A.; Schirmer, B. Online instruction in higher education: Promising, reseacrh-based, and evidence-based practices. *J. Educ. e-Learn. Res.* **2020**, *7*, 130–152. [CrossRef]
21. Henriksen, D.; Creely, E.; Henderson, M. Folk pedagogies for teacher educator transitions: Appoaches to synchronous online learning in the wake of COVID-19. *J. Technol. Teach. Educ.* **2020**, *28*, 201–209.

22. Al-Kumaim, N.H.; Alhazmi, A.K.; Mohammed, F.; Gazem, N.A.; Shabbir, M.S.; Fazea, Y. Exploring the Impact of the COVID-19 Pandemic on University Students' Learning Life: An Integrated Conceptual Motivational Model for Sustainable and Healthy Online Learning. *Sustainability* **2021**, *13*, 2546. [CrossRef]
23. Lee, J. An exploratory study of effective online learning: Assessing satisfaction levels of graduate students of mathematics education associated with human and design factors of an online course. *Int. Rev. Res. Open Distrib. Learn.* **2014**, *15*, 111–132. [CrossRef]
24. Sher, A. Assessing the relationship of student-Instructor and student-student interaction to student learning and satisfaction in web-based online learning environment. *J. Interact. Online Learn.* **2009**, *8*, 102–120.
25. Yen, S.C.; Lo, Y.; Lee, A.; Enriquez, J. Learning online, offline, and In-between: Comparing student academic outcomes and course satisfaction in face-to-face, online, and blended teaching modalities. *Educ. Inf. Technol.* **2018**, *23*, 2141–2153. [CrossRef]
26. Rajabalee, Y.; Santally, M. Learner satisfaction, engagement and performances in an online module: Implications for institutional e-learning policy. *Educ. Inf. Technol.* **2021**, *26*, 2623–2656. [CrossRef]
27. Sáez, J.M. *Investigación Educativa. Fundamentos Teóricos, Procesos y Elementos Prácticos*; Universidad Nacional de Educación a Distancia: Madrid, Spain, 2017.
28. Pastor, S.; Tobarra, L.; Robles-Gómez, A.; Cano, J.; Hammad, B.; Al-Zoubi, A.; Hernández, R.; Castro, M. Renewable energy remote online laboratories in Jordan universities: Tools for training students in Jordan. *Renew. Energy* **2020**, *149*, 749–759. [CrossRef]
29. Nunnaly, J.; Bernstein, I. *Psychometric Theory*, 3rd ed.; McGraw-Hill: New York, NY, USA, 1994.
30. George, D.; Mallery, P. *IBM SPSS Statistics 19 Step by Step a Simple Guide and Reference*; Routledge: Oxfordshire, UK, 2013.
31. Siegel, S.; Castellan, N.J. *Nonparametric Statistics for the Behavioral Sciences*, 2nd ed.; McGraw-Hill: New York, NY, USA, 2009.
32. Fraile-Fernández, F.J.; Martínez-García, R.; Castejón-Limas, M. Constructionist Learning Tool for Acquiring Skills in Understanding Standardised Engineering Drawings of Mechanical Assemblies in Mobile Devices. *Sustainability.* **2021**, *13*, 3305. [CrossRef]
33. Werhner, M.J. A comparison of the performance of online versus traditional on-campus earth science students on identical exams. *J. Geosci. Educ.* **2010**, *58*, 310–312. [CrossRef]
34. Ojeda, A.; Ortega, D.; Boom, E. Análisis de la percepción de los estudiantes presenciales acerca de las clases virtuales como respuesta a la crisis del COVID-19. *Revista Espacios* **2020**, *41*, 81–92. [CrossRef]
35. Al-Kumaim, N.H.; Mohammed, F.; Gazem, N.A.; Fazea, Y.; Alhazmi, A.K.; Dakkak, O. Exploring the Impact of Transformation to Fully Online Learning During COVID-19 on Malaysian University Students' Academic Life and Performance. *Int. J. Interact. Mob. Technol.* **2021**, *15*, 140–158. [CrossRef]
36. Summers, J.; Waigandt, A.; Whittaker, T. A comparison of student achievement and satisfaction in an online versus a traditional face-to face statistics class. *Innivative High. Educ.* **2005**, *29*, 233–250. [CrossRef]
37. Paul, J.; Jefferson, F. A comparative analysis of student performance in an online vs face-to-face environmental science course from 2009 to 2016. *Front. Comput. Sci.* **2019**, *1*, 7. [CrossRef]
38. Moreira, C.; Delgadillo, B. La virtualidad en los procesos educativos: Reflexiones teóricas sobre su implementación. *Tecnología en Marcha* **2015**, *28*, 121–129.
39. Driscoll, A.; Jicha, K.; Hunt, A.; Tichavsky, L.; Thompson, G. Can online courses deliver in-class redults? A comparison of student performance and satisfaction in an online versus a face-to-face introductory socialogy course. *Teach. Sociol.* **2012**, *40*, 312–331. [CrossRef]
40. Bennett, G.; Green, F.P. Student learning in the online environment: No significant difference? *Quest* **2001**, *53*, 1–13. [CrossRef]

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COVID-19 Pandemic Learning: The Uprising of Remote Detailing in Pharmaceutical Sector Using Sales Force Automation and Its Sustainable Impact on Continuing Medical Education

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Abstract: The availability of resources is vital when rapid changes and updated medical information in the provision of care are needed, such as in the fight against COVID-19, which is not a conventional disease. Continuing medical education plays an essential role in preparing for and responding to such emergencies. Workflow has improved based on the virtual meetings, online trainings, and remote detailing conducted by medical representatives in order to deliver educational content instantly through digital tools, such as salesforce automation (SFA), webinars, etc. In terms of its regulatory barriers, the pharmaceutical industry mainly targets healthcare professionals, unlike most businesses that reach end users directly. Medical representatives are equipped with an SFA to enhance customer relationship management (CRM) and closed loop marketing (CLM) capabilities in pharmaceutical companies. This study aimed to fill a gap in the literature by investigating the use of SFA in work patterns, such as health professionals' loyalty and involvement in their medical knowledge in Turkey, and how it allows for differentiating training from marketing. This study intended to compare the data on internists and medical products gathered from a well-known pharmaceutical company's SFA. The data covered the first three months of the year 2020, when medical representatives had a normal daily routine, and that of 2021, when Turkey experienced the most powerful surge of the COVID-19 pandemic. The analysis was based on simple correspondence analysis (SCA) and multiple correspondence analysis (MCA) for 11 variables. Monitoring product, physician's segment, and medical representatives' behaviors with SFA had a significant influence on the pharma-physician relationship strategy, as expected. The findings supported the view that SFA technologies can be deployed to advance the medical knowledge of physicians, in addition to managing and designing superior CRM and CLM capabilities.

Keywords: COVID-19; continuing medical education; pharmaceutical industry; sales force automation; e-detailing

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1. Introduction

The pharmaceutical industry (PI) is one of the fastest-growing sectors, with worldwide sales of more than USD 1.27 trillion in 2020 [1]. "The growth is mainly due to the companies recovering from the COVID-19 impact, which had led to restrictive measures involving social distancing, remote working, and the closure of commercial activities that resulted in operational challenges. In the wake of COVID-19, digitalized technology is more important than ever in allowing firms in all sectors to improve performance through stronger competitive skills, more accurate planning and forecasting, and financial sustainability" [2]. Information technology (IT) can enhance the mobility capabilities in automatic data tracking and can maximize the value of interactions in pharmaceutical business [3].

On the other hand, the pharmaceutical industry is subject to strict surveillance and control due to its direct impact on human health. These surveillance processes may extend to price interventions and advertising regulations by public authorities. While

most businesses reach the end users directly, the pharmaceutical industry mainly addresses healthcare professionals, designing various marketing strategies. Advertising, known as "product promotion" in the pharmaceutical industry, is prohibited in Turkey, as in most member countries of the Organisation for Economic Co-operation and Development (OECD), except for New Zealand and the United States. There is an obligation to refer to risky situations, such as side effects, contraindications, warnings, and taking precautions in advertisements. Some form of a self-regulation model is applied in New Zealand; until a certain period of time has passed after the drug has been put on the market, for example 2 years, it cannot be advertised directly to the consumer [4]. Physicians and/or pharmacists consider medical representatives their major source of information for new product details, key differentiators, and customized solutions for patients.

Current advances in information technology (IT) have changed medical representatives' daily routine activities. They can provide support before and after the scheduled or unscheduled visit, offering a more personalized service to targeted physicians through follow-ups and individualized content via the SFA tool. SFAs are a set of tools providing analyzed information (visits to customers, value-based customer interactions and segmentation, promotion and training opportunities, the provision of medical literature, predictions of future sales) from gathered corporate data to manage detailing-based activities. The possibility of remote detailing with SFA tools was useful to maintain the interaction with physicians that worked in limited conditions during the COVID-19 pandemic, when it was difficult to geographically access the target groups because of the lockdowns and social distancing. Therewith, some key elements in communication techniques changed totally in order to sustain the pharmaceutical field and to counter COVID-19 side effects.

Information technology-based corporate strategies are imperative drivers for business efficiency, growth, and success [5,6], and they show an innovative instrument for CRM [7]. Earlier studies were mainly focused on prescription behaviors to obtain the desired results in the pharmaceutical sector [8–10], but today, firms care about the retention rate of the customers with their field force and digital channels, especially in the pharmaceutical business [11].

This study aimed to investigate how the pharmaceutical industry's involvement using SFA tools with CRM and e-detailing modules can offer a wide detailing and continuing medical education platform for healthcare professionals during COVID-19 in Turkey. Most of the studies about COVID-19 underline the economic, demographic, and clinical dimensions of the pandemic. There is a very limited number of studies that were conducted on the extent of SFA usage, which is mainly a digital pharma marketing tool, as a continuing medical education platform before and during the COVID-19 era. We believe that we are the first to provide new evidence for empowering healthcare professionals' education and training opportunities with SFA by comparing the customer- and product-related needs before and during COVID-19 to establish and maintain effective relationships in value-creating behaviors.

Our paper is organized as follows: The concept of sales force automation capabilities with CRM and CLM modules—their key components for the pharmaceutical industry—are presented based on an extant literature review. Next, the hypothesized relationships between physician segmentation based on product, line, region's behaviors, promotion, and providing medical knowledge strategies of the pharmaceutical's firm are discussed, which is followed by SCA and MCA methods. After discussing an overview of results and associated implications for theory and practice, the manuscript concludes by outlining limitations and opportunities for future research.

2. Theoretical Framework and Development of Hypotheses

While the growth in the total turnover of the Turkish Pharmaceutical Industry was 31.7% in 2019, it remained at 17.7% in 2020, and the total turnover was TRY 47.9 billion [12]. Having controlled the initial outbreak in the first half of 2020 relatively well, Turkey experienced a larger second wave in the second half of the year. Turkey's response to the

pandemic was helped by the government's program, which ensured that patients with chronic diseases could continue to receive their drugs, allowing these patients to collect repeat prescriptions and receive three- or six-months' supplies [13]. At this point, the field specialists were aware of the fact that the pharmaceutical market must apply innovative modes of advanced drug promotion strategies, physician's segmentation, continuing medical education, digital marketing, and CRM activities to influence prescription behaviors.

Every physician segment and product positioning strategy is designed differently based on the interest level of physicians to promotions and packages (i.e., contents for medical knowledge). Despite the negative impacts, often discussed, that the industry may have on prescription behavior, the relationship with pharmaceutical companies, as seen in our study, helped to facilitate the sharing of experiences among researchers and to incorporate the newly gained medical knowledge into real-time physicians' clinical decisions and patient care, facilitating professional developments. Therefore, this paper focused on empowering the field force with SFA systems and their valuable outputs for the pharmaceutical sector and the continuing medical education of physicians.

2.1. Empowering Field with Salesforce Automation

The majority of authors [14–16] agree that IT solutions play a key role in increasing the productivity that transforms business processes. SFA focuses on fundamental strategies, including physicians' segmentation and targeting [17], detailing the right product, which differentiates the pharmaceutical company or its products from the other competitors. A tailored SFA system includes the name of healthcare professionals visited, the name of products promoted, the daily/weekly/monthly expense management, and other related detailing activities. These data ensure better field supervision, management, and monitoring of the whole "lines" (i.e., the entire field team of a pharmaceutical company). With this in mind, how specialized data is collected in real-time and interpreted with automated SFA systems has changed the pharma-physician relationship in pharmaceutical marketing.

Important for this study, SFA capabilities demonstrate that communication with physicians and CRM performances depend on how medical representatives select the right strategies, even in times of restriction, such as the COVID-19 pandemic. This pandemic fundamentally changed how medical representatives interact with healthcare professionals [18], and many businesses were required to quickly pivot different aspects of their strategies and processes [19–21] to develop stronger relationships with their internal customers and other stakeholders, specifically with members of marketing and product fulfillment [22]. Implementing effective communication and detailing strategies may only be ensured with the sincere monitoring of each and every field's activity, which are instantly updated.

We put forth that the number of face-to-face visits to physicians decreased during the COVID-19 pandemic due to quarantine, and remote detailing was performed via the SFA tool. Personalized promotions, according to the physicians' interests, continued during this period when physicians experienced their own treatment protocols for COVID-19. We wanted to scientifically prove this assumption. Therefore, this study hypothesized that these factors would influence the planning of the sales people's visits, as follows:

Hypothesis 1 (H1): *Due to the effect of the COVID-19 pandemic, there is a significant difference between scheduled visits to physicians.*

Hypothesis 2 (H2): *Due to the effect of the COVID-19 pandemic, there is a significant difference between unscheduled visits to physicians.*

Hypothesis 3 (H3): *Due to the effect of the COVID-19 pandemic, there is a significant difference between the total visit times to physicians.*

The entire data set of our study consisted of categorical variables, excluding the visit time variable, since the focus of our study was how the SFA tool monitors whether there are changes due to the effect of the COVID-19 pandemic in detailing strategies. We should

clarify that these first three hypotheses aimed to build a bridge between other hypotheses to be able to show the COVID-19 effect on value-based strategies (designing valuable medical content, providing innovative information, etc.) of the pharmaceutical company with their targeted physicians.

In the next section, closed loop marketing (CLM) capabilities are discussed as a specific strategy applied to healthcare professionals and other procurement entities (pharmacy, etc.) in a highly regulated sector. Due to these restrictions, it is difficult to implement all the promotional tools, but medical representatives may use closed loop marketing (CLM) strategies that contain continuing medical education, the product and "package", detailing, and e-detailing to convince physicians by providing them updated information about new chemical entities and competitive advantages, whereas they must respect the norms led down by the authorities.

2.2. Closed Loop Marketing (CLM) Capabilities

Even though the advertising and promotion of drugs directly to the society is prohibited in accordance with the Pharmaceutical Law in Turkey, it is not completely forbidden to inform and promote drugs to healthcare professionals [23]. Companies have adopted the following specific strategic marketing approaches: promotional and educational activities for all different sector players (e.g., opinion leaders, young physicians); management of relations between healthcare professionals and medical representatives [24]; customer acquisition and retention playing a mediating role in satisfaction, dependency, and intention to prescribe again [25]. Therefore, the company equips the salespeople with tablets with access to an SFA tool that contains promotional materials and other detailing aids. They report all feedback provided by healthcare professionals during the visit. They transform the data gathered from the field into actionable data by linking them to performance indicators and use that data in both marketing and training opportunities to make future communication tactics more targeted and efficient.

2.2.1. Continuing Medical Education

The COVID-19 outbreak with difficult conditions, including insufficient staffing, deficiency of specific treatment protocols, disapproval of new drugs, prolonged periods of hard work, and an ongoing risk of infection, was a strong challenge for healthcare professionals, who needed rapid healthcare resource availability [26] and accessibility [27]. Continuing medical education and training were necessary to prepare medical professionals for public health emergencies. Eftekhar Ardebili et al. [28] suggested in their study that physicians expressed their dissatisfaction with the ambiguity that was the inability to successfully treat patients, causing negative effects on their professional performance during the pandemic. Tanhan, Doyumğaç, and Kiymaz [29] suggested that institutions that switched to online and remote education without preparations during the COVID-19 pandemic should have provided flexibility for the students, employees, and/or instructors should have provided technical support to conduct more efficient online and remote education services.

Continuing medical education consists of various courses and academic and sectoral conferences tightly linked to core specialty knowledge and that are established for medical professionals to maintain and update competence and learn about new and developing areas of their field. Continuing medical education (CME) is one of the detailing strategies frequently used by pharmaceutical companies to maintain long-term relationships with physicians and to promote their particular molecule and thereby brand. However, the pharmaceutical industry's involvement in continuing medical education (CME) has been discussed for many years because of its influence on physicians' prescribing behaviors. On the other hand, this collaboration of pharmaceutical companies in continuing medical education is widely accepted by healthcare professionals due to the high cost and lack of sufficient time. Punchibandara [30] studied factors, such as regular medical representative visits, debate through research materials, and continuous medical education, that were more important than sampling.

High levels of promotion activities with effective communication skills and sufficient documentation, such as the continuing education provided by the pharmaceutical company representative and well-designed and well-reviewed scientific literature, and particular product information are connected to persuade physicians to prescribe a supported brand. These educational contents may be delivered through digital and remote learning tools as live events, virtual meetings, online programs, webcasts, videos, as well as written publications. There is a significant tendency to use online communication tools across multiple channels by pharmaceutical companies in order to affect a strong relationship with healthcare professionals and to communicate effectively with key opinion leaders (KOL). Virtual meetings were revealed as a good alternative to traditional off-line meetings for continued medical education for 66.9% in a study [31] conducted with physicians. The continued use of virtual meetings in all fields was expected by more than 80% of the participants (ibid.). Thus, in this study, we put forth that SFA, as a digital and remote detailing tool, offers an accessible means to increase the number of ways to educate internists with the rapid sharing of scientific and clinical studies, especially during the COVID-19 pandemic. The updated data and medical knowledge are quickly available in an accessible format for targeted physicians regarding their needs and interested molecules and/or products.

2.2.2. Product and "Package"

The strategy entitled "unique selling proposition" (USP) is the principal part of the closed loop marketing (CLM) strategy in the pharmaceutical industry. It essentially underlines the product differentiation, adding the factors that attract physicians, such as drug active ingredients. A well-created USP supported by a well-designed "package" (i.e., content of presentations to physicians) has a strong competitive advantage. These are the presentations created for physicians' visits that should consist of main points for every product in order to help the physicians to remember the product with its uniqueness. The success of this product positioning content is often related to the demonstration of the drug's unique selling proposition, including the brand name, treatment category, price, and key benefit, in a credible and competitive manner. For each new product launch and/or re-launch, pharmaceutical companies need clear and updated insights about each physician's interests and needs. For this, medical representatives use their insight into individual physicians to select the modules (i.e., packages) that best meet their needs via an SFA system. These data, linked to a preexisting CRM system in an SFA tool to derive a more in-depth analysis, are centrally collected and analyzed by the field team.

The detailed product information and literature should be planned by the line's regional director in the same "line" (medical representatives' team working for the same products in a defined region) according to the detailing strategy defined for the region and the targeted health professionals because there is always a risk that even a deviation will lead to inaccurate, misleading, or unclear information. This market intelligence may then be used to personalize detailing strategies for every single customer segmentation, or it can be extended to geographical regions and/or markets.

In addition, the field team can evaluate whether there is any product information not presented to the physician, although it is in the physician's area of interest, because SFA allows a company to keep a record of all packages presented to a physician. This can ensure that physicians are grouped according to the products they are interested in and that they are prioritized in all kinds of information on that product and/or related package. In such a CLM process with the physician, both continuity and consistency may be increased by providing summary information about previous visits and their preferences. Therefore, this study proposed the following:

Hypothesis (H4): *Product and package are significantly associated in the two selected periods before and during the COVID-19 pandemic.*

2.3. Customer Relationship Management (CRM) Capabilities

The success of a company's business in the pharmaceutical industry is fundamentally related to the long-term relationship with physicians. Customer-centric organizations often focus on creating value with the target audience through customer solution technology. The customer is not the client in the pharmaceutical sector. Therefore, physicians are a major factor in the prescription of medicine because they specify the instructions to be used by patients. Within a relational context, rules and steps for analytical processes in SFA tools refer to details and offers mentioned by medical representatives to engage in behaviors directed at analyzing physicians' needs. With SFA, the inclusion of medical representative teams (i.e., line) in the corporate workflow of the pharmaceutical company, fast communication between the company headquarters and drug warehouses, cost management in training funding, accurate segmentation, target-oriented data analysis, and CRM planning are more effective. Salespeople need to move beyond a focus on the prescribing habits of a physician to a focus on comprehensive measurement systems that include a total evaluation of goal achievement, customer feedback, teamwork, and learning orientation [32].

McKinsey's [33] research with pharma companies indicates that field team leaders designing a new strategy should consider paying close attention to some success factors, such as rapidly personalized content, analytic-centric engagement, innovative communication channels, and closed-loop execution. Region managers and medical representatives should integrate communication and data sources with SFA to enable line members to distinguish insights for improving decision making in real time, optimizing messages and channels and scheduling individual healthcare professionals' interactions [34]. For instance, regional managers should be empowered with field insight metrics, such as sales data, volume uptake, targeting philosophy, and product positioning in response to gathered feedback locally. After evaluating the success rate of different detailing strategies, such as medical camp, continuing medical education across various target segments and regions, and ineffective strategies and/or campaigns, they may be replaced with new ones and redefined.

During the COVID-19 pandemic, the job duties of medical representatives were conducted from a remote location to try to stay engaged with their physicians. This new environment could provide a chance to design the customer experience entirely via digital channels. The frequency and timing of digital detailing contents need to be weighed via SFA abilities against the overcharge of physicians' in clinics.

2.3.1. Segmentation and Targeting

The effective implementation of customer segmentation and targeting is equally important to design the detailing strategies, to identify the proper needs of the customer to help in the right investments, and to establish the corporate reputation in the minds of the customers. The need and the positioning strategy will be different for every targeted customer segment. Segmentation may also allow them to evaluate the competitors' strengths and weaknesses, focusing on the following parameters:

(a) Geographic Basis (e.g., urban, rural markets): Geographic segmentation involves selecting potential markets according to where they are located. Markets are divided into "bricks" in pharmaceutical marketing. In these markets, most pharmaceutical sales territories are built based on brick data available for that country [35]. In countries where physician-level prescription data are not available, brick data are a key measure of return on a pharmaceutical company's investment in detailing and sales promotion. Therefore, we hypothesized the following:

Hypothesis (H5): *Line and region are significantly associated in the two selected periods before and during the COVID-19 pandemic.*

(b) Physician segmentation at brick level (specialists, key opinion leaders in different regions).

(c) Qualification of physicians (specialist or key opinion leader) (Of note, a gamification application written by the pharmaceutical company for a product can be integrated with SFA. The segment value of the targeted and communicated physician can be determined by his/her preferences while playing this game).
(d) How volunteer a physician is to try new products.
(e) Type of customers (loyal, switchers, competitors loyal, specialist).
(f) Physicians' prescription habit or frequency (the industry-funded continuation of medical education is widely accepted and considered trustworthy [35].

Therefore, in light of previous literature, we also hypothesized the following:

Hypothesis (H6): *Product and segment are significantly associated in the two selected periods before and during the COVID-19 pandemic.*

These capabilities enable firms to build sustainable competitive advantages, such as a long-term customer-centric relationship in the healthcare ecosystem for future forecasting. Therefore, this study proposed the following:

Hypothesis (H7): *Product, segment, region, and line are significantly associated in the two selected periods before and during the COVID-19 pandemic.*

2.3.2. Effective and Electronic Detailing

The pharma industry has adopted more digital initiatives, even with regulation barriers. Electronic detailing (e-detailing) is one of the drug promotional methods introduced technologically. The purpose of developing new versions of SFA systems as "tailor made" is to offer packages and contents personalized for targeted physician segments by "lines" in the regions determined by the pharmaceutical company in order to offer a value-oriented approach to the customer.

For e-detailing, digital technologies, such as internet-based sales force automations, video conferencing, web casting, interactive voice response, static presentations with instinctive segments, and physician-driven surveys, are adopted to interact with physicians, especially during the COVID-19 pandemic. The fact that medical representatives can access the presentations managed from the headquarters of the company as if they were working in the same office and the ability to plan the visit notes according to the periodic goals make it easier for physicians to present personalized content, meeting the needs of them during the visit. These real-time and remote specificities of SFA make educational events more reasonable, accessible, and financially sustainable.

On the other hand, the importance of "connected consumer" and "omnichannel" concepts is emphasized in new generation sales practices. The technology-based intelligent multi-channel approach affects medical professionals' relationships. Thus, it is claimed that in-store ordering and "click & collect" will be the omnichannel solutions that will be used most frequently by sales points inside and outside the pharmacy. It is possible, with SFA, to stay one step ahead of the customer at the point of sale and to offer the product he/she may need before he/she arrives. It provides the opportunity to instantly convert the correct data obtained from the field into value. Additionally, the performance monitoring of the field can be evaluated with detailed reports. The latest status of the instant targets of the field teams can be seen, and action can be taken according to their results. By collecting instant data from the field, both strengths, weaknesses, opportunities, and threats (SWOT) analysis and competitor analysis can be performed.

Hypothesis (H8): *Product and line are significantly associated in the two selected periods before and during the COVID-19 pandemic.*

The COVID-19 pandemic has presented numerous obstacles for healthcare systems and healthcare professionals. Healthcare providers (HCPs) gave frontline care to patients with COVID-19 in difficult conditions, which include insufficient staffing, unknown treatment protocols, prolonged periods of hard work, wearing mandatory safety equipment, and an ongoing risk of infection. Among physicians that participated in media interviews, some of them expressed dissatisfaction with the frequent change of protocols, prevention and treatment methods, and the attendant negative effects of this on their performance. In the present study, we also measured the behaviors and attitudes of 816 physicians who were visited jointly in a wide-ranging medical field, such as internal medicine, and pre-and post-COVID-19 periods. With the help of this tool, we were able to measure not only the skill of SFA but also the attitudes and behaviors of physicians during the pandemic, when there were uncertain treatment protocols.

3. Materials and Methods

3.1. Data Collection and Sample

This study aimed to compare the data on internists and their products gathered from a well-known pharmaceutical company's SFA system in Turkey, with the approval of the IT company that wrote this tool. The data covered the first three months (January, February, and March) of the year 2020, when medical representatives' daily routine was normal, and that of 2021, when Turkey experienced the most powerful surge of the COVID-19 pandemic. Thus, the samples obtained are comparable to the impact of the COVID-19 pandemic. The comparative analysis was conducted using simple correspondence analysis (SCA) and multiple correspondence analysis (MCA) for 11 variables (Table 1) on a sample of 7083 visits for 2020 and 4893 visits for 2021, recorded for each visit by salespeople.

Table 1. Variables and definitions.

Variable	Definition	Category/Properties
Segment	Physician's loyalty level	16 segments
Customer	Physicians (our sample is internal medicine specialists, in this study)	Sample size for 2020: 1682 physicians Sample size for 2021: 834 physicians Joint physician sample size for both years: 815
Unit	The place where the relevant customer works (public and/or private hospitals, for this study)	Unit sample size for 2020: 404 Unit sample size for 2021: 403
Brick	A collection of accounts and contacts (Turkey consists of 1001 bricks regarding to global pharma standards)	Brick sample size for 2020: 308 Brick sample size for 2021: 304
Line	Medical representatives for the same product	5 lines (Each line consists of an average of 90 people in this company)
Region	Total place where lines run on bricks	8 regions: Adana, Mediterranean, Aegean, Southeastern Anatolia, Istanbul Anatolian side, Istanbul European side, Black Sea, Middle Anatolia
Product	Internal medicine drugs for this study	15 products
Package	Presentations and contents presented to the physician	133 packages for 2020; 17 packages constituting 90.4% of the sample were included in the analysis 126 packages for 2021; 17 packages constituting 90.2% of the sample were included in the analysis
Presentation time of scheduled visit	Total routine visit time defined on SFA	
Presentation time of unscheduled visit	Total remembered visit time for customer retention	
Total presentation time	Total visits time	

Source of Table 1: TCM Software and Consultancy Company, Istanbul, Turkey (gathered date: July 2021).

The unit of the analysis was salespeople's visits to selected physicians for e-detailing. The fundamental variables of a detailing visit to a physician were defined, including the segment, customer, unit, brick, line, region, product, package, presentation time in a scheduled visit, presentation time in an unscheduled visit, and total presentation time. Non-parametric methods were used because eight variables (segment, customer, unit, brick, line, region, product, and package) used in the analysis had categorical scales, and

three continuous variables (presentation time in a scheduled visit, presentation time in an unscheduled visit, and total presentation time) were not normally distributed. Below, Table 1 represents all visit variables in detail, with the numerical data that we analyzed in our study.

Descriptive statistics and frequency distributions of the variables used in the analysis are summarized in Tables 2 and 3 (since these are interim descriptive statistics describing the current situation, we did not include them in the results section).

Table 2. Frequency distribution and descriptive statistics of variables.

Variables (Coding)	2020		2021	
	Frequency	Percent	Frequency	Percent
Segment (S)				
AA (S1)	445	6.3	296	6.0
AB (S2)	458	6.5	272	5.6
AC (S3)	314	4.4	211	4.3
AD (S4)	147	2.1	89	1.8
BA (S5)	425	6.0	287	5.9
BB (S6)	773	10.9	486	9.9
BC (S7)	1224	17.3	836	17.1
BD * (S8)	1297	18.3	908	18.5
CA (S9)	65	0.9	47	1.0
CB (S10)	172	2.4	114	2.3
CC (S11)	403	5.7	256	5.2
CD * (S12)	1178	16.6	935	19.1
DA * (S13)	25	0.4	34	0.7
DB (S14)	28	0.4	20	0.4
DC * (S15)	37	0.5	35	0.7
DD * (S16)	92	1.3	72	1.5
Line (L)				
Alpha * (L1)	86	1.2	70	1.4
Beta * (L2)	276	3.9	293	6.0
Delta (L3)	163	2.3	10	0.2
Epsilon * (L4)	6359	89.8	4511	92.1
Gama (L5)	199	2.8	14	0.3
Region (R)				
Adana * (R1)	1283	18.1	973	19.9
Mediterranean * (R2)	1273	18.0	886	18.1
Aegean (R3)	77	1.1	46	0.9
Southeastern Anatolia * (R4)	28	0.4	25	0.5
İstanbul Anatolian side (R5)	761	10.7	453	9.2
İstanbul European side (R6)	899	12.7	467	9.5
Black Sea * (R7)	1254	17.7	902	18.4
Middle Anatolian * (R8)	1508	21.3	1146	23.4
Product (P)				
Acemethazine * (P1)	846	11.9	844	17.2
Cetirizine D+S (P2)	7	0.1	6	0.1
Cetirizine tablet (P3)	17	0.2	6	0.1
Rupatadin fumarate (P4)	199	2.8	26	0.5
Vitamin b1 in combination with vitamin b6 and/or vitamin b12 * (P5)	1576	22.3	1164	23.8
Vitamin b1-vitamin b6-vitamin b12- thioctic acid (P6)	2510	35.4	1721	35.1
Montelukast sodium, levocetrizin dihydrochloride * (P7)	126	1.8	128	2.6
Levocetrizin dihydrochloride * (P8)	58	0.8	49	1.0

Table 2. *Cont.*

Variables (Coding)	2020		2021	
	Frequency	Percent	Frequency	Percent
Segment (S)				
Diclofenac sodium * (P9)	51	0.7	77	1.6
Dexketoprofen tometamol (P10)	28	0.4	21	0.4
Iron sucrose complex (P11)	163	2.3	10	0.2
Mometazon furoat monohydrate * (P12)	28	0.4	30	0.6
Chlorzoxazone, parasetamol * (P13)	46	0.6	46	0.9
Butamirate citrate(P14)	1	0.0	-	-
Trimebutine(P15)	1427	20.1	770	15.7
TOTAL	7083	100.0	4898	100.0
	n	$\overline{X} \pm s$	n	$\overline{X} \pm s$
Presentation time of scheduled visit (SPT)	6524	58.94 ± 90.38	4452	43.40 ± 76.25
Presentation time of unscheduled visit (USPT)	1423	34.05 ± 67.30	1048	30.59 ± 58.45
Total presentation time (TPT)	7083	61.13 ± 94.47	4898	46.00 ± 81.97

* This shows an increase in frequency percentage compared to 2020.

Table 3. Frequency distribution of package (90% of the sample was summarized).

2020			2021		
Package (PC1) *	**Frequency**	**Percent**	**Package (PC2) ****	**Frequency**	**Percent**
PC1-1	690	9.7	PC2 -1	648	13.2
PC1-2	667	9.4	PC2-2	557	11.4
PC1-3	609	8.6	PC2-3	455	9.3
PC1-4	564	8.0	PC2-4	453	9.2
PC1-5	541	7.6	PC2-5	405	8.3
PC1-6	531	7.5	PC2-6	392	8.0
PC1-7	498	7.0	PC2-7	332	6.8
PC1-8	451	6.4	PC2-8	283	5.8
PC1-9	428	6.0	PC2-9	170	3.5
PC1-10	409	5.8	PC2-10	156	3.2
PC1-11	267	3.8	PC2-11	137	2.8
PC1-12	200	2.8	PC2-12	133	2.7
PC1-13	169	2.4	PC2-13	112	2.3
PC1-14	118	1.7	PC2-14	94	1.9
PC1-15	97	1.4	PC2-15	41	0.8
PC1-16	84	1.2	PC2-16	25	0.5
PC1-17	83	1.2	PC2-17	24	0.5
TOTAL	6406	90.4		4417	90.2

* The packages coded as PC1 represent the presentations and contents made by the relevant lines to the doctors in 2020. In accordance with the regulations and ethical rules, the real names of these contents were replaced with anonymous codes in the study. ** The packages coded as PC2 represent the presentations and contents made by the relevant lines to the doctors in 2021. In accordance with the regulations and ethical rules, the real names of these contents were replaced with anonymous codes in the study.

According to the summary statistics in Table 2, on the basis of segment levels of target doctors in the first three months of 2020, it was determined that the doctors in the BD(S8), BC(S7), and CD(S12) segments were mostly contacted. In 2021, communication and CLM strategies were carried out mostly for the CD (S12), BC(S7), and BD(S8) segment groups,

respectively. Compared to the previous year, an increase was observed in the frequency of the BD(S7), CD(S12), DA(S13), DC(S15), and DD(S16) segments in the first quarter of 2021.

Due to the COVID-19 pandemic, CRM and CLM strategies for physicians, which are limited and can usually be performed remotely, seemed to focus on physicians in the less-loyal segment compared to the level of relationship they established with the relevant pharmaceutical company. In a study conducted in Germany, it was reported that physicians who were "visited more than 2–3 times a day or a week" tended to write more prescriptions and more products compared to those who were visited less frequently [36]. Our findings revealed that salespeople effectively plan customer retention strategies in line with the notes on SFA during their field visits. In order to use this time limit efficiently, lines concentrate on introducing the company's products to new physician segments.

Our findings suggest that the L4 group was the most active online basis in the first three months of 2020 and 2021. This result is consistent with the findings on the most promoted products in 2020 and 2021. We may clearly say this because most of these drugs (for example P1, P5, P6, and P15) are products presented to internal medicine specialists by the line L4. Compared to the previous year, an increase was observed in the frequency of visits of L1, L2, and L4 lines in the first three months of 2021. These results are consistent with the findings of the most promoted drugs in our study because the products promoted by lines L1 and L2 had pain killers and antipyretic and antihistaminic effects, relieving nasal itching and curing allergic rhinitis. Additionally, these clearly revealed the effect of COVID-19 on the marketing plan design of the pharmaceutical company. These products became the most asked-for drugs with the emergence of COVID-19 symptoms by internal medicine specialists. As we mentioned above, medical authorities highlighted that the pathogenesis of the virus is still not fully known. The physicians were interested in different products according to the symptoms they encountered in the COVID-19 period. Hence, the usage of an SFA system is important because the purpose of CLM is to make the data collected from the lines actionable and measurable and to incorporate the proper use of this data to tailor future marketing strategies.

There was a remarkable result regarding the active ingredients of the products under review in this study. The most promoted products in 2020 and 2021 were P5 (vitamin B1 in combination with vitamin B6 and/or vitamin B12) and P6 (vitamin B1-vitamin B6-vitamin B12-thioctic acid), respectively. The active ingredient of the prominent product P15 in 2020 was an agent that regulates digestive motility, whereas (P1), promoted in 2021, contained an agent that has anti-inflammatory, analgesic, and antipyretic effects. This is because people with COVID-19 have a wide range of symptoms, such as fever or chills, muscle or body aches, and headaches [32]. Compared to the previous year, we also observed an increase in the frequency of P1, P5, P7, P8, P9, P12, and P13 products in the first quarter of 2021. When the active ingredients of these products were examined, we affirmed that they are often used in the treatment of COVID-19 symptoms, such as curing allergic rhinitis, improving asthma symptoms, treating allergies with antihistamines, and relieving sneezing, nasal itching, discharge, and congestion. These results revealed again the effect of COVID-19 on the marketing plan and medical education content design of the pharmaceutical company.

These findings are also consistent with the results of the following study: According to a study conducted in the United States of America (USA), between 2008 and 2009 [37], it was reported that the prescription of antibiotics increased significantly with CRM and CLM activities compared to those without. In order to increase the knowledge and the access of internal medicine specialists regarding drugs used in the treatment of COVID-19 during the pandemic in Turkey, target visits and selected packages by the pharmaceutical company's salespeople were introduced through SFA.

When the length of packages was examined, the average presentation time allocated during scheduled visits in 2020 was 58.94 min, and the standard deviation was 90.38 min, while during unscheduled visits, the average of this time dropped to 34.05 min and its standard deviation to 67.30 min. The average of the total length of time was 61.13 min, and the standard deviation was 94.47 min in 2020. However, the average of the presentation

time allotted during scheduled visits in 2021 was 43.4 min, and the standard deviation was 76.25 min, while during unscheduled visits, the average of this time dropped to 30.59 min and its standard deviation to 58.45 min. The average of the total length was 46 min, and the standard deviation was 81.97 min in 2021. The figures in the table above indicate that there was a decrease in the average length of presentation time allocated for each type of visit in 2021. We can argue that the summary statistics reflect the possible impact of the COVID-19 pandemic because of lockdowns.

Table 3 shows the package group that made up 90% of the frequency distributions offered by salespeople during the physician visits. Hence, while the PC1-5 (about diabetes) presentation was delivered at a rate of 7.6% in 2020, this presentation was not made in 2021. Instead, there was an increase in the frequency of the PC2-5 (8.3%) presentation about the P5 product, with the active ingredient vitamin B1 in combination with vitamin B6 and/or vitamin B12, in 2021. This finding reveals the effect of COVID-19 on the medical education content design of the company because researchers were studying whether vitamin B can prevent or reverse a cytokine storm, one of the major complications and causes of death in COVID-19 patients [38]. It has also been suggested that vitamin B not only helps to build and maintain a healthy immune system, but it could potentially prevent or reduce COVID-19 symptoms or treat SARS-CoV-2 infection [39]. While packages about allergic rhinitis were prioritized in 2020, the frequency of presentations of packages about the efficacy of combined therapy in bronchitis (0.5%) and those about the relationship between bronchitis and asthma (0.5%) increased in 2021. These findings coincide with the findings above on the frequency of the most promoted products in the first quarter of 2021.

3.2. Methodology

3.2.1. Correspondence Analysis

Correspondence analysis (CA), a multivariate descriptive statistical method designed to explore relationships among categorical variables, provides a graphical representation of the relationships among variables on two-way or multiple contingency tables. There are two forms of correspondence analysis. The first is simple correspondence analysis, which is used to analyze contingency tables of two categorical variables, whereas the second, multiple correspondence analysis, is applied to cross-tabulation with three or more variables.

Correspondence analysis, which calculates inertia estimates of categorical variables based on the Euclidean distance and defines a loss function, minimizes loss function using weighted least squares in an attempt to maximize variable homogeneity.

3.2.2. Simple Correspondence Analysis (SCA)

Let *X*, with elements x_{ij}, be an I × J two-way table of unscaled frequencies. If n is the total of frequencies in data matrix X, then the matrix of proportions is shown as $P_{(I\times J)} = {}^{1}/_{n}X_{(I\times J)}$. The matrix P is called the correspondence matrix. The vectors of row and column sums r and c, respectively, and diagonal matrices are D_r = diag(r) and D_c = diag(c), respectively. The correspondence analysis can be formulated as follows [40]:

$$\sum_{i=1}^{I}\sum_{j=1}^{j}\frac{\left(p_{ij}-\hat{p}_{ij}\right)^2}{r_i c_j} = \mathrm{tr}\left[\left(D_r^{-1/2}(P-\hat{P})D_c^{-1/2}\right)\left(D_r^{-1/2}(P-\hat{P})D_c^{-1/2}\right)'\right] \quad (1)$$

The term rc' is common to approximation $\hat{P}$ whatever the I × J correspondence matrix P. The reduced rank s approximation to P is as follows:

$$= \sum_{k=1}^{s}\widetilde{\lambda}_k\left(D_r^{1/2}\widetilde{u}_k\right)\left(D_c^{1/2}\widetilde{v}_k\right)' = rc' + \sum_{k=2}^{s}\widetilde{\lambda}_k\left(D_r^{1/2}\widetilde{u}_k\right)\left(D_c^{1/2}\widetilde{v}_k\right)' \quad (2)$$

where $\widetilde{\lambda}_k$ are the singular values, and the I × 1 vectors $\widetilde{u}_k$ and J × 1 vectors $\widetilde{v}_k$ are the corresponding singular vectors of the I × J matrix $D_r^{-1/2}PD_c^{-1/2}$. The reduced rank K > 1 approximation to P-rc' is as follows:

$$P - rc\prime = \sum_{k=1}^{K} \lambda_k \left(D_r^{1/2} u_k \right) \left(D_c^{1/2} v_k \right)' \quad (3)$$

where λ_k are the singular values, and the $I \times 1$ vectors u_k and $J \times 1$ vectors v_k are the corresponding singular vectors of the $I \times J$ matrix $D_r^{-1/2}(P - rc')D_c^{-1/2}$. Here, $\lambda_k = \widetilde{\lambda}_{k+1}$, $u_k = \widetilde{u}_{k+1}$, and $v_k = \widetilde{v}_{k+1}$ for $k = 1, 2, \ldots, J - 1$.

In correspondence analysis, the eigenvalues are often called inertias [41]. The inertia associated with the best reduced rank $K < J$ approximation to the center matrix $P - rc\prime$ has inertia $\sum_{k=1}^{K} \lambda_k^2$.

3.2.3. Multiple Correspondence Analysis (MCA)

The correspondence analysis for bivariate (two-way) crosstabs can be extended with three or more variables crosstabs. Another approach is the multi-way frequency table, known as MCA, organized as a two-way table. The MCA technique uses a distance measure instead of the orthogonalization technique used in the Principal Components Technique. MCA transfers the relationship between categories to coordinates in a multidimensional space. With this technique, the categories are scaled and the variance is maximized to calculate the associations between the variables and the proximity between individuals. Points in the same direction from the origin are highly correlated [42].

The working principle of MCA is that two or more categorical variables can be recoded in an indicator matrix as dummy variables or in a Burt matrix (B), where $B = X'X$, as a combination of categories by categories [43].

There are two main methods for carrying out MCA; one involves the use of an indicator matrix and the other of a Burt matrix, obtained from an initial indicator matrix [44]. A fit analysis with the help of the X matrix and a fit analysis with the help of the $X'X$ matrix, which is called the Burt matrix, are equivalent to each other. The Burt matrix is in the form of a block-square matrix and is obtained as a two-way crosstab. The two main reasons for using the Burt matrix in the current study were that it is easy to interpret and suitable for the analysis of large data sets. In MCA, the proportions of the total inertia (squared singular values) accounted for by the inertia tend to be underestimated because the total inertia is inflated due to fitting both diagonal and off-diagonal blocks of the Burt table [45].

Burt matrices created in the study are presented in Appendices A and B.

4. Results and Discussion

In line with the purpose of the study, analyses were conducted with SPSS-26 and Statgraphics-19 package programs.

H1, H2, and H3 hypotheses were constructed to measure the effect of the COVID-19 pandemic and to determine the differences between the averages of visit times between the two selected periods. The normality test was performed before testing the relevant hypotheses. The results indicated that the data did not follow normal distribution according to the Kolmogorov-Smirnov normality result ($p = 0.00$). In Table 4, alternative hypotheses (H1, H2, H3) were tested with the nonparametric method, Mann–Whitney U, and the results are given.

According to the findings in Table 4, H1, H2, and H3 hypotheses were accepted at a significance level of $\alpha = 0.01$. There was a difference between the average visit times of the years 2020 and 2021. In this respect, the mean ranks indicated that there was a decrease in the scheduled, unscheduled, and total length of visit time during the period in 2021 under review in this study due to the surge of the COVID-19 pandemic.

Table 4. Hypothesis test results.

Alternative Hypothesis	Year	n	Mean Rank	Decision	Mann Whitney U *p*-Value
H_1	2020	6524	5853.12	Null hypothesis rejected	0.000
	2021	4452	4954.18		
H_2	2020	1423	1294.20	Null hypothesis rejected	0.000
	2021	1048	1156.98		
H_3	2020	7083	6397.83	Null hypothesis rejected	0.000
	2021	4898	5402.69		
	Total	11,981			

The relationship between product and package within the time period under review also needed to be explored in this study. Therefore, the H4 hypothesis that was tested by chi-square analysis, and Table 5 was created using Cross-Tabulation.

Table 5. Product and package cross-tabulation.

2020	P(1)	P(4)	P(5)	P(6)	P(15)
PC1-12	200	-	-	-	-
PC1-14	118	-	-	-	-
PC1-11	267	-	-	-	-
PC1-17	83	-	-	-	-
PC1-13	169	-	-	-	-
PC1-16	-	84	-	-	-
PC1-15	-	97	-	-	-
PC1-5	-	-	541	-	-
PC1-4	-	-	564	-	-
PC1-10	-	-	409	-	-
PC1-1	-	-	-	690	-
PC1-2	-	-	-	667	-
PC1-3	-	-	-	609	-
PC1-7	-	-	-	498	-
PC1-6	-	-	-	-	531
PC1-9	-	-	-	-	428
PC1-8	-	-	-	-	451
Chi-Square test statistics = 97,447.98 (*p*-value = 0.000)					

2021	P(1)	P(4)	P(5)	P(6)	P(7)	P(15)
PC2-12	133	-	-	-	-	-
PC2-14	94	-	-	-	-	-
PC2-10	156	-	-	-	-	-
PC2-9	170	-	-	-	-	-
PC2-13	112	-	-	-	-	-
PC2-15	41	-	-	-	-	-
PC2-11	137	-	-	-	-	-
PC2-5	-	3	402	-	-	-
PC2-3	-	2	453	-	-	-
PC2-8	-	1	282	-	-	-
PC2-1	-	2	-	646	-	-
PC2-2	-	1	-	556	-	-
PC2-4	-	-	-	453	-	-
PC2-16	-	-	-	-	25	-
PC2-17	-	-	-	-	24	-
PC2-7	-	1	-	-	-	331
PC2-6	-	1	-	-	-	391
Chi-Square test statistics = 60,290.76 (*p*-value = 0.000)						

According to Table 5, the H4 alternative hypothesis was accepted at a significance level of $\alpha = 0.01$. In this respect, the figures confirmed a statistical correlation between

product and package. As we showed above on this screen shot example about the product and related package introduced to the physician, this watching data (ex. which physician watched which package for how many seconds) are able to derive inferences on the content preferred by the healthcare professional. The results of SCA, which identify the correlation between product and segment (H6), which is another hypothesis put forth in this study, are given in Table 6.

Table 6. Result of SCA (product and segment inertia and chi-square decomposition).

Dimension	Singular Value	Inertia	Chi- Square	Percentage	Cumulative Percentage
2020					
1	0.4467	0.1995	1413.3637	66.1124	66.1124
2	0.1879	0.0353	250.2063	11.7038	77.8162
2021					
1	0.5116	0.2617	1281.7554	65.6446	65.6446
2	0.2467	0.0609	298.1893	15.2717	80.9163

Table 7 indicates that the results of SCA on the basis of two dimensions explained 77.82% of inertia in 2020 and 80.91% of inertia in 2021. The test statistics indicated that the H6 alternative hypothesis was accepted at a significance level of $\alpha = 0.01$ and confirmed a correlation between product and segment. The correspondence map generated based on these results is given in Figure 1.

Table 7. Product and line cross-tabulation.

2020	L1	L2	L3	L4	L5	TOTAL
P1	-	-	-	846	-	846
P2	-	7	-	-	-	7
P3	-	17	-	-	-	17
P4	-	-	-	-	199	199
P5	-	-	-	1576	-	1576
P6	-	-	-	2510	-	2510
P7	-	126	-	-	-	126
P8	58	-	-	-	-	58
P9	-	51	-	-	-	51
P10	28	-	-	-	-	28
P11	-	-	163	-	-	163
P12	-	28	-	-	-	28
P13	-	46	-	-	-	46
P14	-	1	-	-	-	1
P15	-	-	-	1427	-	1427
TOTAL	86	276	163	6359	199	7083
Chi-Square test statistics = 28,332 (p-value = 0.000)						
2021	L1	L2	L3	L4	L5	TOTAL
P1	-	-	-	844	-	844
P2	-	6	-	-	-	6
P3	-	6	-	-	-	6
P4	-	-	-	12	14	26
P5	-	-	-	1164	-	1164
P6	-	-	-	1721	-	1721
P7	-	128	-	-	-	128
P8	49	-	-	-	-	49
P9	-	77	-	-	-	77
P10	21	-	-	-	-	21
P11	-	-	10	-	-	10
P12	-	30	-	-	-	30
P13	-	46	-	-	-	46
P15	-	-	-	770	-	770
TOTAL	70	293	10	4511	14	4898
Chi-Square test statistics = 17,324.37 (p-value = 0.000)						

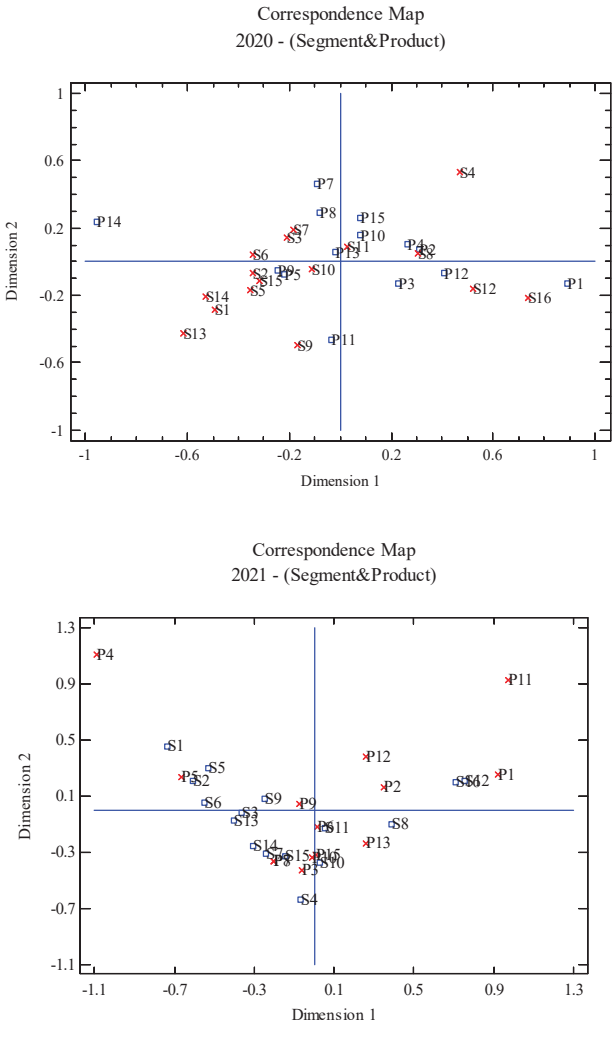

Figure 1. Correspondence maps of segment and product for 2020–2021.

Figure 1 reveals that the decomposition of the products P11 and P4 had the most significant difference between 2020 and 2021, and S4 moved differently in 2021 compared to 2020. In addition, physicians in the S12 and S16 segments preferred the products P1, P2, P3, and P12 in 2020, whereas the physicians in the aforementioned segments preferred P11 instead of P3 in 2021. In 2020, physicians in the S1, S2, S5, and S9 segments preferred P5, whereas P5 and P4 were preferred by physicians in the S1, S2, S3, S5, and S6 segments in 2021.

When the active ingredients of these products often used in the treatment of COVID-19 are examined, it is shown that they are also used to treat symptoms such as allergic rhinitis, asthma symptoms, allergies, sneezing, and nasal itching, discharge, and congestion. These results reveal again the effect of COVID-19 on the marketing design, as mentioned earlier in the text. Considering that the S12 and S16 segments were low categories in terms of physician loyalty level, we may suggest that these well-known drugs of the company were preferred in COVID-19 treatment and provided an advantage to develop effective CRM and CLM strategies to newly targeted physicians.

Another hypothesis (H8) was constructed to investigate the relationship between product and line. Chi-square test statistics were calculated, and the hypothesis was tested. We should clarify that we tried to investigate the COVID-19 pandemic effect on relational dimension, since the variables subject to analysis were categorical. Impact analysis can be performed by adding sales data to further studies.

According to Table 7, alternative hypothesis H8 was accepted at a significance level of $\alpha = 0.01$. The table shows that product and line were statistically correlated. It was reported that physicians who were "visited more than 2–3 times a day or a week" tended to write more prescriptions and content compared to those who were visited less frequently, in a study conducted in Germany [36]. According to another study conducted in the USA between 2008 and 2009, it was reported that the prescription of antibiotics with promotional activities increased significantly compared to those without [37]. In our study, we highlighted the COVID-19 effect on this routine visit process. Clinical studies and vaccination studies are still ongoing. Currently, "effective infection control intervention is the only way to prevent the spread of SARS-CoV-2. The most appropriate prophylactic regimen for patients under observation due to COVID-19 related disease is unknown. For this reason, treatment protocols should be planned by following the current guidelines" [46]. Physicians are interested in different products according to the symptoms they encounter in the COVID-19 period, regarding their own experiences. In order to suggest this scientifically, we found that the line introduces different products by planning more frequent visits, according to the frequency increase in the interest level shown by the physicians to these products.

SCA test results for H5 are shown in Table 8, and the correlation of line and region in 2020 and 2021 is illustrated in Figure 2. We should clarify that we included the first 3 months of 2020 and 2021 in our study. Because, even if we took a full year, it would not change the "significantly associated/not associated" factor that we investigated in our hypotheses. The sample that we used in our study has the ability to represent the main mass.

Table 8. Result of SCA (line and region inertia and chi-square decomposition).

Dimension	Singular Value	Inertia	Chi-Square	Percentage	Cumulative Percentage
2020					
1	0.5082	0.2583	1829.2660	78.8865	78.8865
2	0.2096	0.0439	311.1170	13.4168	92.3034
2021					
1	0.6208	0.3854	1887.5531	81.3667	81.3667
2	0.2624	0.0689	337.3740	14.5432	95.9098

2020: chi-square test statistics = 2318.857 (p-value = 0.000); 2021: chi-square test statistics = 2319.811 (p-value = 0.000).

According to Table 8, the alternative hypothesis H5 was accepted at a significance level of $\alpha = 0.01$. There was a statistical correlation between region and line. The test results of SCA on the basis of the first two dimensions explained 92.30% of inertia in 2020 and 95.91% in 2021. The correspondence maps generated based on these results is given in Figure 2.

Figure 2 shows that there was no significant difference between the line and region relationships between 2020 and 2021 first trimester periods. While lines L2 and L5 operated in the R4 region in 2020, line L5 moved to a different region in 2021. Line L1 worked in the R3 region in both periods.

Finally, the H7 hypothesis, which aimed to investigate the relationship between four variables (product, segment, line, and region), was tested by calculating the Burt matrix, and the relevant results are given in Table 9.

Table 9 indicates the MCA results gathered using the Burt matrix based on the first two dimensions, explaining 20.03% of inertia in 2020 and 22.24% of inertia in 2021. The correspondence maps generated based on these results are given in Figure 3.

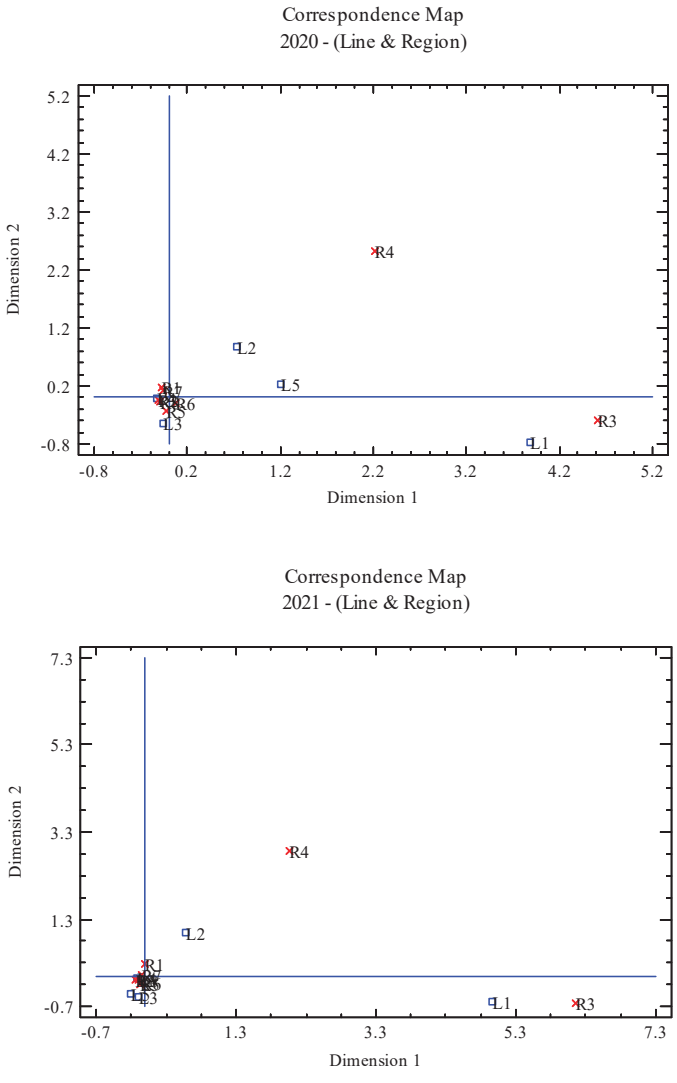

Figure 2. Correspondence maps of line and region for 2020–2021.

Table 9. Result of MCA (product, segment, line, and region inertia and chi-square decomposition).

Dimension	Singular Value	Inertia	Chi-Square	Percentage	Cumulative Percentage
2020					
1	0.5964	0.3557	40,316.3752	11.2716	11.2716
2	0.5256	0.2763	31,310.3030	8.7537	20.0252
2021					
1	0.6314	0.3987	31,244.8029	12.9112	12.9112
2	0.5368	0.2882	22,584.4222	9.3325	22.2437

2020-Mean Cronbach's Alpha: 0.739; 2021-Mean Cronbach's Alpha: 0.763 (Mean Cronbach's Alpha is based on the mean Eigenvalue).

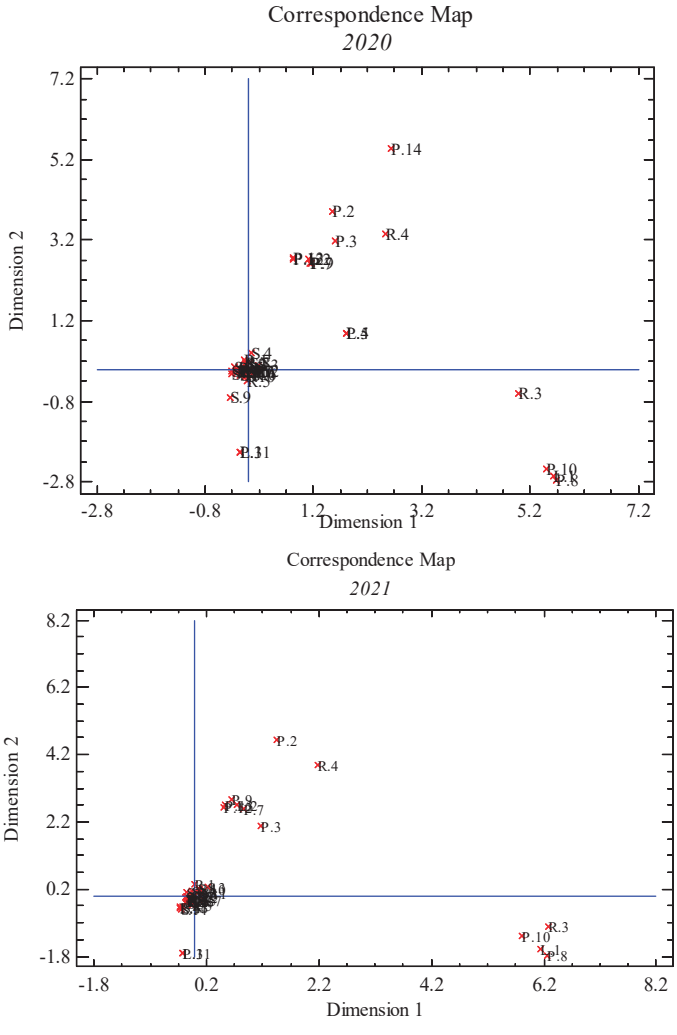

Figure 3. Correspondence maps of product, segment, line, and region for 2020 and 2021.

According to Figure 3, there were four groups formed in both years that provided a multiple correspondence level, but we should underline that we analyzed each year in itself. We did not compare the years 2020 and 2021. We tried to evaluate whether there was an increase in frequency in the number and type of products introduced, the segment profile of the physicians, and the visit planning of the lines due to COVID-19 each year. Thus, we tested the hypotheses by performing correspondence analysis and evaluated the relationship between the product, line, and segment categorical variables. Our inferences for 2020 and 2021 are as follows:

The groups had the following variables in 2020:
Group 1: P14, P2, P3, and R4 (Southeastern Anatolia).
Group 2: P4, P5, P7, P9, P12, P13, and L2.
Group 3: R3 (Aegean), P10, P8, L1, and S9 (CA).
Group 4: P11 and L3.
The groups had the following variables in 2021:
Group 1: P2 and P4

Group 2: P3, P7, P9, P12, P13, and L2
Group 3: R3, P10, P8, and L1
Group 4: P11 and L3.

5. Conclusions

Coronavirus disease seemed to be far away and insignificant to most people and physicians around the world. This caused great anxiety and fear in society. Negative conditions and uncertainties, such as lack of information, misinformation, viruses, unrecognized treatment, and vaccines, have had consequences in a number of sectors, with direct implications for people's daily lives. The measures taken to contain the spread of the virus since the outbreak of the pandemic in March 2020 in Turkey have had a profound impact on the pharma sector, just as on all spheres of life. A lot of people chose to stay home due to the pandemic and reduced non-urgent treatments or needs, followed by a restriction of access to public health care services and physicians, which, in turn, resulted in a regression to a level prior to 2017, with 2.2 billion boxes of products sold [12]. The imposition of pandemic restrictions and the prioritization of the COVID-19 pandemic in health care services culminated in a decrease in continuing medical education activity numbers.

In addition, most of the countries in the world prohibit prescription drug advertising and promotion directly to consumers. The regulation of pharmaceutical promotion is carried out directly by the government (including France and the United States) or through industry self-regulation (including in the United Kingdom). With the increasing competition, the pharmaceutical industry needs to evolve new detailing and education tools in order to make patients and physicians aware of new treatments. Thus, it was identified that real-time customer-centric data-based CLM strategies, such as visit types and durations, drug prescription rates, interested packages, physicians' loyalty levels, etc., in 2020 changed in 2021 due to COVID-19. However, SFA paves the way for easily adapting the lines of the company to digital technologies in a short span of time instead of conventional methods.

For pharma, some of the changes we outlined above will remain even after the crisis has ended, once the pharma industry and its customers learn to function in a world without face-to-face detailing. In the meantime, marketers should not be afraid to experiment with multiple channels and to treat the current operating environment as a learning opportunity. Digital flips match with physicians that prefer to engage via digital channels. However, a survey conducted by McKinsey in Europe showed that the average number of in-person contact between healthcare professionals and pharma sales people was 70 percent lower in September 2020 than before the pandemic [32]. This is consistent with our H1, H2, and H3 hypotheses and our research findings. While the COVID-19 pandemic presented a big crisis to pharmaceutical companies, instant changes in SFA's technology structures allowed them to maintain the relationship between the lines and health professionals. Thus, although COVID-19 is an uncertain disease, and treatment protocols change very rapidly with instant findings, with the digitalization provided by SFA, updated promotional and training materials and detailing strategies can be transmitted to field teams instantly from the center. This also provides the opportunity to rapidly meet the continuing medical education needs of target physicians. Moreover, our findings suggested that many companies may adopt new retargeting strategies when people are under various restrictions during, for example, the pandemic crisis. Finally, we may suggest that digital technologies support organization in the process of transforming from product-centered to value-creating business models.

6. Limitations and Future Research

In the present study, the input data only represented the selected organization. One of the primary reasons for this limitation is they ignore important data relevant to sales because of organizational confidentiality. However, the possibility of remote detailing with SFA tools was useful to maintain interactions with physicians that worked in difficult conditions during the COVID-19 pandemic, when it was difficult to geographically access the target groups because of lockdowns and social distancing. Therewith, some key elements in the

detailing techniques changed totally in order to sustain the pharmaceutical field and to counter COVID-19 side effects. We believe that we are the first to provide new evidence for empowering the field force with SFA by comparing the customer- and product-related capabilities before and during the COVID-19 crisis to establish and maintain customer relationships in value-creating behaviors.

The pharmaceutical industry, one of the most growing industries in the world, accepted to comply with a digital change that required some innovative steps in established business processes and corporate culture, for example, conducting hybrid studies, targeting healthcare professionals remotely, turning collected data into actionable data to optimize sales, and adapting real-time instantly business strategies. From a managerial perspective, resources are finite, pressures to gain or maintain market share are high, and medical representatives are a key contributor to the firm. This field force plays a ubiquitous role in transferring knowledge on a particular product to healthcare professionals. The future research possibilities for medical representatives' performances and adaptive behaviors are exciting. Tanhan and Strack [47] developed the online photovoice (OPV) method to reduce costs and time spent for online interactions where face-to-face interaction is impossible or very difficult due to a pandemic or endemic, security problems, conflicts, or natural disasters. For further studies, online photovoice may be a new research method for hospital meetings organized periodically by pharmaceutical companies in order to reach diverse healthcare providers. In addition to this, further studies may occur regarding behavioral intentions and the user acceptance level of the technology, and that is not the end-result that was sought in this research. The key question to be answered here is whether or not voluntariness and personal skills have an effect on implementation success.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. 2020 Burt Matrix

	L.1	L.2	L.3	L.4	L.5	R.1	R.2	R.3	R.4	R.5	R.6	R.7	R.8	S.1	S.2	S.3	S.4
L.1	86	0	0	0	0	3	0	36	2	14	14	5	12	1	1	6	0
L.2	0	276	0	0	0	94	17	18	16	8	21	67	35	24	19	19	15
L.3	0	0	163	0	0	17	24	0	0	43	46	0	33	14	2	9	0
L.4	0	0	0	6359	0	1160	1181	0	0	682	770	1156	1410	402	421	262	130
L.5	0	0	0	0	199	9	51	23	10	14	48	26	18	4	15	18	2
R.1	3	94	17	1160	9	1283	0	0	0	0	0	0	0	85	38	27	21
R.2	0	17	24	1181	51	0	1273	0	0	0	0	0	0	78	65	62	16
R.3	36	18	0	0	23	0	0	77	0	0	0	0	0	1	1	2	4
R.4	2	16	0	0	10	0	0	0	28	0	0	0	0	0	7	4	0
R.5	14	8	43	682	14	0	0	0	0	761	0	0	0	44	110	49	16
R.6	14	21	46	770	48	0	0	0	0	0	899	0	0	32	86	46	30

	L.1	L.2	L.3	L.4	L.5	R.1	R.2	R.3	R.4	R.5	R.6	R.7	R.8	S.1	S.2	S.3	S.4
R.7	5	67	0	1156	26	0	0	0	0	0	0	1254	0	70	68	56	23
R.8	12	35	33	1410	18	0	0	0	0	0	0	0	1508	135	83	68	37
S.1	1	24	14	402	4	85	78	1	0	44	32	70	135	445	0	0	0
S.2	1	19	2	421	15	38	65	1	7	110	86	68	83	0	458	0	0
S.3	6	19	9	262	18	27	62	2	4	49	46	56	68	0	0	314	0
S.4	0	15	0	130	2	21	16	4	0	16	30	23	37	0	0	0	147
S.5	4	9	15	391	6	76	156	2	0	23	23	55	90	0	0	0	0
S.6	13	39	24	686	11	118	156	2	2	121	115	103	156	0	0	0	0
S.7	28	42	16	1109	29	194	176	20	2	141	160	305	226	0	0	0	0
S.8	10	63	5	1161	58	239	277	17	3	96	225	176	264	0	0	0	0
S.9	0	0	10	55	0	5	16	0	0	5	3	4	32	0	0	0	0
S.10	2	3	9	154	4	53	37	2	1	5	11	15	48	0	0	0	0
S.11	4	9	12	369	9	94	69	10	2	45	35	72	76	0	0	0	0
S.12	15	30	45	1045	43	306	155	16	7	84	124	234	252	0	0	0	0
S.13	0	0	0	25	0	0	0	0	0	3	0	18	4	0	0	0	0
S.14	0	0	0	28	0	0	0	0	0	4	0	11	13	0	0	0	0
S.15	0	1	0	36	0	10	0	0	0	6	0	11	10	0	0	0	0
S.16	2	3	2	85	0	17	10	0	0	9	9	33	14	0	0	0	0
P.1	0	0	0	846	0	242	123	0	0	28	70	171	212	3	12	11	34
P.2	0	7	0	0	0	2	0	0	3	1	0	1	0	0	3	0	1
P.3	0	17	0	0	0	3	4	2	4	0	0	0	4	0	4	0	0
P.4	0	0	0	0	199	9	51	23	10	14	48	26	18	4	15	18	2
P.5	0	0	0	1576	0	227	348	0	0	144	205	293	359	207	216	80	4
P.6	0	0	0	2510	0	439	472	0	0	371	273	461	494	164	131	106	39
P.7	0	126	0	0	0	32	6	11	3	1	19	36	18	9	9	14	14
P.8	58	0	0	0	0	3	0	26	0	7	10	3	9	0	1	2	0
P.9	0	51	0	0	0	21	2	5	2	1	1	14	5	6	0	3	0
P.10	28	0	0	0	0	0	0	10	2	7	4	2	3	1	0	4	0
P.11	0	0	163	0	0	17	24	0	0	43	46	0	33	14	2	9	0
P.12	0	28	0	0	0	20	3	0	1	1	1	1	1	2	0	0	0
P.13	0	46	0	0	0	16	2	0	2	4	0	15	7	7	3	2	0
P.14	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
P.15	0	0	0	1427	0	252	238	0	0	139	222	231	345	28	62	65	53

	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16	P.1	P.2	P.3	P.4
L.1	4	13	28	10	0	2	4	15	0	0	0	2	0	0	0	0
L.2	9	39	42	63	0	3	9	30	0	0	1	3	0	7	17	0
L.3	15	24	16	5	10	9	12	45	0	0	0	2	0	0	0	0
L.4	391	686	1109	1161	55	154	369	1045	25	28	36	85	846	0	0	0
L.5	6	11	29	58	0	4	9	43	0	0	0	0	0	0	0	199
R.1	76	118	194	239	5	53	94	306	0	0	10	17	242	2	3	9
R.2	156	156	176	277	16	37	69	155	0	0	0	10	123	0	4	51
R.3	2	2	20	17	0	2	10	16	0	0	0	0	0	0	2	23
R.4	0	2	2	3	0	1	2	7	0	0	0	0	0	3	4	10
R.5	23	121	141	96	5	5	45	84	3	4	6	9	28	1	0	14
R.6	23	115	160	225	3	11	35	124	0	0	0	9	70	0	0	48
R.7	55	103	305	176	4	15	72	234	18	11	11	33	171	1	0	26
R.8	90	156	226	264	32	48	76	252	4	13	10	14	212	0	4	18
S.1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	4
S.2	0	0	0	0	0	0	0	0	0	0	0	0	12	3	4	15
S.3	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	18
S.4	0	0	0	0	0	0	0	0	0	0	0	0	34	1	0	2
S.5	425	0	0	0	0	0	0	0	0	0	0	0	15	0	0	6
S.6	0	773	0	0	0	0	0	0	0	0	0	0	11	0	2	11
S.7	0	0	1224	0	0	0	0	0	0	0	0	0	53	0	2	29
S.8	0	0	0	1297	0	0	0	0	0	0	0	0	272	1	4	58

	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16	P.1	P.2	P.3	P.4
S.9	0	0	0	0	65	0	0	0	0	0	0	0	5	0	0	0
S.10	0	0	0	0	0	172	0	0	0	0	0	0	13	0	0	4
S.11	0	0	0	0	0	0	403	0	0	0	0	0	46	0	0	9
S.12	0	0	0	0	0	0	0	1178	0	0	0	0	334	2	5	43
S.13	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0
S.14	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0
S.15	0	0	0	0	0	0	0	0	0	0	37	0	2	0	0	0
S.16	0	0	0	0	0	0	0	0	0	0	0	92	35	0	0	0
P.1	15	11	53	272	5	13	46	334	0	0	2	35	846	0	0	0
P.2	0	0	0	1	0	0	0	2	0	0	0	0	0	7	0	0
P.3	0	2	2	4	0	0	0	5	0	0	0	0	0	0	17	0
P.4	6	11	29	58	0	4	9	43	0	0	0	0	0	0	0	199
P.5	204	307	259	85	17	14	78	81	4	2	10	8	0	0	0	0
P.6	117	209	465	533	23	85	136	414	21	23	18	26	0	0	0	0
P.7	7	19	16	28	0	0	4	6	0	0	0	0	0	0	0	0
P.8	4	9	22	6	0	0	3	11	0	0	0	0	0	0	0	0
P.9	2	12	9	6	0	3	2	4	0	0	1	3	0	0	0	0
P.10	0	4	6	4	0	2	1	4	0	0	0	2	0	0	0	0
P.11	15	24	16	5	10	9	12	45	0	0	0	2	0	0	0	0
P.12	0	2	7	6	0	0	1	10	0	0	0	0	0	0	0	0
P.13	0	3	8	18	0	0	2	3	0	0	0	0	0	0	0	0
P.14	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P.15	55	159	332	271	10	42	109	216	0	3	6	16	0	0	0	0

	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16	P.1	P.2	P.3	P.4
L.1	4	13	28	10	0	2	4	15	0	0	0	2	0	0	0	0
L.2	9	39	42	63	0	3	9	30	0	0	1	3	0	7	17	0
L.3	15	24	16	5	10	9	12	45	0	0	0	2	0	0	0	0
L.4	391	686	1109	1161	55	154	369	1045	25	28	36	85	846	0	0	0
L.5	6	11	29	58	0	4	9	43	0	0	0	0	0	0	0	199
R.1	76	118	194	239	5	53	94	306	0	0	10	17	242	2	3	9
R.2	156	156	176	277	16	37	69	155	0	0	0	10	123	0	4	51
R.3	2	2	20	17	0	2	10	16	0	0	0	0	0	0	2	23
R.4	0	2	2	3	0	1	2	7	0	0	0	0	0	3	4	10
R.5	23	121	141	96	5	5	45	84	3	4	6	9	28	1	0	14
R.6	23	115	160	225	3	11	35	124	0	0	0	9	70	0	0	48
R.7	55	103	305	176	4	15	72	234	18	11	11	33	171	1	0	26
R.8	90	156	226	264	32	48	76	252	4	13	10	14	212	0	4	18
S.1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	4
S.2	0	0	0	0	0	0	0	0	0	0	0	0	12	3	4	15
S.3	0	0	0	0	0	0	0	0	0	0	0	0	11	0	0	18
S.4	0	0	0	0	0	0	0	0	0	0	0	0	34	1	0	2
S.5	425	0	0	0	0	0	0	0	0	0	0	0	15	0	0	6
S.6	0	773	0	0	0	0	0	0	0	0	0	0	11	0	2	11
S.7	0	0	1224	0	0	0	0	0	0	0	0	0	53	0	2	29
S.8	0	0	0	1297	0	0	0	0	0	0	0	0	272	1	4	58
S.9	0	0	0	0	65	0	0	0	0	0	0	0	5	0	0	0
S.10	0	0	0	0	0	172	0	0	0	0	0	0	13	0	0	4
S.11	0	0	0	0	0	0	403	0	0	0	0	0	46	0	0	9
S.12	0	0	0	0	0	0	0	1178	0	0	0	0	334	2	5	43
S.13	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0
S.14	0	0	0	0	0	0	0	0	0	28	0	0	0	0	0	0
S.15	0	0	0	0	0	0	0	0	0	0	37	0	2	0	0	0
S.16	0	0	0	0	0	0	0	0	0	0	0	92	35	0	0	0
P.1	15	11	53	272	5	13	46	334	0	0	2	35	846	0	0	0
P.2	0	0	0	1	0	0	0	2	0	0	0	0	0	7	0	0

	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16	P.1	P.2	P.3	P.4
P.3	0	2	2	4	0	0	0	5	0	0	0	0	0	0	17	0
P.4	6	11	29	58	0	4	9	43	0	0	0	0	0	0	0	199
P.5	204	307	259	85	17	14	78	81	4	2	10	8	0	0	0	0
P.6	117	209	465	533	23	85	136	414	21	23	18	26	0	0	0	0
P.7	7	19	16	28	0	0	4	6	0	0	0	0	0	0	0	0
P.8	4	9	22	6	0	0	3	11	0	0	0	0	0	0	0	0
P.9	2	12	9	6	0	3	2	4	0	0	1	3	0	0	0	0
P.10	0	4	6	4	0	2	1	4	0	0	0	2	0	0	0	0
P.11	15	24	16	5	10	9	12	45	0	0	0	2	0	0	0	0
P.12	0	2	7	6	0	0	1	10	0	0	0	0	0	0	0	0
P.13	0	3	8	18	0	0	2	3	0	0	0	0	0	0	0	0
P.14	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
P.15	55	159	332	271	10	42	109	216	0	3	6	16	0	0	0	0

	P.5	P.6	P.7	P.8	P.9	P.10	P.11	P.12	P.13	P.14	P.15
L.1	0	0	0	58	0	28	0	0	0	0	0
L.2	0	0	126	0	51	0	0	28	46	1	0
L.3	0	0	0	0	0	0	163	0	0	0	0
L.4	1576	2510	0	0	0	0	0	0	0	0	1427
L.5	0	0	0	0	0	0	0	0	0	0	0
R.1	227	439	32	3	21	0	17	20	16	0	252
R.2	348	472	6	0	2	0	24	3	2	0	238
R.3	0	0	11	26	5	10	0	0	0	0	0
R.4	0	0	3	0	2	2	0	1	2	1	0
R.5	144	371	1	7	1	7	43	1	4	0	139
R.6	205	273	19	10	1	4	46	1	0	0	222
R.7	293	461	36	3	14	2	0	1	15	0	231
R.8	359	494	18	9	5	3	33	1	7	0	345
S.1	207	164	9	0	6	1	14	2	7	0	28
S.2	216	131	9	1	0	0	2	0	3	0	62
S.3	80	106	14	2	3	4	9	0	2	0	65
S.4	4	39	14	0	0	0	0	0	0	0	53
S.5	204	117	7	4	2	0	15	0	0	0	55
S.6	307	209	19	9	12	4	24	2	3	1	159
S.7	259	465	16	22	9	6	16	7	8	0	332
S.8	85	533	28	6	6	4	5	6	18	0	271
S.9	17	23	0	0	0	0	10	0	0	0	10
S.10	14	85	0	0	3	2	9	0	0	0	42
S.11	78	136	4	3	2	1	12	1	2	0	109
S.12	81	414	6	11	4	4	45	10	3	0	216
S.13	4	21	0	0	0	0	0	0	0	0	0
S.14	2	23	0	0	0	0	0	0	0	0	3
S.15	10	18	0	0	1	0	0	0	0	0	6
S.16	8	26	0	0	3	2	2	0	0	0	16
P.1	0	0	0	0	0	0	0	0	0	0	0
P.2	0	0	0	0	0	0	0	0	0	0	0
P.3	0	0	0	0	0	0	0	0	0	0	0
P.4	0	0	0	0	0	0	0	0	0	0	0
P.5	1576	0	0	0	0	0	0	0	0	0	0
P.6	0	2510	0	0	0	0	0	0	0	0	0
P.7	0	0	126	0	0	0	0	0	0	0	0
P.8	0	0	0	58	0	0	0	0	0	0	0
P.9	0	0	0	0	51	0	0	0	0	0	0
P.10	0	0	0	0	0	28	0	0	0	0	0
P.11	0	0	0	0	0	0	163	0	0	0	0
P.12	0	0	0	0	0	0	0	28	0	0	0

	P.5	P.6	P.7	P.8	P.9	P.10	P.11	P.12	P.13	P.14	P.15
P.13	0	0	0	0	0	0	0	0	46	0	0
P.14	0	0	0	0	0	0	0	0	0	1	0
P.15	0	0	0	0	0	0	0	0	0	0	1427

Appendix B. 2021 Burt Matrix

	S.1	S.2	S.3	S.4	S.5	S.6	S.7	S.8	S.9	S.10	S.11	S.12	S.13	S.14	S.15	S.16	L.1
S.1	296	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S.2	0	272	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
S.3	0	0	211	0	0	0	0	0	0	0	0	0	0	0	0	0	6
S.4	0	0	0	89	0	0	0	0	0	0	0	0	0	0	0	0	1
S.5	0	0	0	0	287	0	0	0	0	0	0	0	0	0	0	0	2
S.6	0	0	0	0	0	486	0	0	0	0	0	0	0	0	0	0	11
S.7	0	0	0	0	0	0	836	0	0	0	0	0	0	0	0	0	24
S.8	0	0	0	0	0	0	0	908	0	0	0	0	0	0	0	0	5
S.9	0	0	0	0	0	0	0	0	47	0	0	0	0	0	0	0	0
S.10	0	0	0	0	0	0	0	0	0	114	0	0	0	0	0	0	2
S.11	0	0	0	0	0	0	0	0	0	0	256	0	0	0	0	0	5
S.12	0	0	0	0	0	0	0	0	0	0	0	935	0	0	0	0	11
S.13	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0	0
S.14	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0
S.15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	35	0	0
S.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	72	1
L.1	0	2	6	1	2	11	24	5	0	2	5	11	0	0	0	1	70
L.2	15	10	23	10	8	43	39	72	4	10	16	37	0	0	2	4	0
L.3	0	0	0	0	2	0	0	0	0	0	0	8	0	0	0	0	0
L.4	278	257	179	78	274	431	772	829	43	102	235	879	34	20	33	67	0
L.5	3	3	3	0	1	1	1	2	0	0	0	0	0	0	0	0	0
R.1	49	31	24	17	50	77	154	210	2	38	62	238	0	0	4	17	5
R.2	53	23	36	8	84	119	141	203	9	21	44	134	0	1	2	8	0
R.3	1	2	3	1	0	0	18	7	0	2	5	7	0	0	0	0	34
R.4	0	1	7	0	0	4	1	2	0	0	4	6	0	0	0	0	4
R.5	21	58	22	7	33	53	85	64	5	5	19	60	6	5	7	3	6
R.6	18	48	27	12	9	50	86	112	1	4	18	78	0	0	0	4	6
R.7	58	41	48	14	49	62	217	120	6	15	54	159	24	3	14	18	8
R.8	96	68	44	30	62	121	134	190	24	29	50	253	4	11	8	22	7
P.1	2	8	7	6	21	11	34	247	5	11	43	415	0	0	2	32	0
P.2	0	1	0	0	0	0	0	0	0	0	3	2	0	0	0	0	0
P.3	0	1	0	0	0	0	3	1	0	0	0	1	0	0	0	0	0
P.4	15	3	3	0	1	1	1	2	0	0	0	0	0	0	0	0	0
P.5	148	134	66	11	148	216	201	77	16	12	53	54	11	5	7	5	0
P.6	97	88	71	27	71	137	350	361	14	55	92	292	21	12	13	20	0
P.7	5	7	5	10	5	23	24	31	0	4	6	8	0	0	0	0	0
P.8	0	2	3	0	2	7	20	2	0	1	4	8	0	0	0	0	49
P.9	6	0	9	0	3	13	5	16	4	6	0	9	0	0	2	4	0
P.10	0	0	3	1	0	4	4	3	0	1	1	3	0	0	0	1	21
P.11	0	0	0	0	2	0	0	0	0	0	0	8	0	0	0	0	0
P.12	2	0	6	0	0	5	1	4	0	0	0	12	0	0	0	0	0
P.13	2	1	3	0	0	2	6	20	0	0	7	5	0	0	0	0	0
P.15	19	27	35	34	34	67	187	144	8	24	47	118	2	3	11	10	0

	L.2	L.3	L.4	L.5	R.1	R.2	R.3	R.4	R.5	R.6	R.7	R.8	P.1	P.2	P.3	P.4	P.5
S.1	15	0	278	3	49	53	1	0	21	18	58	96	2	0	0	15	148
S.2	10	0	257	3	31	23	2	1	58	48	41	68	8	1	1	3	134
S.3	23	0	179	3	24	36	3	7	22	27	48	44	7	0	0	3	66
S.4	10	0	78	0	17	8	1	0	7	12	14	30	6	0	0	0	11

	L.2	L.3	L.4	L.5	R.1	R.2	R.3	R.4	R.5	R.6	R.7	R.8	P.1	P.2	P.3	P.4	P.5
S.5	8	2	274	1	50	84	0	0	33	9	49	62	21	0	0	1	148
S.6	43	0	431	1	77	119	0	4	53	50	62	121	11	0	0	1	216
S.7	39	0	772	1	154	141	18	1	85	86	217	134	34	0	3	1	201
S.8	72	0	829	2	210	203	7	2	64	112	120	190	247	0	1	2	77
S.9	4	0	43	0	2	9	0	0	5	1	6	24	5	0	0	0	16
S.10	10	0	102	0	38	21	2	0	5	4	15	29	11	0	0	0	12
S.11	16	0	235	0	62	44	5	4	19	18	54	50	43	3	0	0	53
S.12	37	8	879	0	238	134	7	6	60	78	159	253	415	2	1	0	54
S.13	0	0	34	0	0	0	0	0	6	0	24	4	0	0	0	0	11
S.14	0	0	20	0	0	1	0	0	5	0	3	11	0	0	0	0	5
S.15	2	0	33	0	4	2	0	0	7	0	14	8	2	0	0	0	7
S.16	4	0	67	0	17	8	0	0	3	4	18	22	32	0	0	0	5
L.1	0	0	0	0	5	0	34	4	6	6	8	7	0	0	0	0	0
L.2	293	0	0	0	117	32	12	21	4	14	56	37	0	6	6	0	0
L.3	0	10	0	0	0	0	0	0	0	8	0	2	0	0	0	0	0
L.4	0	0	4511	0	851	843	0	0	440	439	838	1100	844	0	0	12	1164
L.5	0	0	0	14	0	11	0	0	3	0	0	0	0	0	0	14	0
R.1	117	0	851	0	973	0	0	0	0	0	0	0	237	1	0	1	205
R.2	32	0	843	11	0	886	0	0	0	0	0	0	86	0	1	14	246
R.3	12	0	0	0	0	0	46	0	0	0	0	0	0	0	1	0	0
R.4	21	0	0	0	0	0	0	25	0	0	0	0	0	4	0	0	0
R.5	4	0	440	3	0	0	0	0	453	0	0	0	31	0	1	3	104
R.6	14	8	439	0	0	0	0	0	0	467	0	0	58	1	0	1	149
R.7	56	0	838	0	0	0	0	0	0	0	902	0	159	0	2	3	202
R.8	37	2	1100	0	0	0	0	0	0	0	0	1146	273	0	1	4	258
P.1	0	0	844	0	237	86	0	0	31	58	159	273	844	0	0	0	0
P.2	6	0	0	0	1	0	0	4	0	1	0	0	0	6	0	0	0
P.3	6	0	0	0	0	1	1	0	1	0	2	1	0	0	6	0	0
P.4	0	0	12	14	1	14	0	0	3	1	3	4	0	0	0	26	0
P.5	0	0	1164	0	205	246	0	0	104	149	202	258	0	0	0	0	1164
P.6	0	0	1721	0	288	322	0	0	255	149	340	367	0	0	0	0	0
P.7	128	0	0	0	39	11	10	7	3	13	26	19	0	0	0	0	0
P.8	0	0	0	0	5	0	26	1	3	3	5	6	0	0	0	0	0
P.9	77	0	0	0	38	9	1	7	0	0	12	10	0	0	0	0	0
P.10	0	0	0	0	0	0	8	3	3	3	3	1	0	0	0	0	0
P.11	0	10	0	0	0	0	0	0	0	8	0	2	0	0	0	0	0
P.12	30	0	0	0	14	11	0	1	0	0	4	0	0	0	0	0	0
P.13	46	0	0	0	25	0	0	2	0	0	12	7	0	0	0	0	0
P.15	0	0	770	0	120	186	0	0	50	82	134	198	0	0	0	0	0

	P.6	P.7	P.8	P.9	P.10	P.11	P.12	P.13	P.15
S.1	97	5	0	6	0	0	2	2	19
S.2	88	7	2	0	0	0	0	1	27
S.3	71	5	3	9	3	0	6	3	35
S.4	27	10	0	0	1	0	0	0	34
S.5	71	5	2	3	0	2	0	0	34
S.6	137	23	7	13	4	0	5	2	67
S.7	350	24	20	5	4	0	1	6	187
S.8	361	31	2	16	3	0	4	20	144
S.9	14	0	0	4	0	0	0	0	8
S.10	55	4	1	6	1	0	0	0	24
S.11	92	6	4	0	1	0	0	7	47
S.12	292	8	8	9	3	8	12	5	118
S.13	21	0	0	0	0	0	0	0	2
S.14	12	0	0	0	0	0	0	0	3
S.15	13	0	0	2	0	0	0	0	11

	P.6	P.7	P.8	P.9	P.10	P.11	P.12	P.13	P.15
S.16	20	0	0	4	1	0	0	0	10
L.1	0	0	49	0	21	0	0	0	0
L.2	0	128	0	77	0	0	30	46	0
L.3	0	0	0	0	0	10	0	0	0
L.4	1721	0	0	0	0	0	0	0	770
L.5	0	0	0	0	0	0	0	0	0
R.1	288	39	5	38	0	0	14	25	120
R.2	322	11	0	9	0	0	11	0	186
R.3	0	10	26	1	8	0	0	0	0
R.4	0	7	1	7	3	0	1	2	0
R.5	255	3	3	0	3	0	0	0	50
R.6	149	13	3	0	3	8	0	0	82
R.7	340	26	5	12	3	0	4	12	134
R.8	367	19	6	10	1	2	0	7	198
P.1	0	0	0	0	0	0	0	0	0
P.2	0	0	0	0	0	0	0	0	0
P.3	0	0	0	0	0	0	0	0	0
P.4	0	0	0	0	0	0	0	0	0
P.5	0	0	0	0	0	0	0	0	0
P.6	1721	0	0	0	0	0	0	0	0
P.7	0	128	0	0	0	0	0	0	0
P.8	0	0	49	0	0	0	0	0	0
P.9	0	0	0	77	0	0	0	0	0
P.10	0	0	0	0	21	0	0	0	0
P.11	0	0	0	0	0	10	0	0	0
P.12	0	0	0	0	0	0	30	0	0
P.13	0	0	0	0	0	0	0	46	0
P.15	0	0	0	0	0	0	0	0	770

References

1. Matej, M. Top 10 Global Pharmaceutical Companies by Revenue 2021. 2022. Available online: https://www.statista.com/statistics/407969/projected-sales-of-top-pharmaceutical-companies-worldwide/ (accessed on 9 June 2022).
2. Faraj, S.; Renno, W.; Bhardwaj, A. Unto the breach: What the COVID-19 pandemic exposes about digitalization. *Inf. Organ.* **2021**, *31*, 100337. [CrossRef]
3. Pothal, L.K.; Tripathy, S.; Kumar, K.; Dash, A. Study of customer relationship management in automobile industry. In *Advances in Mechanical Processing and Design*; Springer: Singapore, 2021; pp. 649–660.
4. Wellington, A. To ban or not to ban: Direct-to-consumer advertising and human rights analysis. *AMJ* **2012**, *3*, 749–766. [CrossRef]
5. Gil-Gomez, H.; Guerola-Navarro, V.; Oltra-Badenes, R.; Lozano-Quilis, J.A. Customer relationship management: Digital transformation and sustainable business model innovation. *Econ. Res.-Ekon. Istraž.* **2020**, *33*, 2733–2750. [CrossRef]
6. Nawaz, R.; Bakhsh, K.; Ullah, S.; Rehman, S.; Azeem, M.; Hayat, A. Drivers of ICT adoption in small and very small businesses in technologically least developed district of Southern Punjab. *Int. Trans. J. Eng. Manag. Appl. Sci. Technol.* **2021**, *12*, 1–10.
7. Mano, R. The institutionalization of ICT and civic participation: Evidence from eight European nations. *Technol. Soc.* **2021**, *64*, 101518. [CrossRef]
8. Cohen, J.; Gangi, W.; Lineen, J.; Manard, A.; Hughes, E.X. *Strategic Alternatives in: The Pharmaceutical Industry*; Kellogg School of Management, Northwestern University: Evanston, IL, USA, 2004.
9. Faisal, A.; Ahmad, M.S.; Thurasamy, R.; Ahmed, R. Doctors' interactions with pharmaceutical sales representatives: Modelling doctors' prescription behaviour. *Community Ment. Health J.* **2020**, *56*, 456–463. [CrossRef]
10. Hailu, A.D.; Workneh, B.D.; Kahissay, M.H. Influence of pharmaceutical marketing mix strategies on physicians' prescribing behaviors in public and private hospitals, Dessie, Ethiopia, a Mixed Study Design. *BMC Public Health* **2021**, *21*, 65. [CrossRef]
11. Paguntalan, L.C. The effectiveness of promotional mix of pharmaceutical companies in the Philippines: The sales force perspective. *Asian J. Res. Bus. Manag.* **2020**, *2*, 1–10.
12. Turkrating. Pharmaceutical Industry May 2021. Available online: https://turkrating.com/ilac-sektoru-mayis-2021-41375.html (accessed on 10 November 2021).
13. IQVIAa. The Impact of COVID-19 on Pharmaceutical Markets. 2021. Available online: https://www.iqvia.com/-/media/iqvia/pdfs/library/publications/the-impact-of-covid-19-on-pharmaceutical-markets.pdf?_=1636552194292 (accessed on 10 November 2021).
14. Nair, M.; Pradhan, R.P.; Arvin, M.B. Endogenous dynamics between R&D, ICT and economic growth: Empirical evidence from the OECD countries. *Technol. Soc.* **2020**, *62*, 101315.

15. Hashem, G. Organizational enablers of business process reengineering implementation: An empirical study on the service sector. *Int. J. Prod. Perform. Manag.* **2020**, *69*, 321–343. [CrossRef]
16. Baiyere, A.; Salmela, H.; Tapanainen, T. Digital transformation and the new logics of business process management. *Eur. J. Inf. Syst.* **2000**, *29*, 238–259. [CrossRef]
17. Wang, H.; Schrock, W.A.; Kumar, A.; Hughes, D.E. Effectual selling in service ecosystems. *J. Pers. Sell. Sales Manag.* **2020**, *40*, 251–266. [CrossRef]
18. Hartmann, N.; Lussier, B. Managing the sales force through the unexpected exogenous COVID-19 crisis. *Ind. Mark. Manag.* **2020**, *88*, 101–111. [CrossRef]
19. Craven, M.; Liu, L.; Mysore, M.; Wilson, M. *COVID-19: Implications for Business*; McKinsey & Company: Hong Kong, China, 2020.
20. Pedersen, C.L.; Ritter, T.; Di Benedetto, C.A. Managing through a crisis: Managerial implications for business-to-business firms. *Ind. Mark. Manag.* **2020**, *88*, 314. [CrossRef]
21. Sharma, P.; Leung, T.Y.; Kingshott, R.P.; Davcik, N.S.; Cardinali, S. Managing uncertainty during a global pandemic: An international business perspective. *J. Bus. Res.* **2020**, *116*, 188–192. [CrossRef]
22. Epler, R.T.; Leach, M.P. An examination of salesperson bricolage during a critical sales disruption: Selling during the Covid-19 pandemic. *Ind. Mark. Manag.* **2021**, *5*, 114–127. [CrossRef]
23. Official Gazette. Regulation About Promotional Activities of Medicinal Products. 2015. Available online: https://www.resmigazete.gov.tr/eskiler/2015/07/20150703-2.htm (accessed on 3 October 2021).
24. Barnes, B.R.; Carroll, A. A relationship marketing pilot study of British and French medium-sized medical firms. *J. Med. Mark.* **2000**, *1*, 161–175. [CrossRef]
25. Sohn, Y.S.; Seung, K.Y.; Seo, S.Y.; Kim, S.E. The mediating role of commitment in healthcare B2B marketing. *Serv. Ind. J.* **2013**, *33*, 1381–1401. [CrossRef]
26. Ji, Y.; Ma, Z.; Peppelenbosch, M.P.; Pan, Q. Potential association between COVID-19 mortality and health-care resource availability. *Lancet Glob. Health* **2020**, *8*, e480. [CrossRef]
27. Xu, Z.; Shi, L.; Wang, Y.; Zhang, J.; Huang, L.; Zhang, C.; Liu, S.; Zhao, P.; Liu, H.; Zhu, L.; et al. Pathological findings of COVID-19 associated with acute respiratory distress syndrome. *Lancet Respir. Med.* **2020**, *8*, 420–422. [CrossRef]
28. Eftekhar Ardebili, M.; Naserbakht, M.; Bernstein, C.; Alazmani-Noodeh, F.; Hakimi, H.; Ranjbar, H. Healthcare providers experience of working during the COVID-19 pandemic: A qualitative study. *Am. J. Infect. Control* **2021**, *49*, 547–554. [CrossRef]
29. Doyumğaç, İ.; Tanhan, A.; Kiymaç, M. Understanding the Most Important Facilitators and Barriers for Online Education during COVID-19 through Online Photovoice Methodology. *Int. J. High. Educ.* **2021**, *10*, 166–190. [CrossRef]
30. Punchibandara, M.M.T. The impact of promotional strategies of pharmaceutical companies on doctor's recommendation of branded drugs: An empirical study on pharmaceutical industry in Sri Lanka. Kelaniya. *J. Manag.* **2018**, *6*, 55. [CrossRef]
31. Onesti, C.E.; Tagliamento, M.; Curigliano, G.; Harbeck, N.; Bartsch, R.; Wildiers, H.; Tjan-Heijnen, V.; Martin, M.; Rottey, S.; Generali, D.; et al. Expected Medium- and Long-Term Impact of the COVID-19 Outbreak in Oncology. *JCO Glob. Oncol.* **2021**, *7*, 162–172. [CrossRef]
32. CDC. Symptoms of COVID-19. 2021. Available online: https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html (accessed on 22 September 2021).
33. Mlika, A.; Mong, J.; Peters, N.; Salazar, P. Ready for Launch: Reshaping Pharma's Strategy in the Next Normal. 2020. Available online: https://www.mckinsey.com/industries/life-sciences/our-insights/ready-for-launch-reshaping-pharmas-strategy-in-the-next-normal (accessed on 8 September 2021).
34. IQVIAb. Track Sales Progress from Every Angle. 2018. Available online: https://www.iqvia.com/locations/belgium/solutions/business-intelligence-and-data-science/pharmareport (accessed on 14 August 2021).
35. Makowska, M. Polish physicians' cooperation with the pharmaceutical industry and its potential impact on public health. *PLoS ONE* **2017**, *12*, e0184862. [CrossRef]
36. Lieb, K.; Scheurich, A. Contact between doctors and the pharmaceutical industry, their perceptions, and the effects on prescribing habits. *PLoS ONE* **2014**, *9*, 110130. [CrossRef]
37. Joslin, J.; Wojcik, S.M.; Fisher, A.; Grant, W.D. Do free or low-cost antibiotic promotions alter prescription filling habits? *Pharm. Pract.* **2014**, *12*, 416. [CrossRef]
38. Shakoor, H.; Feehan, J.; Mikkelsen, K.; Al Dhaheri, A.S.; Ali, H.I.; Platat, C.; Ismail, L.C.; Stojanovska, L.; Apostolopoulos, V. Be well: A potential role for vitamin B in COVID-19. *Maturitas* **2020**, *144*, 108–111. [CrossRef]
39. Mikkelsen, K.; Apostolopoulos, V. Vitamin B.1, B2, B3, B5, and B6 and the immune system. *Nutr. Immun.* **2019**, 115–125.
40. Johnson, R.A.; Wichern, D.W. *Applied Multivariate Statistical Analysis*; Prentice Hall: Englewood Cliffs, NJ, USA, 1992.
41. Hwang, H.; Tomiuk, M.; Takane, Y. Correspondence analysis, multiple correspondence analysis and recent developments. In *The Handbook of Quantitative Methods in Psychology*; Millsap, R., Maydeu-Olivares, A., Eds.; Sage Publications: New York, NY, USA, 2009.
42. Dungey, M.; Tchatoka, F.D.; Yanotti, M.B. Using multiple correspondence analysis for finance: A tool for assessing financial inclusion. *Int. Rev. Financ. Anal.* **2018**, *59*, 212–222. [CrossRef]
43. Pasaribu, U.S.; Lestari, K.E.; Indratno, S.W.; Garminia, H.; Sari, R.R.K.N. Some Properties of the Scaled Burt Matrix on Multiple Correspondence Analysis. *J. Hum. Univ. Nat. Sci.* **2021**, *48*, 5.
44. Sergio, C.S.; Gomez, G.C. Alternative Methods to Multiple Correspondence Analysis in Reconstructing The Relevant Information in a Burt's Table. *Pesqui. Oper.* **2016**, *36*, 23–44.

45. Greenacre, M.J. *Theory and Application of Correspondence Analysis*; Academic Press: London, UK, 1984.
46. TÜBA. COVID-19 Küresel Salgın Değerlendirme Raporu (Global Outbreak Assessment Report) Türkiye Bilimler Akademisi Yayınları, TÜBA Raporları (34). 2020. Available online: https://www.tuba.gov.tr/files/images/2020/kovidraporu/T%C3%9CBA%20Covid19%20Raporu%206.%20G%C3%BCncelleme.pdf (accessed on 21 June 2022).
47. Tanhan, A.; Strack, R.W. Online photovoice to explore and advocate for Muslim biopsychosocial spiritual wellbeing and issues: Ecological systems theory and ally development. *Curr. Psychol.* **2020**, *39*, 2010–2025. [CrossRef]

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Emotions of Educators Conducting Emergency Remote Teaching during COVID-19 Confinement

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Abstract: The home confinement of the population in Spain caused by the COVID-19 pandemic interrupted face-to-face teaching and led teachers of all educational levels to perform their activities remotely. This represented a radical change in daily tasks. The goal of this study is to analyse and understand the emotions teachers experienced while performing Emergency Remote Teaching during home confinement. We performed a descriptive quantitative analysis and a comparison of the means (ANOVA) related to the independent sociodemographic variables (age, gender, and educational stage). The study sample consisted of 4589 teachers from the Basque Country, and represents the largest study with these characteristics conducted in Spain. The results obtained in the research show that, despite suffering great stress, teachers also felt pride in the work they had done. The study concludes that the teachers in the group who suffered the most negative feelings were women, primary school teachers, and middle-aged educators.

Keywords: emotions; emergency remote teaching; teachers; COVID-19

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1. Introduction

On 14 March 2020, the Government of Spain decreed 'Alarm State' [1] throughout its territory, limiting the free movement of the population and establishing mandatory home confinement. The health crisis triggered by the COVID-19 pandemic unexpectedly and urgently led to the entire academic population (i.e., teachers and students) to be confined at home [2].

In order to overcome this situation, the institutions and centres of all levels of education across the various autonomous communities of Spain decided to implement telematic teaching via the Internet [3]. This re-adaptation of the teaching–learning process to an alternative mode of teaching, in an unplanned way, led to the performance of Emergency Remote Teaching (ERT) [4]. This method has nothing to do with the different types and modalities of online training, which tend to have a careful instructional design and proven efficacy [5–7].

For a significant amount of time, the current 'knowledge society' [8] has allowed teachers to take advantage of technology and perform their educational activities virtually through different interactive and collaborative resources. The Internet allows searching, creating, or sharing educational content [9–11]. Thus, during home confinement, it allowed teachers and students to remain in contact. In addition, students could retrieve their learning material from educational platforms and Web 2.0 resources [12]. However, teachers have experienced difficulties and doubts when implementing digital educational resources in teaching–learning processes [13–16]. Not surprisingly, the training for teaching digital competence has been traditionally linked closely to aspects of a more technical and instrumental nature, and not so much to pedagogical and methodological development [17,18], which was what the situation demanded.

During ERT, a significant part of the educational community, and society in general, disregarded teachers' conditions, difficulties, and their limitations to perform their educational activities whilst confined. All of the attention was focused on how the teachers taught curricular content, how they assessed the students [4] and the pressures that these activities might entail. Maintaining the demands imposed by teaching may have generated, beyond physical fatigue, emotional exhaustion [19,20].

2. Teachers' Emotional Experiences

Given the scientific discussion on the conceptualisation of the meaning of emotions [21,22], in the present study we started from the idea coined by [23], based on the following conception: in teachers' professional field, emotions are constituted of teachers' emotional states, which are the responses they give to exceptional situations that involve synchronised patterns of experiences, assessments, physiological changes, and expressions and/or behaviour tendencies, whose interpretation depend on the socio-cultural meaning of the context in which they occur [24].

The interconnectedness between emotional well-being and labour performance is widely acknowledged in both scientific and institutional spheres, substantiated by their inclusion in the Sustainable Development Goals (SDGs), particularly the third objective: Health and Wellbeing [25]. Achieving a state of well-being encompassing physical, emotional, and mental health is indispensable for optimal performance in both personal and professional domains. This principle is universally applicable, irrespective of individual characteristics such as race, ethnicity, or gender, and extends to all roles and occupations.

In the realm of education, educators are expected to operate at their highest standards, a commitment underscored by the fourth SDG objective emphasizing Quality Education [25]. Despite the prevalence of negative emotions during the COVID era, teachers expressed satisfaction for their efforts, even amidst emotional and physical challenges [26]. Considering these factors, the fulfilment of teachers' health and well-being becomes crucial for delivering the quality education necessary for societal development. Whereas these concerns held priority before COVID, the profound implications of the pandemic have underscored the heightened clarity of this imperative.

It is possible for confined teachers, depending on their experience in the development of their professional performance, to experience positive emotions such as pride, satisfaction, enthusiasm, confidence, and relief. Concomitantly, they may experience negative feelings such as insecurity, stress, concern, anger, and frustration [27–29].

The fact of unexpectedly having to perform ERT [4] and in an unplanned manner could have led teachers to greater psychological stress and, consequently, influenced their emotional states [30,31]. The forced inclusion of technology as a resource for teaching can cause burnout syndrome in some teachers [32], which is characterised by physical fatigue, loss of motivation, and emotional exhaustion [33,34]. Moreover, this can become exacerbated in a scenario of uncertainty, fear, and insecurity, such as the one which occurred during confinement. However, when teachers perform adequately using technological instruments in education, they tend to value their emotions in a more satisfactory way, and vice versa [35,36].

The COVID-19 pandemic significantly influenced the mental health of those individuals who were overwhelmed by the stressors to which they were exposed [37]. As some studies point out, organisational changes influence the emotional state of teachers [38–41] and affect some aspects of their professional performance, such as the academic results of students and the quality of the relationships they establish with them [42–44]. In this respect, the resistance that some teachers may experience, when they have to change [45] to ERT, can also contribute to their perception of negative emotions.

From the teachers' perspective, the implications of COVID-19 in education are still scarce. Most of the studies conducted have addressed this topic from the students' perspective [46,47]. Despite the fact that different authors [48–50] emphasise the influence of emotions on learning and technology-mediated teaching, the studies have been mainly lim-

ited to analysing the feelings of students in the educational field, the emotions of students related to the teaching-learning process, and how they feel when they are assessed [51–54].

The analysis of the emotional experience of the confined teachers performing their educational activities through ERT allows us to know their emotional responses, and identify whether negative or positive emotions prevail [53].

Therefore, the interest of the present study is based on knowing the affective states of the teaching staff in terms of emotional experience linked to ERT, within the home confinement context. Moreover, this study also contributes to visualising the efforts made by teaching staff during home confinement while performing telematic teaching.

3. Objectives and Hypotheses

The main goal of the present study is to analyse the emotional response of teachers during home confinement caused by the COVID-19 pandemic in the Basque Country, Spain. To that end, the following research hypotheses (H) was proposed:

H1. *Teachers consider negative emotions more than positive ones.*

As a secondary objective, we want to know the characteristics of the teachers that exhibited the most negative emotional response. The independent variables in the analysis allow for segmenting the population into more homogeneous groups, thus enabling a more detailed and specific study. In this way, gender was analysed under the criteria of equity and social justice. The age of teachers was examined considering generational contexts, and the level at which they teach was explored due to the diversity in pedagogical practices. In this regard, the following research hypotheses (H) were proposed:

H2. *There are no significant differences in negative emotional responses between men and women.*

H3. *There are significant differences in negative emotional responses depending on age.*

H4. *There are significant differences in negative emotional responses depending on the educational level in which the teachers perform.*

In the comparison of variables, a null hypothesis (H0) is presented, which refers to the non-existence of significant differences (0.5% significance level or lower); whereas the alternative hypothesis (H1) refers to the existence of significant differences at the aforementioned significance level. In this way, if H0 was rejected, Cohen's g would be applied to determine the effect size of such differences [55,56].

4. Method

4.1. Sample

A non-random and non-probabilistic convenience sampling was performed to conduct the present study. We sent a questionnaire to all the teachers that were performing in research fields. The universe of our study was the teaching staff of the Basque Country, Spain (N = 42,772), of which 36,934 were non-university teachers, and 5838 were from the university. With an error of $\pm$ 4%, a confidence interval of 99%, and p = q = 0.5, the sample size estimated was 1008 teachers [57,58]. Finally, the sample was composed of 4589 teachers who answered the questionnaire satisfactorily, of which 23.3% were men, 75.5% women, and 0.8% non-binary, with a mean age of 37 years (SD = 6.24).

The surveyed individuals worked professionally as teachers in the following fields: early childhood education stages (10.8); primary education (31.6%); compulsory secondary education (38.3%); vocational training (5.3%); higher education (8.6%); state-owned education and training centres (77.2%); subsidised centres (20.6%); and private centres (2.2%).

4.2. Instrument

The emotional responses of teachers who were performing ERT were measured using a scale composed of ten items. Half measured positive emotions (pride, satisfaction, confidence, enthusiasm, and security) and the other half measured negative emotions (insecurity, stress, concerns, anger, and frustration) [27].

The instrument used was generated by adapting the questionnaire for virtual learning environments (WebCT) proposed by [59], which features an internal consistency of 0.845 according to the Cronbach's alpha reliability coefficient. In this respect, in order to achieve the objectives proposed in the present study, the scale was adapted to the situation produced by the COVID-19 pandemic.

In order to assess the aspects addressed in each item (IT), we used a Likert-type scale, with response options from 1 (little) to 5 (much). Similarly, the surveyed teachers valued the following items relating to how they felt emotionally during COVID-19 in their professional performance as teachers. On the one hand, the that items related to positive emotions were: (IT1) I am proud of the work done during the confinement; (IT2) I am satisfied with the work performed during the confinement; (IT3) I am confident that my work is adequate; (IT4) I feel encouraged when I finish my work activity; and (IT5) I feel safe when I work in confinement. On the other hand, the items related to negative emotions were: (IT6) I feel stress while teaching; (IT7) My work worries me during confinement; (IT8) I feel irritated doing my job in this situation; (IT9) Working in this situation makes me feel frustrated; and (IT10) Working in this confined situation causes me general stress.

To obtain the sociodemographic data of the teaching staff, an ad hoc tool was created taking into account the defining variables of the profession, such as age, gender, educational stage in which they were working, and profile of the centres in which they worked. The assessment of the validity of the instrument adapted and used to analyse how confined teachers performing ERT felt emotionally was carried out by calculating the factor load of the questionnaire, and through a confirmatory factor analysis [60]. The other tests, which determined the psychometric properties of the questionnaire used, are specified in the results section.

4.3. Process

The distribution of the questionnaire among teachers of different educational levels was carried out by means of bulk sending to their institutional email accounts, which belong to the educational centres of the entire Basque Country. The snowball or recruitment network technique was used through successive steps [61,62], making use of social networks (Facebook, Twitter, and Instagram) and other educational networks articulated through WhatsApp groups. Data collection was performed over three weeks.

We performed a descriptive quantitative analysis and a comparison of means (ANOVA) of the independent variables (age, gender, educational stage) relating to the research topic, i.e., the emotional response of the teaching staff that was performing ERT. The data were exported and adapted to the Statistical Package for the Social Sciences (SPSS) version 24 software to perform the statistical analysis.

4.4. Data Analysis

First, we assessed the psychometric properties of the Workload and Effort Questionnaire. The validity and reliability of the questionnaire was ensured with the methods most used by social researchers [58,63]: Cronbach's alpha reliability analysis of positive ($\alpha = 0.804$) and negative emotions ($\alpha = 0.868$); Cronbach's alpha if one item is removed, for each item (see Table 1); KMO test (0.835); and Bartlett's test of factor analysis ($p = 0.000$), test of the two halves.

The sample was randomly divided into two halves. A parallel analysis was performed with the first subsample (n = 2296) to assess the factorial structure of the instrument. In this case, we used the Factor 10.4.01 software [64]. The procedure selected for determining the number of dimensions was the optimal implementation of the parallel analysis [65]. The

parameter estimation method was the diagonal weighted least squares (DWLS), given that it is the best method when the variables analysed are ordinal, as in the case of Likert-type scales [66]. Finally, the rotation method used to find the factorial solution was Direct Oblimin, since the factors were expected to correlate significantly with each other. In this respect, the results of this first analysis suggested a bi-factorial structure, so that the items related to positive emotions were saturated within one factor, and the items related to negative emotions were saturated within another factor.

Table 1. Descriptive statistics of the items and factors of the Emotions Questionnaire (n = 4589).

	M	SD	Asymmetry	α of Cronbach	α If the Element Is Eliminated
Positive Emotions	18.32	3.87	−0.42		-
(IT1) I am proud of the work done during the confinement.	4.14	0.89	−0.88		0.77
(IT2) I am satisfied with the work performed during the confinement.	3.89	0.95	−0.64		0.74
(IT3) I am confident that my work is adequate.	3.84	0.94	−0.57	0.804	0.74
(IT4) I feel encouraged when I finish my work activity.	3.46	1.28	−0.33		0.82
(IT5) I feel safe when I work in confinement.	2.99	1.06	0.07		0.77
Negative Emotions	19.40	4.47	−0.80		-
(IT6) I feel stress while teaching.	4.12	1.00	−1.07		0.85
(IT7) My work worries me during confinement.	4.00	1.01	−0.89		0.86
(IT8) I feel irritated doing my job in this situation.	3.41	1.25	−0.36	0.868	0.84
(IT9) Working in this situation makes me feel frustrated.	3.72	1.19	−0.67		0.82
(IT10) Working in this confined situation causes me general stress.	4.14	1.05	−1.17		0.82
Total Emotions (Positive—Negative)	1.08	6.79	−0.22		-

Note. M = mean; SD = standard deviation.

Based on these first exploratory results, a confirmatory factor analysis was performed with the second subsample (n = 2294). This analysis was carried out using the Lisrel 8.80 software [67] using the DWLS parameter estimation method. Fit quality was assessed using the following goodness-of-fit indices: Root Mean Square Error of Approximation (RMSEA) fit index, whose value should be less than 0.08 [68]; and the Non-Normed Fit Index (NNFI), Comparative Fit Index (CFI), and Goodness-of-Fit Index (GFI), whose values should be greater than 0.90 [69]. The results of this analysis indicated that the two-factor model was a poor fit to the data (RMSEA = 0.13; NNFI = 0.91; CFI = 0.93; GFI = 0.97). Consequently, the adjustment of the bi-factorial model was assessed in two dimensions so the two initial factors (i.e., positive emotions and negative emotions) were maintained, in addition to a third factor common to all items, which was representative of the construct 'emotions'. In this case, the model achieved a satisfactory fit according to the assessed indices (RMSEA = 0.81; NNFI = 0.97; CFI = 0.98; GFI = 0.99). The results are illustrated in Figure 1. As can be seen in the case of factor 1 (Positive emotions, α = 0.80), the factorial weights with the primary factor ranged between 0.43 (item 5) and 0.83 (item 1); whereas in the case of factor 2 (Negative emotions, α = 0.87), the weights ranged between 0.31 (item 9) and 0.93 (item 6). Regarding the second-order factor, the weights (in absolute terms) ranged between 0.14 and 0.91.

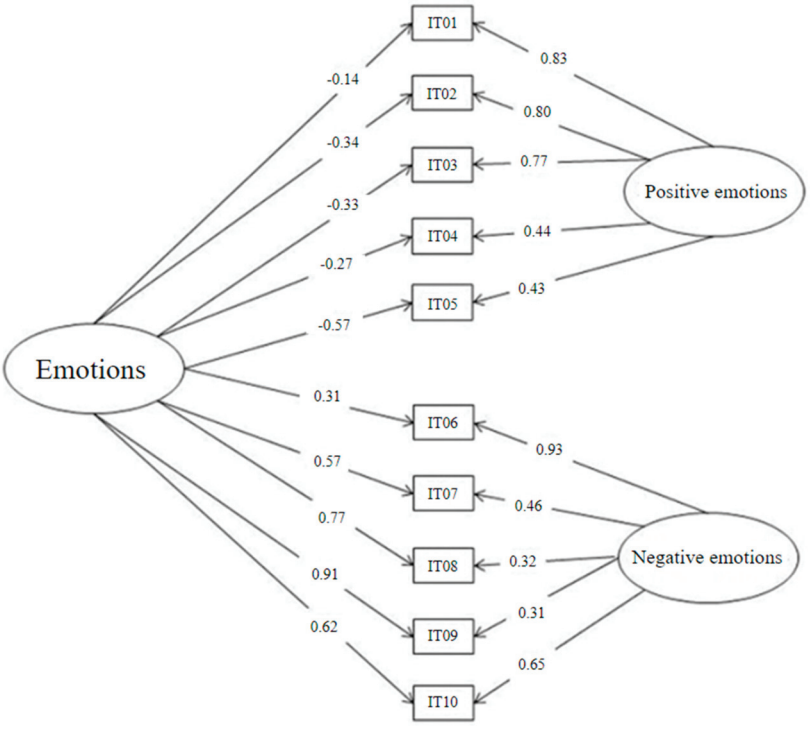

Figure 1. Flowchart of the confirmatory factor analysis of the Emotions Questionnaire.

5. Results

5.1. Positive and Negative Emotions

Next, we assessed the descriptive statistics of the items, along with the factors whose results are illustrated in Table 1. The data obtained indicate that the teachers scored more the negative emotions (19.4) than the positive ones (18.32). In this respect, it is possible to accept the first research hypothesis, which states that teachers value the negative emotions more than the positive emotions.

The most highly rated negative emotional response was general stress from working in confinement (4.14), followed by stress in the provision of teaching (4.12), and concern about teacher performance (M = 4). However, it is noted that teachers were proud of the work they did (M = 4.14) while performing emergency remote teaching.

The differences in a series of sociodemographic variables in the two resulting factors were also examined. Specifically, the differences analysed were related to gender, age, and educational level to which teaching was provided. The analyses were carried out by means of ANOVA. Both statistical significance and effect size (η^2) were calculated, which was interpreted as follows: values between 0.01 and 0.04 were considered small; between 0.04 and 0.14 medium; and above 0.14, large [70].

5.2. Gender

Concerning the gender, it is observed that women felt more stress, worry, and frustration than men while performing their work, as shown in Table 2. The results indicated a significant and small effect for positive emotions (F [2, 4589] = 6.18, p = 0.002, η^2 = 0.01) with men (M = 18.55) scoring above women (M = 18.26). However, in negative emotions (F [2, 4589] = 48.59, p < 0.61001, η^2 = 0.16), women (M = 19.74) scored higher than men (M = 18.24) and this is statistically significant. Regarding total emotions (F [2, 4589] = 32.33, p < 0.001, η^2 = 0.09) women (M = 1.48) also scored above men (M = −0.31). In this way, with

respect to the second research hypothesis, the values obtained allowed rejecting the H0 and accepting the alternative hypothesis related to negative emotional responses, since there were significant differences between men and women.

Table 2. Descriptive statistics of the items and factors in the questionnaire on emotions from the point of view of sex (n = 4589).

	Sex	N	M	SD	F	Sig
Positive Emotions						
(IT1) I am proud of the work done during the confinement.	Man Woman	1071 3475	4.11 4.15	0.912 0.881	0.14	0.702
(IT2) I am satisfied with the work performed during the confinement.	Man Woman	1071 3475	3.86 3.90	0.965 0.942	0.92	0.336
(IT3) I am confident that my work is adequate.	Man Woman	1071 3475	3.85 3.83	0.955 0.939	0.32	0.568
(IT4) I feel encouraged when I finish my work activity.	Man Woman	1071 3475	3.63 3.42	1.214 1.289	17.96	0.000
(IT5) I feel safe when I work in confinement.	Man Woman	1071 3475	3.10 2.97	1.094 1.041	9.24	0.002
Negative Emotions						
(IT6) I feel stress while teaching.	Man Woman	1071 3475	3.86 4.20	1.061 0.961	15.30	0.000
(IT7) My work worries me during confinement.	Man Woman	1071 3475	3.81 4.05	1.054 0.985	16.76	0.000
(IT8) I feel irritated doing my job in this situation.	Man Woman	1071 3475	3.26 3.46	1.282 1.234	2.75	0.097
(IT9) Working in this situation makes me feel frustrated.	Man Woman	1071 3475	3.50 3.79	1.243 1.166	21.76	0.000
(IT10) Working in this confined situation causes me general stress.	Man Woman	1071 3475	3.82 4.24	1.172 0.990	46.94	0.000

Note. M = mean; SD = standard deviation; F = continuous probability distribution; Sig = significance.

5.3. Age

Regarding the age, the study of the data shows that middle-aged teachers (36–40 years) were the most stressed (M = 4.22). These teachers felt that working in the confined situation caused them general stress (M = 4.25) and their level of irritability was higher than any other age group (M = 3.51).

In the means comparison analysis, we did not find any significant effect on positive emotions (F [7, 4589] = 1.84, p = 0.075). On the contrary, there was a significant effect on negative emotions (F [2, 4589] = 4.34, $p < 0.001$, $\eta^2 = 0.17$), and on the total emotions (F [2, 4589] = 2.77, $p = 0.007$, $\eta^2 = 0.14$).

Hochberg's post hoc test of WG2 reveals significant differences between middle-aged and younger teachers, as seen in Table 3. Thus, the stress in teacher performance (M = 3.87, ng 0.18), the stressful feeling of being confined (M = 3.91, ng 0.045), and the perception of irritability (M = 3.20, ng 0.001) had less incidence among younger teachers.

Regarding the feeling of frustration, middle-aged teachers (36–40 years) also rated the higher (M = 3.88). However, in contrast to the previous emotional states, older teachers (61–70 years; M = 3.44) were significantly less frustrated, as can be seen from Table 3. Despite this, older teachers showed the greatest concern for the work done during confinement (56–60 years; M = 4.12). These data allow us to assume the third alternative hypothesis, which referred to the fact that there might be significant differences in negative emotional responses depending on age.

Table 3. Descriptive statistics of the items and factors in the questionnaire on negative emotions from the point of view of sex (n = 4589).

	Age Range	N	M	SD	F	Sig
(IT6) I feel stress while teaching.	21–25	106	3.87	1.015	6.226	0.000
	26–30	440	3.92	1.034		
	31–35	522	4.03	1.077		
	36–40	670	4.22	0.925		
	41–50	651	4.20	0.958		
	46–50	665	4.12	0.941		
	51–55	697	4.12	1.018		
	56–60	705	4.14	0.991		
	61–70	133	4.06	1.057		
	Total	4589	4.12	0.997		
(IT7) My work worries me during confinement.	21–25	106	3.75	1.005	3.145	0.003
	26–30	440	3.93	0.958		
	31–35	522	3.96	1.013		
	36–40	670	3.98	1.020		
	41–50	651	3.99	1.006		
	46–50	665	3.88	1.020		
	51–55	697	4.03	1.013		
	56–60	705	4.12	0.976		
	61–70	133	3.94	1.140		
	Total	4589	4.00	1.007		
(IT8) I feel irritated doing my job in this situation.	21–25	106	3.23	1.197	3.970	0.000
	26–30	440	3.20	1.258		
	31–35	522	3.34	1.238		
	36–40	670	3.51	1.219		
	41–50	651	3.48	1.255		
	46–50	665	3.41	1.19		
	51–55	697	3.37	1.263		
	56–60	705	3.47	1.239		
	61–70	133	3.38	1.283		
	Total	4589	3.41	1.249		
(IT9) Working in this situation makes me feel frustrated.	21–25	106	3.61	1.109	4.753	0.000
	26–30	440	3.77	1.146		
	31–35	522	3.75	1.187		
	36–40	670	3.88	1.121		
	41–50	651	3.76	1.202		
	46–50	665	3.61	1.201		
	51–55	697	3.59	1.217		
	56–60	705	3.67	1.213		
	61–70	133	3.44	1.269		
	Total	4589	3.72	1.191		
(IT10) Working in this confined situation causes me general stress.	21–25	106	3.91	1.100	4.917	0.000
	26–30	440	4.00	1.094		
	31–35	522	4.06	1.100		
	36–40	670	4.25	0.983		
	41–50	651	4.22	1.004		
	46–50	665	1.19	0.992		
	51–55	697	4.10	1.077		
	56–60	705	4.14	1.067		
	61–70	133	3.98	1.128		
	Total	4589	4.14	1.051		

Note. M = mean; SD = standard deviation; F = continuous probability distribution; Sig = significance.

5.4. Educational Levels

With respect to the educational levels to which teaching was provided, a significant effect of small magnitude was observed in the three variables analysed, namely: positive

emotions (F [6, 4560] = 6.19, $p < 0.001$, $\eta^2 = 0.01$); negative emotions (F [2, 4589] = 13.39, $p < 0.001$, $\eta^2 = 0.02$); and total emotions (F [2, 4589] = 15.75, $p < 0.001$, $\eta^2 = 0.02$). The Hochberg's GT2 post hoc test revealed that, in general terms, primary school teachers (M = 17.98) scored lower in positive emotions than secondary school teachers (M = 18.73) and university teachers (M = 18.98). In the case of negative emotions, primary school teachers (M = 20.25) scored significantly higher than the rest of the educational levels: childhood education (M = 19.08); compulsory secondary education (M = 19.24); baccalaureate (M = 18.83); university (M = 18.72); and vocational training (M = 18.09).

Finally, regarding total emotions, primary education teachers (M = 2.27) also scored higher than teachers of the remaining educational levels: childhood (M = 0.52); compulsory secondary education (M = 1.07); baccalaureate (M = 0.10); university (M = −0.26); and vocational training (M = −0.70). These results allowed us to accept the alternative hypothesis, which stated that there would be significant differences in negative emotional responses depending on the educational level in which the teachers performed.

6. Discussion

The present research has facilitated the understanding of the emotional response of teachers in the Basque Country while performing Emergency Remote Teaching, which was caused by the COVID-19 pandemic. It represents the largest study carried out on teachers in confinement in Spain.

The results obtained in this research show that the teachers had more negative than positive emotions during the abovementioned confinement period. Teachers were basically under great stress while teaching and were concerned about student learning during confinement. It is worth mentioning that different studies have argued that the design of the physical work environment, as well as the scarcity of resources—in this case, teachers' homes—can enhance that stress [71,72]. Similarly, paradoxically, the study also evidences that the teachers felt pride and satisfaction with the work carried out.

Identification of teachers with more negative emotional responses regarding ERT performed during confinement was also possible. In this regard, it was observed that women had significantly more negative emotions than men, which is consistent with results obtained by other studies [73,74], according to which women tend to have higher rates of fatigue and emotional exhaustion than men. It is worth noting that women suffer greater vulnerability to social stress, because they develop professionally and, at the same time, they are involved in raising or caring for the family to a greater extent than men [75,76]. It is possible that this aspect has increased during the confinement resulting from the health alarm caused by the COVID-19 pandemic. In addition, intra-work conditions—like extra-work conditions—promotes the emergence of stress when, for example, responsibility or excessive work increases [77], as happened during confinement with ERT.

Moreover, women may have experienced more negative than positive feelings due to the fact that they tend to report their emotional states more than men [78]. Similarly, it should be taken into account that women manifest coping strategies based on inter-social competencies [79–81] and on the search for social support to overcome stressful situations [82]. It is likely, during confinement, they encountered limitations in supporting their colleagues and being supported themselves.

Furthermore, the study reveals that the age of the teachers had a significant impact on the perception of negative emotions. Specifically, teachers between the ages of thirty and thirty-five suffered the most frustration, irritation, and stress while teaching during confinement. It can be assumed that they found more difficulties to reconcile family care and work activities during confinement. Not surprisingly, this age range is the most common in Spain for having children for the first time, and those activities related to raising children are more demanding at this stage [83].

The youngest teachers (under 30 years of age) had, in general, the least negative feelings; on the contrary, the older ones showed more concern about their teaching perfor-

mance. The explanation for this issue can be found in the fact that younger teachers have a higher digital competence [16,84] and remote teaching requires of such skills.

Regarding the educational level in which teachers performed, primary education teachers perceived a more negative emotional state than the rest. Similarly, it is necessary to underline that studies addressing teachers who perform in early childhood education is still very scarce [85,86]. In addition, with regards to negative emotions, from the perspective of the type of educational centre, the assessment of teachers were practically the same, so no differences were found.

7. Conclusions

Research on Basque Country teachers who participated in Emergency Remote Teaching (ERT) during the COVID-19 pandemic reveals a predominantly negative emotional response. Levels of worry and stress during the confinement period were high. Despite this, they also expressed pride and satisfaction in the work they performed under these special circumstances.

The study also concluded that women expressed more negative emotions than men because they tend to have more work and family responsibilities, and this situation was aggravated in confinement. Age was another factor that influenced the emotional experiences of the teachers. Those between the ages of thirty and thirty-five suffered the most frustration and stress since they have to reconcile family care and work in addition to facing the situation of confinement. Younger teachers, being more digitally competent, are more adaptable to remote teaching environments, and therefore were likely to have fewer negative feelings and stress than their older peers. This study sheds light on teachers' emotional responses during emergency remote teaching, providing valuable insights for future educational strategies and development of teachers' digital competence.

The COVID-19 pandemic presented an unprecedented global challenge, compelling nations and institutions to make decisions that had not been made before, including the imposition of widespread lockdowns. Consequently, a significant shift towards remote work occurred, and even after the lifting of lockdowns, remote work persisted. This transformation has ignited a societal debate on the possibility and efficacy of delivering certain services, traditionally administered by public institutions, through in-person, remote, or hybrid modalities.

In the realm of education, the conducted study highlights that online teaching is not accessible to everyone and remote teaching cannot be successfully implemented in all knowledge areas, educational levels, etc., without negatively affecting the emotions of educators.

Moreover, our research brings to light that women, teachers aged 30 to 35, and those in primary education are particularly vulnerable demographics, experiencing heightened negative emotions in this context. In anticipation of similar situations in the future, it is recommended that administrations and educational institutions formulate action protocols or best practices, with a primary focus on enhancing teacher training in e-teaching and digital teaching competences. Such initiatives are poised to alleviate the negative emotional experiences of educators.

Recognizing that emotional, physical, and mental well-being is intrinsic to optimal professional performance, it is imperative to acknowledge that without adequate training, educators may struggle to adapt to unforeseeable future scenarios, including health emergencies and technological advancements. The holistic care of educators significantly contributes to societies attaining the educational standards they aspire to provide for their citizens.

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References

1. Real Decreto 476/2020, de 27 de Marzo, por el que se Prorroga el Estado de Alarma Declarado por el Real Decreto 463/2020, de 14 de marzo, por el Quese Declara el Estado de Alarma para la Gestión de la Situación de Crisis Sanitaria Ocasionada por el COVID-19, BOE núm. 86. Available online: https://www.boe.es/boe/dias/2020/03/28/pdfs/BOE-A-2020-4155.pdf (accessed on 23 December 2023).
2. UNESCO. Adverse Consequences of School Closures. UNESCO´s COVID-19 Education Response. 2020. Available online: https://es.unesco.org/node/320395 (accessed on 23 December 2023).
3. Moorhouse, B.L. Adaptations to a face-to-face initial teacher education course 'forced' online due to the COVID-19 pandemic. *J. Educ. Teach.* **2020**, *46*, 609–611. [CrossRef]
4. Hodges, C.; Moore, S.; Lockee, B.; Trust, T.; Bond, A. The difference between emergency remote teaching and online learning. In *Educause Review*; Educause: Denver, CO, USA, 2020; Available online: https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning (accessed on 23 December 2023).
5. Czerkawski, B.C.; Lyman, E.W. An Instructional Design Framework for Fostering Student Engagement in Online Learning Environments. *TechTrends* **2016**, *60*, 532–539. [CrossRef]
6. Johnson, R.D.; Hornik, S.; Salas, E. An empirical examination of factors contributing to the creation of successful e-learning environments. *Int. J. Human-Comput. Stud.* **2008**, *66*, 356–369. [CrossRef]
7. Noesgaard, S.S.; Ørngreen, R. The effectiveness of e-learning: An explorative and integrative review of the definitions, methodologies and factors that promote e-learning effectiveness. *Electron. J. e-Learn.* **2015**, *13*, 278–290.
8. Mansell, R.; Tremblay, G. Renewing the Knowledge Societies Vision: Towards Knowledge Societies for Peace and Sustainable Development. In Proceedings of the UNESCO's First WSIS+10 Review Event, Paris, France, 25–27 February 2013; Available online: http://unesdoc.unesco.org/images/0022/002245/224531E.pdf (accessed on 23 December 2023).
9. European Commission. Digitally Competent Educational Organisations. DigCompOrg. 2016. Available online: https://ec.europa.eu/jrc/en/digcomporg (accessed on 23 December 2023).
10. Consejo de la Unión Europea. *Recomendación del Consejo, de 18 de Diciembre de 2018, Relativa a las Competencias Clave para el Aprendizaje Permanente*; Diario Oficial de la Unión Europea: Luxembourg, 2018.
11. INTEF. Portafolio de la Competencia Digital Docente. Recuperadode. 2018. Available online: http://enlinea.intef.es/courses/course-v1:SPOOC (accessed on 23 December 2023).
12. Adedoyin, O.B.; Soykan, E. COVID-19 pandemic and online learning: The challenges and opportunities. *Interact. Learn. Environ.* **2020**, *31*, 863–875. [CrossRef]
13. Guillén-Gámez, F.D.; Lugones, A.; Mayorga-Fernández, M.J. ICT use by pre-service foreign languages teachers according to gender, age and motivation. *Cogent Educ.* **2019**, *6*, 1574693. [CrossRef]
14. Pinto-Llorente, A.M.; Sánchez-Gómez, M.C.; García-Peñalvo, F.J.; Casillas-Martín, S. Students' perceptions and attitudes towards asynchronous technological tools in blended-learning training to improve grammatical competence in English as a second language. *Comput. Hum. Behav.* **2017**, *72*, 632–643. [CrossRef]
15. Sadaf, A.; Newby, T.J.; Ertmer, P.A. An investigation of the factors that influence preservice teachers' intentions and integration of Web 2.0 tools. *Educ. Technol. Res. Dev.* **2016**, *64*, 37–64. [CrossRef]
16. Scherer, R.; Siddiq, F.; Teo, T. Becoming more specific: Measuring and modeling teachers' perceived usefulness of ICT in the context of teaching and learning. *Comput. Educ.* **2015**, *88*, 202–214. [CrossRef]
17. Loveless, A. Technology, pedagogy and education: Reflections on the accomplishment of what teachers know, do and believe in a digital age. *Technol. Pedagog. Educ.* **2011**, *20*, 301–316. [CrossRef]
18. Almenara, J.C.; Gimeno, A.M. Las tecnologías de la información y comunicación y la formación inicial de los docentes. Modelos y competencias digitales. *Profr. Rev. Curric. Form. Profr.* **2019**, *23*, 247–268. [CrossRef]
19. Chang, M.-L. Emotion Display Rules, Emotion Regulation, and Teacher Burnout. *Front. Educ.* **2020**, *5*, 90. [CrossRef]
20. Skaalvik, E.M.; Skaalvik, S. Does school context matter? Relations with teacher burnout and job satisfaction. *Teach. Teach. Educ.* **2009**, *25*, 518–524. [CrossRef]

21. Alvandi, E.O. A review on meanings of emotions: Steps to a neural-informational notion of semantics. *Cogn. Brain Behav.* **2016**, *20*, 45–63. Available online: https://ehu.idm.oclc.org/login?url=https://www.proquest.com/docview/1776352167?accountid=17248 (accessed on 23 December 2023).
22. Oatley, K. Emotion: Theories. In *Encyclopedia of Psychology*; Kazdin, A.E., Ed.; Oxford University Press: Oxford, UK, 2000; pp. 167–171. Volume 3.
23. Niedenthal, P.; Krauth-Gruber, S.; Ric, R. *Psychology of Emotion*; Psychology Press: London, UK, 2006.
24. Ekman, P. Basic emotions. In *Handbook of Cognition and Emotion*; Dalgleish, T., Power, M., Eds.; Wiley: Hoboken, NJ, USA, 1999; pp. 45–60.
25. United Nations. The Sustainable Development Goals Report 2023: Special Edition. 2023. Available online: https://unstats.un.org/sdgs/report/2023/ (accessed on 23 December 2023).
26. Chan, M.-K.; Sharkey, J.D.; Lawrie, S.I.; Arch, D.A.N.; Nylund-Gibson, K. Elementary school teacher well-being and supportive measures amid COVID-19: An exploratory study. *Sch. Psychol.* **2021**, *36*, 533–545. [CrossRef] [PubMed]
27. Gondim, S.M.G.; Mutti, C. Affections in learning situations: A study of an entrepreneurship skills development course. *J. Work. Learn.* **2010**, *23*, 195–208. [CrossRef]
28. Rajkumar, R.P. COVID-19 and mental health: A review of the existing literature. *Asian J. Psychiatry* **2020**, *52*, 102066. [CrossRef] [PubMed]
29. Segura, M.; Arcas, M. *Relacionarnos bien. Programas de Competencia Social*; Narcea: Madrid, Spain, 2007.
30. Bakker, A.B.; Demerouti, E. The job demands-resources model: State of the art. *J. Manag. Psychol.* **2007**, *22*, 309–328. [CrossRef]
31. Mansfield, C.F.; Beltman, S.; Price, A.; McConney, A. "Don't sweat the small stuff": Understanding teacher resilience at the chalkface. *Teach. Teach. Educ.* **2012**, *28*, 357–367. [CrossRef]
32. Uluyol, C.; Sahin, S.C.; Uluyol, S. Sahin Elementary School Teachers' ICT Use in the Classroom and Their Motivators for Using ICT. *Br. J. Educ. Technol.* **2016**, *27*, 66–75. [CrossRef]
33. Freudenberger, H.J. Staff Burn-Out. *J. Soc. Issues* **1974**, *30*, 159–165. [CrossRef]
34. Kim, L.E.; Jörg, V.; Klassen, R.M. A Meta-Analysis of the Effects of Teacher Personality on Teacher Effectiveness and Burnout. *Educ. Psychol. Rev.* **2019**, *31*, 163–195. [CrossRef] [PubMed]
35. Valverde, J.; Fernández, M.R.; Revuelta, F.I. El bienestar subjetivo ante las buenas prácticas educativas con TIC: Su influencia en profesorado innovador. *Educación XX1* **2013**, *16*, 255–280. [CrossRef]
36. Chigona, A.; Chigona, W.; Davids, Z. Educators' Motivation on Integration of ICTs into Pedagogy: A Case of Disadvantaged Areas. *South Afr. J. Educ.* **2014**, *34*, 1–8. [CrossRef]
37. Besser, A.; Lotem, S.; Zeigler-Hill, V. Psychological stress and vocal symptoms among university professors in israel: Implications of the shift to online synchronous teaching during the COVID-19 Pandemic. *J. Voice* **2020**, *36*, 291.e9–291.e16. [CrossRef] [PubMed]
38. Cornejo, R.; Quiñónez, M. Factores asociados al malestar/bienestar docente. Una investigación actual. *REICE Rev. Electrónica Iberoam. Sobre Calid. Efic. Cambio En Educ.* **2007**, *5*, 75–80.
39. Marqués, A.; Lima, M.L.; Lopes, A. Fuentes de estrés, burnout y estrategias de coping en profesores portugueses. *Rev. Psicol. Trab. Organ.* **2005**, *21*, 123–143.
40. Molina-Jiménez, T.; Gutiérrez-García, A.G.; Hernández-Domínguez, L.; MContreras, C. Psychosocial stress: Some clinical and experimental aspects. *An. Psicol./Ann. Psychol.* **2008**, *24*, 353–360. Available online: https://revistas.um.es/analesps/article/view/42951 (accessed on 23 December 2023).
41. Richards, K.A.R.; Hemphill, M.A.; Templin, T.J. Personal and contextual factors related to teachers' experience with stress and burnout. *Teach. Teach.* **2018**, *24*, 768–787. [CrossRef]
42. Becker, E.S.; Goetz, T.; Morger, V.; Ranellucci, J. The importance of teachers' emotions and instructional behavior for their students' emotions. An experience sampling analysis. *Teach. Teach. Educ.* **2014**, *43*, 15–26. [CrossRef]
43. Beilock, S.L.; Gunderson, E.A.; Ramirez, G.; Levine, S.C. Female teachers' math anxiety affects girls' math achievement. *Proc. Natl. Acad. Sci. USA* **2010**, *107*, 1860–1863. [CrossRef]
44. Yan, E.M.; Evans, I.M.; Harvey, S.T. Observing Emotional Interactions Between Teachers and Students in Elementary School Classrooms. *J. Res. Child. Educ.* **2011**, *25*, 82–97. [CrossRef]
45. Griffiths, D.; Goddard, T. An explanatory framework for understanding teachers resistance to adopting educational technology. *Kybernetes* **2015**, *44*, 1240–1250. [CrossRef]
46. Choi, B.; Jegatheeswaran, L.; Minocha, A.; Alhilani, M.; Nakhoul, M.; Mutengesa, E. The impact of the COVID-19 pandemic on final year medical students in the United Kingdom: A national survey. *BMC Med. Educ.* **2020**, *20*, 206. [CrossRef]
47. Du, W.; Yu, J.; Wang, H.; Zhang, X.; Zhang, S.; Li, Q.; Zhang, Z. Clinical characteristics of COVID-19 in children compared with adults in Shandong Province, China. *Infection* **2020**, *48*, 445–452. [CrossRef]
48. Binali, H.; Wu, C.; Potdar, V. Computational approaches for emotion detection in text. In Proceedings of the 2010 4th IEEE International Conference on Digital Ecosystems and Technologies (DEST), Dubai, United Arab Emirates, 13–16 April 2010; pp. 172–177. [CrossRef]
49. Lopatovska, I.; Arapakis, I. Theories, methods and current research on emotions in library and information science, information retrieval and human–computer interaction. *Inf. Process. Manag.* **2011**, *47*, 575–592. [CrossRef]
50. Halverson, L.R.; Graham, C.R. Learner Engagement in Blended Learning Environments: A Conceptual Framework. *Online Learn.* **2019**, *23*, 145–178. [CrossRef]

51. Costa, A.; Faria, L. The impact of emotional intelligence on academic achievement: A longitudinal study in Portuguese secondary. *Learn. Individ. Differ.* **2015**, *37*, 38–47. [CrossRef]
52. Pekrun, R.; Perry, R.P. Control-value theory of achievement emotions. In *International Handbook of Emotions in Education*; Pekrun, R., Linnenbrink-Garcia, L., Eds.; Taylor & Francis: Abingdon, UK, 2014; pp. 120–141.
53. Pekrun, R.; Goetz, T.; Daniels, L.M.; Stupnisky, R.H.; Perry, R.P. Boredom in achievement settings: Exploring control–value antecedents and performance outcomes of a neglected emotion. *J. Educ. Psychol.* **2010**, *102*, 531–549. [CrossRef]
54. Pekrun, R.; Hall, N.C.; Goetz, T.; Perry, R.P. Boredom and academic achievement: Testing a model of reciprocal causation. *J. Educ. Psychol.* **2014**, *106*, 696–710. [CrossRef]
55. Ellis, P.D. *The Essential Guide to Effect Sizes: Statistical Power, Meta-Analysis, and the Interpretation of Research Results*; Cambridge University Press: Cambridge, UK, 2010.
56. Hedges, L.V. Distribution theory for Glass's estimator of effect size and related estimators. *J. Educ. Stat.* **1981**, *6*, 107–128. [CrossRef]
57. MacCallum, R.C.; Browne, M.W.; Sugawara, H.M. Power analysis and determination of sample size for covariance structure modeling. *Psychol. Methods* **1996**, *2*, 130–149. [CrossRef]
58. McMillan, J.H.; Schumacher, S.; Baides, J.S. *Investigación Educativa: Una Introducción Conceptual*; Pearson: London, UK, 2005.
59. Rebollo-Catalán, M.A.; García-Pérez, R.; Buzón-García, O.; Vega-Caro, L. Las emociones en el aprendizaje universitario apoyado en entornos virtuales: Diferencias según actividad de aprendizaje y motivación del alumnado. *Rev. Complut. Educ.* **2013**, *25*, 69–93. [CrossRef]
60. Podsakoff, P.M.; MacKenzie, S.B.; Lee, J.-Y.; Podsakoff, N.P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *J. Appl. Psychol.* **2003**, *88*, 879–903. [CrossRef]
61. Atkinson, R.; Flint, J. Accessing hidden and hard-to-reach populations: Snowball research strategies. *Soc. Res. Update* **2001**, *33*, 1–4.
62. Noy, C. Sampling Knowledge: The Hermeneutics of Snowball Sampling in Qualitative Research. *Int. J. Soc. Res. Methodol.* **2008**, *11*, 327–344. [CrossRef]
63. D'ancona, C. *Metodología Cuantitativa: Estrategias y Técnicas de Investigación Social*; Síntesis: Los Angeles, CA, USA, 1991.
64. Lorenzo-Seva, U.; Ferrando, P.J. Factor 9.2: A comprehensive program for fitting exploratory and semiconfirmatory factor analysis and IRT models. *Appl. Psychol. Meas.* **2013**, *37*, 497–498. [CrossRef]
65. Timmerman, M.E.; Lorenzo-Seva, U. Dimensionality assessment of ordered polytomous items with parallel analysis. *Psychol. Methods* **2011**, *16*, 209–220. [CrossRef]
66. Mîndrilă, D. Maximum Likelihood (ML) and Diagonally Weighted Least Squares (DWLS) Estimation Procedures: A Comparison of Estimation Bias with Ordinal and Multivariate Non-Normal Data. *Int. J. Digit. Soc.* **2010**, *1*, 60–66. [CrossRef]
67. Jöreskog, K.; Sörbom, D. *Lisrel 8: User's Reference Guide*; Scientific Software International: Lincolnwood, IL, USA, 1997.
68. Browne, M.W.; Cudeck, R. Alternative ways of assessing fit. In *Testing Structural Equation Models*; Bollen, K.A., Ed.; Sage: Thousand Oaks, CA, USA, 1993; pp. 136–162.
69. Bentler, P.M.; Bonett, D.G. Significance test and goodness of fit in the analysis of covariance structures. *Psychol. Bull.* **1980**, *88*, 588–606. [CrossRef]
70. Cohen, J. *Statistical Power Analysis for the Behavioral Sciences*, 2nd ed.; Erlbaum: Mahwah, NJ, USA, 1988.
71. Bakker, A.B.; de Vries, J.D. Job Demands-Resources theory and self-regulation: New explanations and remedies for job burnout. *Anxiety Stress Coping* **2020**, *34*, 1–21. [CrossRef]
72. Chiang, M.M.; Heredia, S.A.; Santamaría, E.J. Clima organizacional y salud psicológica: Una dualidad organizacional. *Dimens. Empres.* **2017**, *15*, 63–76.
73. Arquero, J.L.; Donoso, J.A. Docencia, investigación y burnout: El síndrome del quemado en profesores universitarios de Contabilidad. *Rev. Contab.* **2013**, *16*, 94–105. [CrossRef]
74. Sánchez Fernández, M.; Clavería, M. Profesorado universitario: Estrés laboral. Factor de riesgo de salud. *Enfermería Glob.* **2005**, *6*, 1–16.
75. Maslach, C. *Burnout: The Cost of Caring*; Prentice Hall: Upper Saddle River, NJ, USA, 1982.
76. Noh, J.-W.; Kim, K.-B.; Park, J.; Hong, J.; Kwon, Y.D. Relationship between the number of family members and stress by gender: Cross-sectional analysis of the fifth Korea National Health and Nutrition Examination Survey. *PLoS ONE* **2017**, *12*, e0184235. [CrossRef]
77. Lemos, M.C.; Arnott, J.C.; Ardoin, N.M.; Baja, K.; Bednarek, A.T.; Dewulf, A.; Fieseler, C.; Goodrich, K.A.; Jagannathan, K.; Klenk, N.; et al. To co-produce or not to co-produce. *Nat. Sustain.* **2018**, *1*, 722–724. [CrossRef]
78. Hess, U.; Senécal, S.; Kirouac, G.; Herrera, P.; Philippot, P.; Kleck, R.E. Emotional expressivity in men and women: Stereotypes and self-perceptions. *Cogn. Emot.* **2000**, *14*, 609–642. [CrossRef]
79. Chan, D. Emotional intelligence, self-efficacy, and coping among chinese prospective and inservice teachers in Hong Kong. *Educ. Psychol.* **2008**, *28*, 397–408. [CrossRef]
80. Mouton, A.; Hansenne, M.; Delcour, R.; Cloes, M. Emotional Intelligence and Self-Efficacy Among Physical Education Teachers. *J. Teach. Phys. Educ.* **2013**, *32*, 342–354. [CrossRef]
81. Yin, H. The effect of teachers' emotional labour on teaching satisfaction: Moderation of emotional intelligence. *Teach. Teach.* **2015**, *21*, 789–810. [CrossRef]

82. Greenglass, E.R.; Burke, R.J.; Konarski, R. Components of Burnout, Resources, and Gender-Related Differences. *J. Appl. Soc. Psychol.* **1998**, *28*, 1088–1106. [CrossRef]
83. Penit, E. La Encuesta de Fecundidad de 2018. *Rev. Estadística Soc.* **2019**, *7*, 6–9.
84. Gudmundsdottir, G.B.; Hatlevik, O.E. Newly qualified teachers' professional digital competence: Implications for teacher education. *Eur. J. Teach. Educ.* **2017**, *41*, 214–231. [CrossRef]
85. Berkovich, I.; Eyal, O. Educational leaders and emotions: An international review of empirical evidence 1992–2012. *Rev. Educ. Res.* **2015**, *85*, 129–167. [CrossRef]
86. Yin, H.-B.; Lee, J.C.K.; Zhang, Z.-H.; Jin, Y.-L. Exploring the relationship among teachers' emotional intelligence, emotional labor strategies and teaching satisfaction. *Teach. Teach. Educ.* **2013**, *35*, 137–145. [CrossRef]

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