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Risks for Companies during the COVID-19 Crisis: Dataset Modelling and Management through Digitalisation

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Abstract: The goal is to create a systemic risk profile of companies during the COVID-19 crisis, which reflects their cause-and-effect relationships and risk management. The research objects are the following types of risks for companies listed in "Global-500" (Fortune) and the top 55 most competitive digital economies of the world (IMD) in 2017–2022: (1) risk of reduction in competitiveness (rank), (2) risk of reduction in revenue, and (3) risk of reduction in profit. The research methodology is based on the method of structural equation modelling (SEM), which allowed for exploring the cause-and-effect relationships between risk changes and digital risk management for companies during the COVID-19 crisis. As a result, based on the SEM model, it was proven that risks for companies during the COVID-19 crisis only slightly increased compared with that at the pre-crisis level. It was determined that companies faced large risks during the COVID-19 crisis in developed countries. It was discovered that, due to successful adaptation, risk management of companies assuaged the manifestations of the COVID-19 crisis in the economy. The key conclusion is that, under the conditions of a crisis of a non-economic nature (e.g., the COVID-19 crisis), companies independently and successfully manage their risks with the help of measures of digitalisation: corporate risk management with the limitation of state intervention is preferable. The contribution to the literature consists of the development of the concept of risks for companies by clarifying the specifics of risks and risk management of companies during the COVID-19 crisis. The theoretical significance lies in the fact that the authors' conclusions rethought the risks for companies under the conditions of a crisis given the special context of a crisis of a non-economic nature (via the example of the COVID-19 crisis). The practical significance is that the developed novel approach to risk management of companies through digitalisation, which is based on the experience of the COVID-19 crisis, will be useful for risk management of companies under the conditions of future crises of non-economic nature caused by epidemics/pandemics and/or environmental disasters.

Keywords: risks for companies; COVID-19 crisis; crisis of non-economic nature; dataset modelling; digitalisation of business; risk management

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1. Introduction

The most important feature of the COVID-19 crisis (which was accompanied by the economic decline in 2020), which distinguishes it from many other similar crises, is its unpredictability. Due to the critically high level of uncertainty of the COVID-19 crisis, caused by its unique non-economic nature, it is expedient to study this crisis from the perspective of risk. Thus, the social risks of the COVID-19 crisis were connected with the

limitation of offline communications, the psychological pressure of which could be treated as social drama.

The risks of state management consisted in the necessity to implement dual measures of management. On the one hand, state policy in the sphere of healthcare dictated the need to impose strict limitations and, in a range of cases, bans on economic activity. On the other hand, state economic policy required an increase in economic activity to support economic growth. Risks for companies manifested in the deterioration of their position in the global rankings for companies with the complex reduction in business indicators: competitiveness of revenues and profits.

The relevance of studying the experience of the COVID-19 crisis is explained by the fact that, though it became the first crisis of its type in the 21st century—a crisis of a non-economic nature—there is a high probability of emergence of new similar crises in the coming decades and, in particular, in the Decade of Action. They might become a series of implications of forced economic growth with high environmental costs: insufficient attention to the issues of healthcare, environmental protection, and the fight against climate change. The climate version was not supported with sufficient scientific argumentation—however, neither were other alternative versions—but was not disproved either and so cannot be discarded.

Regardless of the fact of what exactly was the direct cause of the crisis (COVID-19), there is a range of good reasons for the emergence of future crises of a non-economic nature. These reasons include environmental pollution, greenhouse gas emissions, reduction in biodiversity, and the emergence of new and the dissemination of existing zoonotic diseases. New crises, predetermined by epidemics/pandemics and/or environmental disasters, will contrast against the background of economic crises, but their risks, in particular, risks for companies, will be very similar to the risks for companies during the COVID-19 crisis.

That is why it is important to study—as quickly as possible—the essence and successful experience of the management of risks for companies during the COVID-19 crisis. The problem is that the existing literature does not fully reflect this experience. The cause of the posed problem consists of the imperfection of the methodology, the drawback of which is the foundation on the data on individual companies or selected countries. This allows for determining individual but not common risks and thus has limited scientific and practical value. This paper strived toward filling the discovered literature gap and forming a comprehensive view of risks for companies during the COVID-19 crisis due to the use of the improved method of data analysis—dataset modelling.

The goal of this paper is to create a systemic risk profile of companies under the conditions of the COVID-19 crisis, which reflects their cause-and-effect relationships and risk management. The paper's originality lies in its proposed novel approach to risk management of companies during the COVID-19 crisis, which is based on digitalisation. The theoretical significance of the obtained results consists of their allowing rethinking of the digitalisation of companies from the perspective of risk. Unlike the traditional presentation of digitalisation as an innovative process, which is accompanied by risks and raises the general risk burden on companies, this paper proved that, during the COVID-19 crisis, digitalisation helped reduce the risk burden on companies.

The practical significance of the authors' conclusions and recommendations lies in the following: being based on the experience of the COVID-19 crisis, they will be useful for the management of risks for companies under the conditions of future crises of non-economic nature, caused by epidemics/pandemics and/or environmental disasters. This goal predetermined the order of this research and led to the setting of three research tasks. The first task consists of measuring risks for companies during the COVID-19 crisis and discovering the specific features of risks in developed and developing countries. The second task is the determination of cause-and-effect relationships between the change and digital management of risks for companies during the COVID-19 crisis. The third task consists of identifying the potential of digital management of risks for companies under the conditions of a crisis of a non-economic nature on the example of the COVID-19 pandemic.

2. Literature Review and Gap Analysis

This paper is based on scientific provisions of the concept of risks for companies, which defines them as risks of deterioration in companies' position in the global rankings due to the reduction in indicators of business activity, financial performance, and investment attractiveness (competitiveness of revenues and profits) (Kolchin et al. 2023; Sozinova and Popkova 2023). The indicators used for quantifying risks are the annual increase in rank (position in the ranking of companies) and the revenues and profits of companies (Abdelwahed and Soomro 2023; Litvinova 2022; Yeşildağ 2019).

In the existing literature by Abakah et al. (2023) and Vogl (2022), the risks for companies during the 2008 global financial and economic crisis, as an illustrative crisis of economic nature (which happened because of the bubble burst in the US stock market), were studied in detail. As this experience shows, under the conditions of a crisis of an economic nature, the risks for companies are very high and much higher than that under the conditions of stability and economic growth. This highlights the importance of studying business under crisis conditions from a risk perspective.

However, the COVID-19 crisis took place because of the pandemic and has a non-economic nature, due to which the risks for companies during this crisis might be specific. The results of recent published work on the topic of the influence of the COVID-19 pandemic and crisis on risks for companies are reflected in the work by Abdi et al. (2023), Erer et al. (2023), Fortunato et al. (2023), Hean and Chairassamee (2023), Kanamura (2023), Loughran and McDonald (2023), and Tang et al. (2023). In the existing literature (Popkova and Sergi 2021; Yelikbayev and Andronova 2022), only certain aspects of the risks for companies during the COVID-19 crisis are reflected. Because of this, it does not allow for a comprehensive and full characterisation of risks for companies during the COVID-19 crisis, which is a literature gap and causes the following research questions (RQs).

RQ_1: What is the level of risks for companies during the COVID-19 crisis (in 2020): higher or lower than the pre-crisis level (2019)? Based on experience of crises of an economic nature, the existing literature—Moreno Moreno Ramírez et al. (2022), Tan et al. (2022), and Zhou and Li (2022)—notes that risks for companies are very high during the COVID-19 crisis. At the same time, certain proofs from the experience of the COVID-19 crisis, which were reflected in the work of Hohenstein (2022) and Tingey-Holyoak and Pisaniello (2021)—show that the risks for companies are relatively small under the conditions of the COVID-19 crisis. This is the basis for proposing hypothesis H_1: annual increase in rank, revenues, and profits during the COVID-19 crisis (in 2020) only slightly changed compared with that during the pre-crisis period (2019).

RQ_2: Which countries experienced the highest risks for companies during the COVID-19 crisis: developed or developing nations? Based on the experience of crises of an economic nature, the existing work by Abdullah et al. (2022) and Dohale et al. (2023) points to the fact that companies in developing countries faced larger risks during the COVID-19 crisis compared with those in developed countries, which demonstrated higher crisis resilience. At that, the specifics of developing countries, which are connected to their most dynamic economic growth and increased flexibility of business—noted in the work by Kukoyi et al. (2022) and Metwally and Diab (2023)—allow for proposing hypothesis H_2: in developing countries, risks for companies during the COVID-19 crisis turned out to be lower due to the increased adaptability of businesses to the crisis.

RQ_3: What are the consequences of risks for companies during the COVID-19 crisis for the economy: increase or reduction in crisis phenomena in the economy? Based on the experience of crises of an economic nature, Mezghani et al. (2021) and Yamen (2021) state that, because of the unpreparedness of companies for the COVID-19 crisis, risks for them (deterioration in business indicators of listed domestic companies) increased the economic decline, causing a decrease in GDP, an increase in tax evasion (development of the shadow economy), and a growth in state budget deficit.

At the same time, the existing work on the topic of the digitalisation of business (Inshakova et al. 2021; Leung et al. 2023; Ngo et al. 2023) shows that it facilitates an increase

in economic (digital) growth; more successful fights against tax evasion (overcoming the shadow economy); and an increase in revenues and, therefore, state budget surplus. This is the basis for proposing hypothesis H_3: the use of digital measures of risk management of companies during the COVID-19 crisis allowed for mitigating the economic manifestations of the crisis, increasing GDP (supporting economic growth), reducing the shadow economy, and increasing state budget surplus.

RQ_4: How (and with what measures) can we manage risks under the conditions of a crisis of a non-economic nature given the experience of the COVID-19 crisis: measures of state or corporate management? Based on the experience of crises of an economic nature, to reduce the risk burden on businesses during the COVID-19 crisis, the existing literature suggests implementing external (state) management with the help of standard measures of protectionism (Phang et al. 2023; Salami et al. 2022; Velayutham et al. 2021) and special (which became actual during the pandemic) measures of development of the healthcare infrastructure (Abdel Fattah et al. 2022).

In this case, the existing literature on the topic of the digital economy notes the advantages of digitalisation of businesses to raise the competitiveness, return, and profitability of companies. In particular, the following management measures are offered for this:

- Development of digital/technological skills of employees to implement digital innovations in business (Türk 2022);
- Raising the activity of the use of big data and analytics to create and develop smart productions with a high level of automatisation of all business operations (Cui et al. 2022);
- Performing digital transformation in companies to raise their effectiveness and digital competitiveness (Busco et al. 2023);
- Dissemination of mobile broadband subscribers (transition to 4G and 5G mobile Internet) for the development of e-commerce (Attaran 2023)

This is the basis for proposing hypothesis H_4: digital measures (increase in digital/technological skills, growth in the activity of the use of big data and analytics, acceleration of digital transformation in companies, and increase in the number of mobile broadband subscribers) allowed for reducing the risks for companies (improving business indicators of listed domestic companies) during the COVID-19 crisis.

To fill the discovered gap, to search for answers to the posed RQs, and to verify the proposed hypotheses, we performed dataset modelling of the international experience of change in the risks for companies during the COVID-19 crisis, as well as management of these risks with the help of digitalisation of businesses.

3. Methodology

The research objects in this paper are the following types of risks of listed companies: (1) risk of the reduction in competitiveness (rank, position in the ranking of companies), (2) risk of the reduction in revenue, and (3) risk of the reduction in profit. To compile the most precise risk profile of companies during the COVID-19 crisis, we conducted a quantitative study based on the methodology of econometrics. The considered statistics were unified in "massive time series"—datasets—with their further analysis. The authors' term "massive time series" was offered in this paper to define the notion of a "dataset" according to the categorical apparatus of mathematical sciences and econometrics.

In mathematics, a data array or data structure is treated as the structure of data that stores a set of values (elements of the array) of the indicators of a certain set continuous range. A classic example of a data array is a table—it is used in this paper (Garcia and Lumsdaine 2005). A specific feature of an array as a data structure (unlike, for example, a linked list) is the constant computational complexity of access to the element of the array via the index (McMillan 2014).

A time series is treated in mathematics as statistical material, collected during different time periods, on the values of any parameters of the studied process. In a time series, the time of measuring or order number of measuring is indicated for each calculation (e.g.,

calendar year—like in this paper). Time series substantially differs from a simple data sample, for during the analysis, the interconnection of measurements with time, not only statistical diversity and statistical characteristics of the sample, is taken into account—this was an argument in favour of the provision of the statistical basis of this research in the form of a time series.

Time series consist of two elements: a period of time, for which or as of which numerical values are given; numerical values of a certain indicator, called levels of the series. A time series analysis is treated in mathematics as a totality of mathematical and statistical methods of analysis for determining the structure of a time series. These include, in particular, the methods of regression analysis, which are used in this paper (De Gooijer and Hyndman 2006).

The time series studied in this paper includes data before the pandemic (2017–2019) and during the COVID-19 pandemic and crisis (2020–2022). These periods were calculated and determined according to the following logic. The pandemic was announced by the WHO on 11 March 2020. Due to this, the entire 2020 year was a pandemic and crisis year because, according to the World Bank (2023), the growth rate of the world GDP was negative (−3.1%), which is a sign of a deep recession of the world economic system.

The pre-pandemic period was marked by growth rates of the world economy of 3.4% in 2017, 3.3% in 2018, and 2.6% in 2019 (World Bank 2023). During the pandemic (the end of which was officially announced by the WHO on 5 May 2023, due to which the year 2023 is COVID-19-neutral), the world GDP reduced by 3.1% in 2020 and then grew by 6% in 2021 and by 3.1% in 2022 (World Bank 2023).

The logic of differentiation of these periods is that, in 2017–2019, the pandemic did not have any influence on the economy. That is why, an analysis of business in the pre-pandemic period allows for revealing its natural risks. In 2020–2022, the COVID-19 pandemic and crisis determined the pandemic context of the business environment and influenced business risks.

The advantage of a dataset analysis is that the statistics fully cover the studied economic processes, with the error of results being at the minimum. The essence of the method of dataset analysis was described in many studies (e.g., Yuan et al. 2023), and the specifics of using this method during the study of risks for companies were reflected in the work of Popkova and Sergi (2021) and Sozinova and Popkova (2023). The authors' datasets, formed based on the official international statistics of respectable sources—Fortune (2023) and IMD (2023)—can be found in a separate file, submitted with this paper. The experimental design of this research is shown in Table 1.

To search for answers to RQ_1 and RQ_2, task 1 was set: to measure risks for companies during the COVID-19 crisis and to determine the features of risks in developed and developing countries. It is solved with the help of the method of horizontal analysis. Sample 1 contains the world's largest listed companies from the ranking "Global 500" (Fortune 2023) in 2019–2022, with division into developed and developing countries. The annual growth in the values of rank, revenue, and profits of these companies in 2019–2022 is assessed—separately for developed and developing countries.

Sample 2 contains the top 55 (without gaps in data) most competitive digital economies of the world (IMD 2023) in 2017–2022. The annual growth in the following values is assessed: (1) digital management measures of risk management, such as digital/technological skills (DGT_1), use of big data and analytics (DGT_2), digital transformation in companies (DGT_3), and mobile broadband subscribers (DGT_2); (2) alternative measures of state regulation, aimed at reducing the risk burden on businesses, such as protectionism (GOV_1) and health infrastructure (GOV_2); (3) risks that are measured with the help of the indicator "listed domestic companies" (RISK); and (4) potential economic implications of risks and risk management of companies, such as gross domestic product (GDP) ($ECON_1$), tax evasion ($ECON_2$), and government budget surplus/deficit (GBD).

Table 1. Experimental design.

Research Question (RQ)	Research Task	Research Method	Sample
RQ_1: What is the level of risks for companies during the COVID-19 crisis (in 2020): higher or lower than the pre-crisis level (2019)?	Task 1: to measure risks for companies during the COVID-19 crisis and to determine the features of risks in developed and developing countries	Method of horizontal analysis	Sample 1: "Global 500" (Fortune 2023) in 2019–2022 with division into developed and developing countries (rank, revenue, and profits) Sample 2: The top 55 most competitive digital economies of the world (IMD 2023) in 2017–2022 (listed domestic companies and connected statistics)
RQ_2: Which countries experienced the highest risks for companies during the COVID-19 crisis: developed or developing nations?			
RQ_3: What are the consequences of risks for companies during the COVID-19 crisis for the economy: increase or reduction in crisis phenomena in the economy?	Task 2: to determine cause-and-effect relationships between the change and digital management of risks for companies during the COVID-19 crisis	Method of regression analysis	Sample 2: The top 55 most competitive digital economies of the world (IMD 2023) in 2017–2022 (econometric modelling of the connection between listed domestic companies and alternative measures of risk management and potential implications for the economy)
RQ_4: How (and with what measures) can we manage risks under the conditions of a crisis of a non-economic nature given the experience of the COVID-19 crisis: measures of state or corporate management?	Task 3: to determine the potential for digital management of risks for companies under the conditions of a crisis of a non-economic nature via the example of the COVID-19 pandemic	Method of foresight, method of trend analysis	

Source: authors.

To assess reliability, an important aspect is a normal distribution of variables that are used in the regression function. The assumption of normality is very important in a regression analysis since it allows for using different statistical techniques. Deviation from normality may lead to distortion or influence the reliability of the results. The reliability and correctness of the calculation of risks in this paper are ensured and assessed according to the methodology proposed by Popkova and Sergi (2021) and the method proposed by Sozinova and Popkova (2023). Histograms of the normal distribution of data, which are used in the paper, are given in Figure 1.

The performed evaluation showed that the variables fall under a normal distribution—therefore, it is possible to interpret and confirm the regression model.

To search for answers to RQ_3 and RQ_4, task 2 was set: to determine cause-and-effect relationships between the change and digital management of risks for companies during the COVID-19 crisis. It is solved in the strategy of assessment with the use of structural equation modelling with the help of the method of regression analysis. Based on the data from Sample 2—the top 55 most competitive digital economies of the world (IMD 2023) in 2017–2022—we performed econometric modelling of the connection between listed domestic companies and alternative measures of risk management and potential implications for the economy. Research model (1) systemically reflects the connections of the indicators from the sample and has the following mathematical expression:

$$\begin{cases} (1) RISK = a_{RISK} + b_{1RISK} \times DGT_1 + b_{2RISK} \times DGT_2 + b_{3RISK} \times DGT_3 + b_{4RISK} \times DGT_4 + b_{5RISK} \times GOV_1 + b_{6RISK} \times GOV_2; \\ (2) ECON = a_{RECON} + b_{1ECON} \times RISK + b_{2ECON} \times DGT_1 + b_{3ECON} \times DGT_2 + b_{4ECON} \times DGT_3 + b_{5ECON} \times DGT_4 + b_{6ECON} \times GOV_1 + b_{7ECON} \times GOV_2; \\ (3) GBD = a_{GBD} + b_{GBD} \times ECON_2; \\ (4) GOV_2 = a_{GOV} + b_{1GOV} \times DGT_1 + b_{2GOV} \times DGT_2 + b_{3GOV} \times DGT_3 + b_{4GOV} \times DGT_4. \end{cases} \quad (1)$$

Research model (1) reflects four dependencies: (1) dependence of the risks for listed companies on the totality of digital management measures of risk management and alternative measures of state regulation, aimed at reducing the risk burden on businesses; (2) dependence of GDP and tax evasion (separately) on the risks for listed companies and on the totality of the digital management measures of risk management and alternative measures of state regulation, aimed at reducing the risk burden on businesses; (3) dependence of the government budget surplus/deficit on tax evasion; and (4) dependence of the health infrastructure on the totality of digital management measures of risk management.

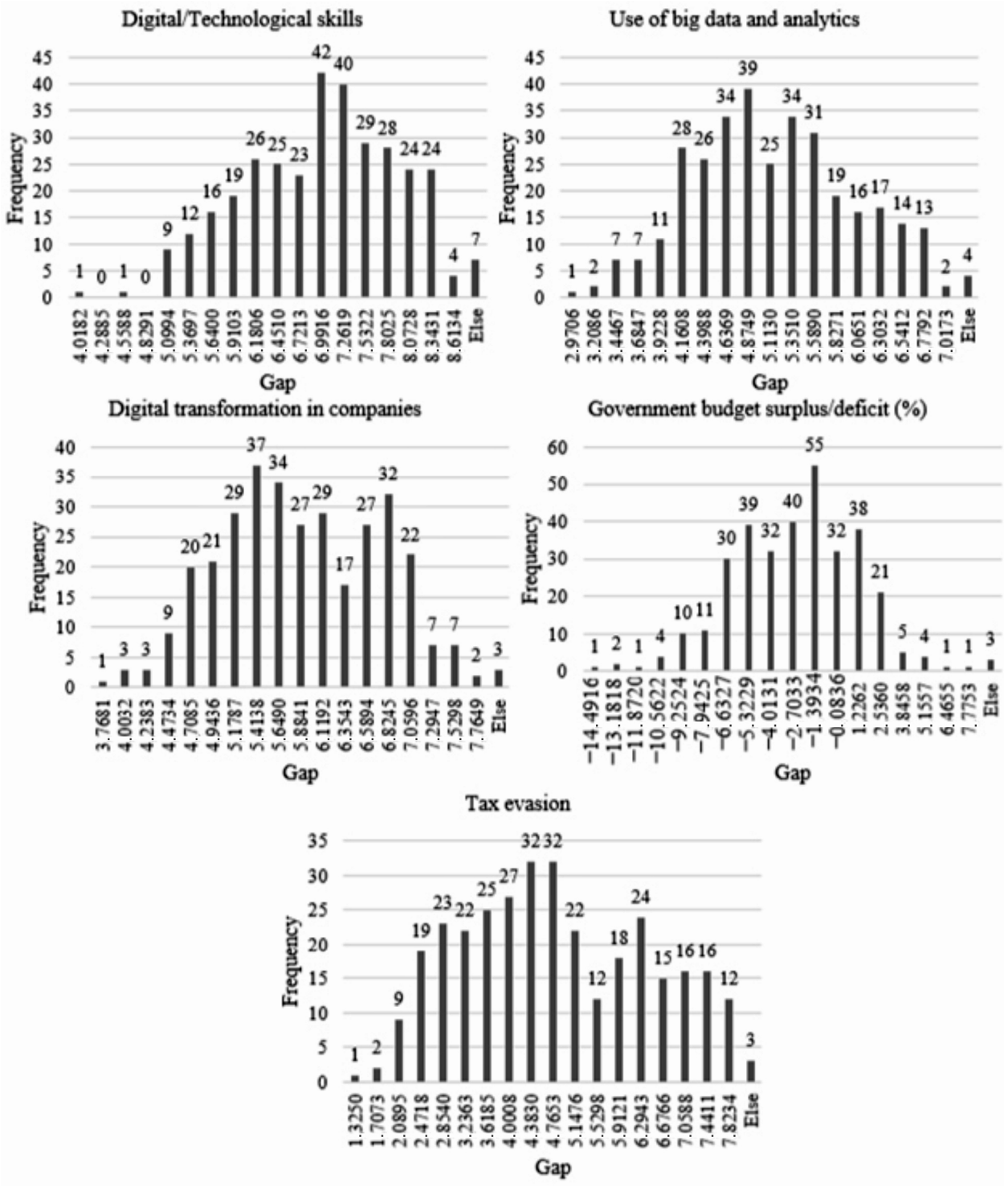


Figure 1. Histograms of normal distribution of the values of variables. Source: authors.

The reliability of the results of the regression analysis is verified with the help of the F-test. It should be noted that, when performing a regression analysis with the variables of a time series, it is very important to follow certain important steps to ensure the reliability and substantiation of the results. These steps usually include tests for unit roots to assess stationarity and residual tests to evaluate the appropriateness of the model.

To follow these steps and to guarantee the reliability of the results of the regression analysis, we performed, first, stationarity tests, with the help of the Augmented Dickey–Fuller test (ADF), which is very important for determining whether the variables demonstrate unit roots or are stationary. Stationarity is a fundamental assumption in an analysis of a time series; violation of this assumption may lead to imprecise and unreliable results.

The augmented Dickey–Fuller test (ADF) checks the value of the regression coefficient (a) in the autoregression equation of the first order. If $a \geq 1$, the process has a unit root—in this case, the row is not stationary, and it is an integrated time row of the first order. If $a < 1$, the row is stationary. The Dickey–Fuller test was performed in this paper with the help of MS Excel software for each studied time row separately.

In the Dickey–Fuller test, the null hypothesis assumes that the time series has a unit root (it is non-stationary). Within this test, to conclude that the series is stationary, it is necessary to check the given null hypothesis, given the significance of the regression coefficients.

Second, residual tests are very important for the evaluation of the criteria of agreement and determination of potential problems with the model. Residual tests in this paper include the research on residuals for autocorrelation with the use of techniques such as the Durbin–Watson test.

Third, the structural break test—to determine whether there are important changes or breaks in the data. Structural breaks can take place due to various factors, e.g., changes in policy, economic turmoil, or other external events. Ignoring the possibility of structural breaks may lead to incorrect results. In econometrics and statistics, a structural break is an unexpected change (in time) in the parameters of the regression models, which may lead to big errors in forecasting and to the unreliability of the model on the whole.

The Chow test, offered by the econometrist Gregory Chow (1960), is a verification of whether true coefficients are equal in two linear regressions at different sets of data. In econometrics, it is most often used in the analysis of a time series to check the presence of a structural break in the period that can be considered known a priori (e.g., a large historical event, such as a war). During the evaluation of a programme, the Chow test is often used to determine whether independent variables have different effects on different sub-groups of the population.

For models with linear regression, the Chow test is used to check the unit break of the mean for a given time period. This test evaluates whether the coefficients in the regression model are equal for different time periods (Davidson and MacKinnon 1993).

The null hypothesis of the Chow test states that there is no significant difference between the coefficients of the two regression models. Interpreting the results of the Chow test involves analysing the calculated F-statistic and comparing it with the critical value at a chosen significance level (usually 5% or 1%). If the F-statistic is greater than the critical value, it suggests that there is a significant difference in coefficients between the two regression models or subgroups being compared. This indicates the presence of a structural break or a significant difference in the relationships between variables over time or across subgroups.

It should be noted that the period of the sample (2017–2022) is rather large, which ensures the accuracy of the evaluation. This allows for effective use of the Chow test with the existing data. We compared regression coefficients for 2019 (pre-pandemic) and 2020 (during the COVID-19 crisis). The reliability of estimations obtained within this timeframe is ensured by a rather large number of observations in each sub-period—55 observations (54 degrees of freedom).

It should be also noted that the connection between cause and effect is not necessarily unidirectional. While changes in the causal variable directly influence changes in the effect variable, the connections are more complex and may include bidirectional or reverse dynamics. Acknowledging the limitations of a unidirectional perspective, for a better understanding of the cause-and-effect connection in the context of this research, we have additionally performed a correlation analysis—we calculated the coefficients of cross correlation, which also allows for performing a multicollinearity test of variables (avoiding their duplication in the econometric model).

These steps help with the concern raised about the potential bidirectional or feedback dynamics in real-world relationships. The bidirectional nature of the cause-and-effect relationship was studied with the help of correlation coefficients, which demonstrate the character (inhibiting each other with the negative sign of the correlation coefficient and catalysing each other with the positive sign of the correlation coefficient) and tightness (the closer the value of the correlation coefficient to 1, the tighter the connection) of the connection between the indicators.

Task 3 was set: to determine the potential of digital management of risks for companies under the conditions of a crisis of a non-economic nature via the example of the COVID-19 pandemic. It is solved with the help of the foresight method; it is used to insert in model (1) the maximum values of the digital management measures of risk management. Also, the method of trend analysis is used to evaluate the growth in the indicators' values.

Reliability of the empirical data is ensured due to the following: (1) a large number of observations (the full sample includes 330 observations and 229 degrees of freedom); (2) a long research period, which covers the pre-pandemic (2017–2019) and pandemic (2020–2022) periods (we studied six periods—calendar years); and (3) the use of methodology that, on the one hand, is rather complex for obtaining precise and reliable results and, on the other hand, is widely accessible for rechecking data.

4. Results

4.1. Risks for Companies during the COVID-19 Crisis: Specifics of Developed and Developing Countries

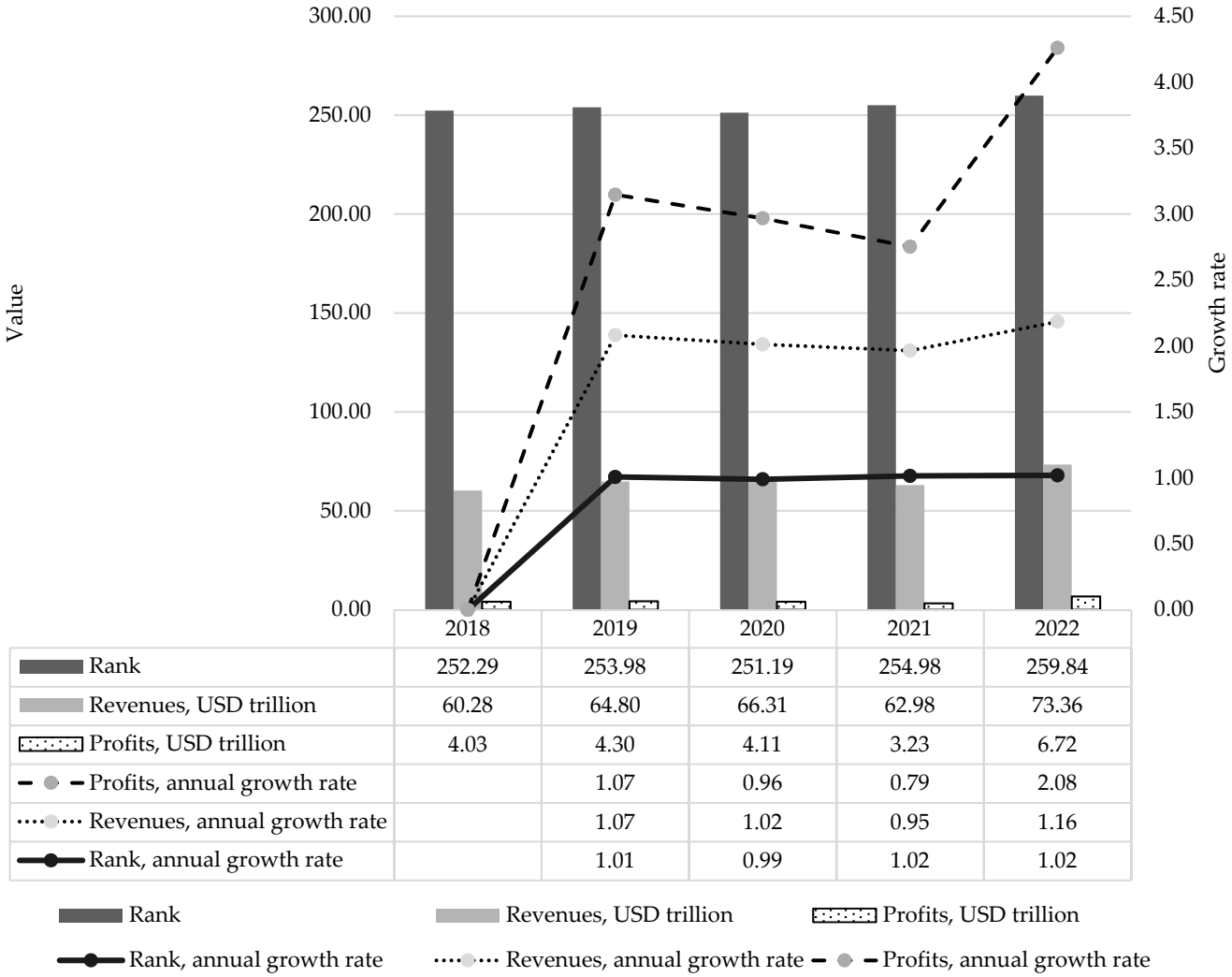
To solve the first task of this research and to measure the risks for companies during the COVID-19 crisis, as well as to identify the specifics of risks in developed and developing countries, we performed a horizontal analysis of the data in sample 1. The obtained results are presented in Figures 2 and 3.

As shown in Figure 2, the position (rank) of companies in developed countries listed in the Fortune (2023) ranking during the COVID-19 crisis (in 2020 compared with 2019) deteriorated (growth rate—0.99), while during the pre-crisis period, it was improving (growth rate in 2019 equalled 1.01). After the crisis, the growth in profits was restored: the growth rates in 2021 and 2022 equalled 1.02.

Similarly, the profits of these companies during the COVID-19 crisis (in 2020 compared with 2019) reduced (growth rate—0.96), while during the pre-crisis period, they were increasing (growth rate equalled 1.07 in 2019). The negative effect of the COVID-19 crisis was prolonged—the decline in companies' profits continued and even increased in 2021 (growth rate—0.79). However, in 2022, profits were restored (growth rate was 2.08). The obtained results demonstrate significant risks faced by companies in developed countries during the COVID-19 crisis. For comparison, let us consider the experience of developing countries (Figure 2).

As shown in Figure 3, companies' profits during the COVID-19 crisis (in 2020 compared with 2019) in developing countries did not change, and revenues grew (growth rate was 1.01), though the growth rate of revenues reduced compared with that of the pre-crisis period (growth rate was 1.09 in 2019). The position (rank) of listed companies from developing countries in the Fortune (2023) ranking during the COVID-19 crisis (in 2020 compared with 2019) improved significantly: the growth rate was 1.03. It should be

noted that before (0.99 in 2019) and after (0.95 in 2021 and 0.96 in 2022) the COVID-19 crisis, their rank was decreasing.

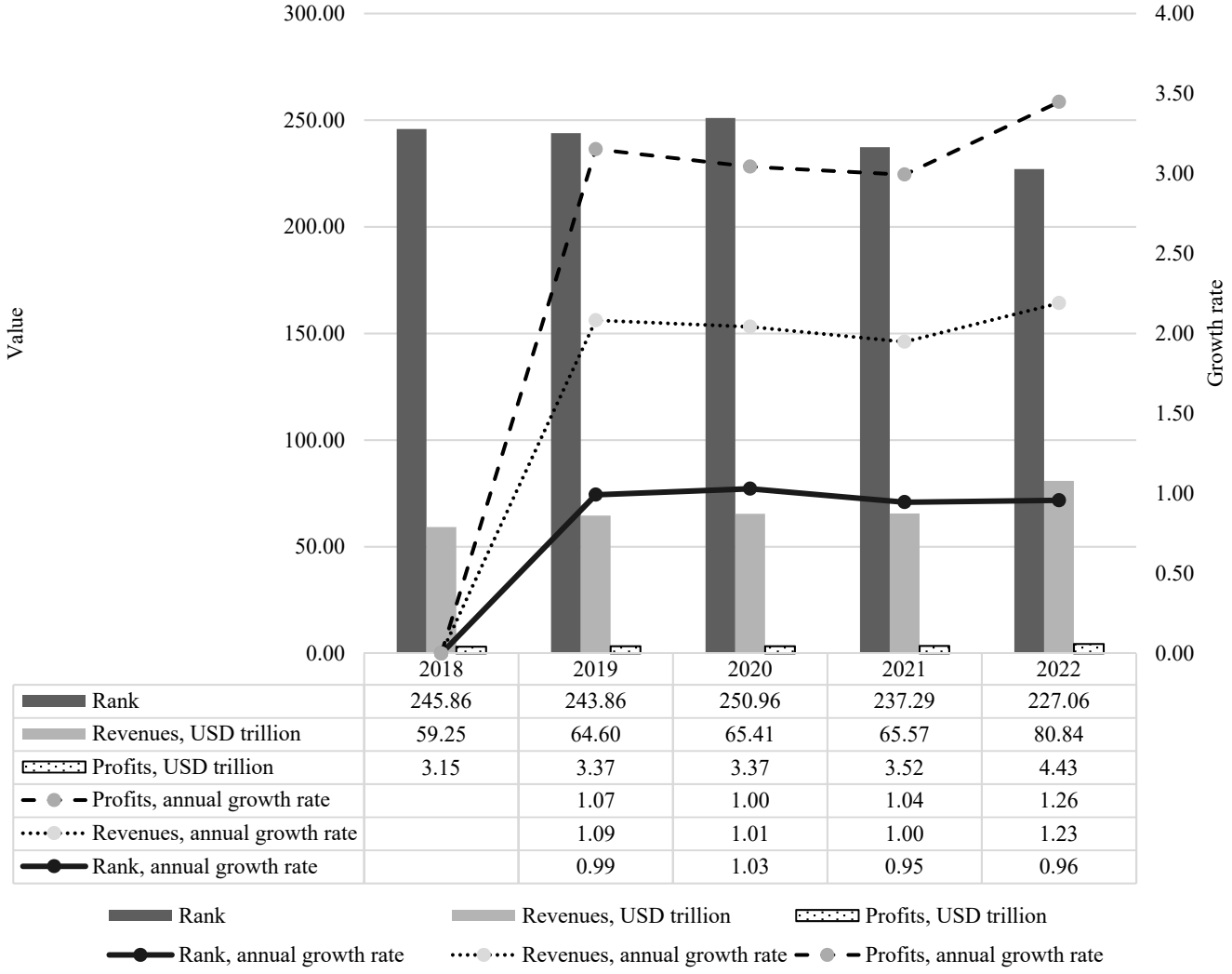


	2018	2019	2020	2021	2022
Rank	252.29	253.98	251.19	254.98	259.84
Revenues, USD trillion	60.28	64.80	66.31	62.98	73.36
Profits, USD trillion	4.03	4.30	4.11	3.23	6.72
Profits, annual growth rate		1.07	0.96	0.79	2.08
Revenues, annual growth rate		1.07	1.02	0.95	1.16
Rank, annual growth rate		1.01	0.99	1.02	1.02

Figure 2. Risks for companies in developed countries in 2019–2022. Source: authors.

This shows that companies in developing countries faced a much lower level of risk during the COVID-19 crisis than companies in developed countries. On the whole, the risk of companies from developing countries was minimal and even reduced during the COVID-19 crisis. To specify the reasons for this unique phenomenon, let us consider the results of the horizontal analysis of the data from sample 2 (Table 2).

The results presented in Table 2 show that the risks for companies, on the whole for the world in 2020, during the COVID-19 crisis remained unchanged at the 2019 level. Thus, the annual growth rate of listed domestic companies equalled 1.01 in 2019 and 2020, and it was even better compared with the pre-crisis period in 2018 (0.99). At that, the measures of protectionism remained at the pre-crisis level (growth rate in 2020: 1.00). The health infrastructure improved significantly during the COVID-19 crisis due to the ambitious measures of state regulation for the fight against the pandemic (growth rate in 2020 was 1.01), but this is not enough to reduce the risks for companies.



	2018	2019	2020	2021	2022
Rank	245.86	243.86	250.96	237.29	227.06
Revenues, USD trillion	59.25	64.60	65.41	65.57	80.84
Profits, USD trillion	3.15	3.37	3.37	3.52	4.43
Profits, annual growth rate		1.07	1.00	1.04	1.26
Revenues, annual growth rate		1.09	1.01	1.00	1.23
Rank, annual growth rate		0.99	1.03	0.95	0.96

Figure 3. Risks for companies in developing countries in 2019–2022. Source: authors.

Against this background, we should note the active implementation of the digital measures of risk management of companies. Thus, digital/technological skills grew by 1.01 in 2020 (compared with 1.00 in 2019 and 0.99 in 2018). The use of big data and analytics continued to grow with the pre-crisis rate: in 2019 and 2020, the growth rate equalled 1.03. The digital transformation in companies accelerated: the growth rate was 1.02 in 2020 against 0.94 in 2019 and 0.99 in 2018. Mobile broadband subscribers demonstrated visible growth (1.10), though it was lower compared with those at the pre-crisis level (1.14 in 2019).

The mentioned digital measures, which were actively implemented, could play a key role in the successful adaptation of companies to the conditions of the COVID-19 crisis and allow for avoiding high risks for companies. Among the economic implications of the COVID-19 crisis, we should mention the reduction in GDP (0.97 in 2020 vs. 1.01 in 2019), the substantial deepening of the government budget deficit (growth rate was 5.88 in 2020 vs. 1.36 in 2019) and the continuation of the successful fight against the shadow economy (growth rate of success in 2020 remained at the 2019 level and was assessed at 1.03).

Thus, an analysis of the experience of the top 55 most competitive digital economies of the world (IMD 2023) in 2017–2022 showed that the digital measures of risk management of companies were actively implemented during the COVID-19 crisis and could potentially have an important role for mitigating the economic implications of the crisis. To specify this, it is necessary to model—in more detail—the cause-and-effect relationships between the change and digital management of risks for companies during the COVID-19 crisis.

Table 2. Risks for companies in 2019–2022.

Year	Digital/Technological Skills	Use of Big Data and Analytics	Digital Transformation in Companies	Mobile Broadband Subscribers	Protectionism	Health Infrastructure	Listed Domestic Companies	Gross Domestic Product (GDP)	Tax Evasion	Exports of Goods—Growth	Government Budget Surplus/Deficit (%)
2017	6.96	4.90	5.99	46.09	5.81	5.67	720.04	1334.21	4.43	12.62	−1.55
2018	6.88	4.85	5.95	55.60	5.94	5.66	713.07	1421.45	4.51	11.83	−0.88
2019	6.87	5.00	5.58	63.21	5.76	5.67	722.93	1441.75	4.65	−2.93	−1.19
2020	6.95	5.15	5.70	69.80	5.78	5.91	727.16	1396.19	4.77	−7.66	−7.01
2021	6.84	5.05	5.68	76.06	5.44	5.92	-	1582.30	4.54	28.48	−4.13
2022	6.69	5.25	5.82	-	5.55	5.83	-	-	4.86	-	-
2018/2017	0.99	0.99	0.99	1.21	1.02	1.00	0.99	1.07	1.02	0.94	0.56
2019/2018	1.00	1.03	0.94	1.14	0.97	1.00	1.01	1.01	1.03	−0.25	1.36
2020/2019	1.01	1.03	1.02	1.10	1.00	1.04	1.01	0.97	1.03	2.61	5.88
2021/2020	0.98	0.98	1.00	1.09	0.94	1.00	-	1.13	0.95	−3.72	0.59
2022/2021	0.98	1.04	1.02	-	1.02	0.98	-	-	1.07	-	-

Source: Calculated and compiled by the authors.

4.2. Cause-and-Effect Relationships of the Change and Digital Management of Risks for Companies during the COVID-19 Crisis

To solve the second task and to identify the cause-and-effect relationships between the change and digital management of risks for companies during the COVID-19 crisis, we conducted a regression analysis of the data from sample 2. Based on the experience of the top 55 most competitive digital economies of the world (IMD 2023) in 2017–2022, we performed econometric modelling of the connection between listed domestic companies, and alternative measures of risk management and potential implications for the economy. This allowed for specifying research model (1) and receiving the following system of equations of linear regression:

$$\begin{cases} (1) RISK = -647.6480 - 21.1858 \times DGT_1 - 23.1690 \times DGT_2 + 287.6776 \times DGT_3 + 7.6846 \times DGT_4 - 196.7826 \times GOV_1 + 103.3040 \times GOV_2; \\ (2) ECON_1 = -1984.6080 + 386.1310 \times RISK + 993.0822 \times DGT_1 - 898.886 \times DGT_2 + 7.0497 \times DGT_3 + 12.1996 \times DGT_4 - 150.2545 \times GOV_1 + 1.8530 \times GOV_2; \\ (3) ECON_2 = -1.0557 - 0.1706 \times RISK + 0.2690 \times DGT_1 + 0.0961 \times DGT_2 + 0.0134 \times DGT_3 + 0.6611 \times DGT_4 + 0.1229 \times GOV_1 + 0.0001 \times GOV_2; \\ (4) GBD = -4.9940 + 0.3987 \times ECON_2; \\ (5) GOV_2 = -2.0686 + 0.6197 \times DGT_1 - 0.0785 \times DGT_2 + 0.3723 \times DGT_3 + 0.0284 \times DGT_4. \end{cases} \quad (2)$$

To ensure the correctness of the conclusions for econometric model (2), we used important steps in statistical analysis—including the F-test, stationarity test, the Augmented Dickey–Fuller test (ADF), and residuals analysis (Durbin–Watson test), as well as the Chow test (the unit break of the mean for a given time period)—to confirm the regression model and to evaluate its appropriateness. This guarantees the reliability and precision of analysis, providing a strong foundation for high-precision conclusions from the data.

The Dickey–Fuller test was performed for all variables: the regression of their values in period t and of their values in period t-1 was found (Figures A1–A10). The obtained results are reflected in the regression curves, which showed that the values of almost all regression coefficients are below 1, except for the following:

- Digital/technological skills (DGT_1) in 2021 compared with that in 2020;
- Digital transformation in companies (DGT_3) in 2019 compared with that in 2018;
- Protectionism (GOV_1) in 2019 compared with that in 2018;
- Health infrastructure (GOV_2) in 2018 compared with that in 2017;
- "listed domestic companies" (RISK) in 2019 compared with those in 2018 and in 2020 compared with in 2019.

Based on this, on the whole, the time rows of all studied variables can be characterised as stationary. This allows for disproving the null hypothesis of the Dickey–Fuller test (that the time series has a unit root, i.e., is non-stationary), based on the level of significance, and concluding that the series is stationary.

Econometric model (2) reflects four dependencies: first, the dependence of the risks for listed companies on the totality of digital management measures of risk management and alternative measures of state regulation, aimed at reducing the risk burden on business. Its characteristics are demonstrated in detail in Table 3.

Table 3. Regression dependence of risks for companies on the digital management measures of risk management and the measures of state regulation.

Regression statistics						
Multiple R	0.2830					
R-square	0.0801					
Adjusted R-square	0.0630					
Standard error	1195.5137					
Observations	330					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	6	40,180,810.2300	6,696,801.7050	4.6855	0.0001	
Residual	323	461,648,735.7215	1,429,253.0518			
Total	329	501,829,545.9515				
	Coefficients	*Standard error*	*t-Stat*	*p-Value*	*Lower 95%*	*Upper 95%*
Constant	−647.6480	530.7913	−1.2202	0.2233	−1691.8927	396.5967
DGT_1	−21.1858	101.3259	−0.2091	0.8345	−220.5278	178.1562
DGT_2	−23.1690	135.9699	−0.1704	0.8648	−290.6675	244.3295
DGT_3	287.6776	149.7063	1.9216	0.0555	−6.8449	582.2000
DGT_4	7.6846	3.3696	2.2806	0.0232	1.0555	14.3138
GOV_1	−196.7826	68.0364	−2.8923	0.0041	−330.6331	−62.9321
GOV_2	103.3040	48.6336	2.1241	0.0344	7.6254	198.9826
Chow test						
	Before the pandemic (2019)		During the pandemic (2020)			
	Coefficients	*p-Value*	*Coefficients*	*p-Value*		
Constant	−471.2037	0.7195	−803.4855	0.5851		
DGT_1	−23.7715	0.9273	93.8439	0.7575		
DGT_2	−190.0792	0.6732	−33.9622	0.9432		
DGT_3	365.7956	0.4432	77.4060	0.8743		
DGT_4	10.5258	0.3183	14.5071	0.1725		
GOV_1	−190.3167	0.2885	−151.6951	0.3714		
GOV_2	122.9987	0.3465	80.5655	0.5496		

Source: Calculated and compiled by the authors.

The results obtained in Table 3 show that the risks for listed companies are increased by 28.30%, determined via the implementation of the set of the considered management measures. The F-test was passed at the level of significance of 0.001. It should be noted that the protectionism measures do not reduce but only raise the risks for companies, which is confirmed via the negative value of the regression coefficient.

An increase in digital transformation in companies by one point leads to an improvement in the business indicators (e.g., reduction in risks) of the listed domestic companies by 287.6776. An increase in the number of mobile broadband subscribers by 1% leads to an improvement in the business indicators (e.g., reduction in risks) of the listed domestic companies by 7.6846. We should note the substantial effect of the development of healthcare infrastructure, for which a growth rate by one point leads to improvement in the business indicators (i.e., reduction in risks) of the listed domestic companies by 103.3040.

The residual test (Durbin–Watson test) was performed based on the data on residuals given in Table A1: d = 963863383.4683/461648735.7215 = 2.0879. Since the test statistics, 2.0879, did not exceed the critical value (at the level of significance of 0.01 at n = 330 and m(k) = 6), there is no correlation between the residuals, i.e., the residuals are independent. Therefore, the assumption was confirmed, and the Durbin–Watson test was successfully passed.

A structural break test (the Chow test) was performed in Table 4, with the values of the coefficients of the regression before the pandemic (in 2019) and under the conditions of the COVID-19 pandemic and crisis (in 2020).

Table 4. The Chow test for the resulting variable RISK.

Coefficients	Values of the Coefficients	
	Before the Pandemic (in 2019)	**During the COVID-19 Pandemic and Crisis (in 2020)**
Constant	−471.2037	−803.4855
DGT_1	−23.7715	93.8439
DGT_2	−190.0792	−33.9622
DGT_3	365.7956	77.4060
DGT_4	10.5258	14.5071
GOV_1	−190.3167	−151.6951
GOV_2	122.9987	80.5655
Level of significance (α)	0.01 (1%)	
F-table at the level of significance α	3.2036 At $k_1 = m = 6$; $k_2 = n - m - 1 = 55 - 6 - 1 = 48$	
F-observed	0.8011	0.7810

Source: authors.

As shown in Table 4, coefficients in the considered regression model are approximately equal for different time periods—the period before the pandemic (in 2019) and that during the COVID-19 pandemic and crisis (in 2020). This shows the absence of structural breaks.

The performed analysis of F-statistic and its comparison with the critical value (F-table = 3.2036) at the selected level of significance (α = 0.01, i.e., 1%) showed that the observed F-statistic is below the critical level (F-observed in 2019 was 0.8011, and that in 2020 was 0.7810). Therefore, there is no significant difference in the coefficients between two regression models or sub-groups that are compared. This is a sign of the absence of a structural break or insignificant difference in the ties between variables in time or sub-groups. Thus, we confirmed the null hypothesis of the Chow test on the absence of a significant difference between the coefficients of the two regression models.

Second is the dependence of GDP and tax evasion (in isolation) on the risks for listed companies and on the totality of the digital management measures of risk management and alternative measures of state regulation, aimed at reducing the risk burden on businesses. Its characteristics are demonstrated in detail in Tables 5–8.

Table 5. Regression dependence of GDP on the risks for companies, the digital management measures of risk management, and measures of state regulation.

Regression statistics						
Multiple R	0.6910					
R-square	0.4775					
Adjusted R-square	0.4661					
Standard error	2551.3779					
Observations	330					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	7	1,915,243,144.1090	273,606,163.4441	42.0316	6.746×10^{-42}	
Residual	322	2,096,068,391.9956	6,509,529.1677			
Total	329	4,011,311,536.1046				
	Coefficients	*Standard error*	*t-Stat*	*p-Value*	*Lower 95%*	*Upper 95%*
Constant	−1984.6080	1135.3836	−1.7480	0.0814	−4218.3147	249.0987
DGT_1	386.1310	216.2569	1.7855	0.0751	−39.3238	811.5859
DGT_2	993.0822	290.1901	3.4222	0.0007	422.1742	1563.9903
DGT_3	−898.8861	321.3132	−2.7975	0.0055	−1531.0245	−266.7478
DGT_4	7.0497	7.2489	0.9725	0.3315	−7.2115	21.3108
GOV_1	12.1996	147.0666	0.0830	0.9339	−277.1332	301.5324
GOV_2	−150.2545	104.5127	−1.4377	0.1515	−355.8683	55.3594
RISK	1.8530	0.1187	15.6051	0.0000	1.6194	2.0867
Chow test						
	Before the pandemic (2019)		During the pandemic (2020)			
	Coefficients	*p-Value*	*Coefficients*	*p-Value*		
Constant	−703.2492	0.7870	−2029.0648	0.5085		
DGT_1	287.4853	0.5782	411.8522	0.5152		
DGT_2	1898.4237	0.0380	1427.2338	0.1539		
DGT_3	−1878.5130	0.0523	−1447.6214	0.1587		
DGT_4	18.7260	0.3749	11.9684	0.5921		
GOV_1	−118.6725	0.7400	135.9525	0.7012		
GOV_2	−131.6089	0.6134	−243.5808	0.3866		
RISK	1.9450	0.00000002	1.7591	0.0000004		

Source: Calculated and compiled by the authors.

The results obtained in Table 4 show that GDP decreased by 69.10%, determined via the risks for listed companies and the implementation of the set of considered management measures. The F-test was passed at the level of significance of 0.001.

The residual test (Durbin–Watson test) was performed based on the data on residuals that are given in Table A1: 6746900467.5637/3681271967.3473 = 1.8328. Since the test statistics, 2.0879, did not exceed the critical value (at the level of significance of 0.01 at n = 330 and m(k) = 7), there is no correlation between the residuals, i.e., the residuals are independent. Therefore, the assumption is correct, and the Durbin–Watson test was successfully passed.

A structural break test (the Chow test) was performed in Table 6, where the values of the coefficients of regression before the pandemic (in 2019) and during the COVID-19 pandemic and crisis (in 2020) are shown.

As shown in Table 6, the coefficients in the considered regression model are approximately equal for different time periods—the period before the pandemic (in 2019) and under the conditions of the COVID-19 pandemic and crisis (in 2020). This is a sign of the absence of structural breaks.

Table 6. The Chow test for the resulting variable $ECON_1$.

Coefficients	Values of the Coefficients	
	Before the Pandemic (in 2019)	**During the COVID-19 Pandemic and Crisis (in 2020)**
Constant	−703.2492	−2029.0648
DGT_1	287.4853	411.8522
DGT_2	1898.4237	1427.2338
DGT_3	−1878.5130	−1447.6214
DGT_4	18.7260	11.9684
GOV_1	−118.6725	135.9525
GOV_2	−131.6089	−243.5808
RISK	1.9450	1.7591
Level of significance (α)	0.000001 (0.0001%)	
F-table at the level of significance α	8.5622 At $k_1 = m = 7$; $k_2 = n - m - 1 = 55 - 7 - 1 = 47$	
F-observed	7.9598	6.2082

Source: authors.

The performed analysis of F-statistic and its comparison with the critical value (F-table = 8.5622) at the selected level of significance (α = 0.000001, i.e., 0.0001%) showed that the observed F-statistic is below the critical level (F-observed in 2019 was 7.9598, and that in 2020 was 6.2082). Therefore, there is no significant difference in the coefficients between two regression models or sub-groups that are compared. This is a sign of the absence of a structural break or insignificant difference in the ties between variables in time or sub-groups. Thus, we confirmed the null hypothesis of the Chow test on the absence of a significant difference between the coefficients of the two regression models.

It is noteworthy that the development of healthcare infrastructure does not provide support for economic growth but, on the contrary, slows it down. An increase in digital/technological skills by one point leads to an increase in GDP of USD 386.1310 billion. An increase in the activity of the use of big data and analytics by one point leads to an increase in GDP by USD 993.0822 billion. An increase in the number of mobile broadband subscribers by 1% leads to an increase in GDP by USD 7.0497 billion. An improvement in business indicators (i.e., reduction in risks) of listed domestic companies by 1 leads to an increase in GDP by USD 1.8530 billion.

The results obtained in Table 7 show that the success of the fight against tax evasion (de-shadowing of the economy) improved by 78.78%, determined via the risks for listed companies and implementation of the set of considered management measures. The F-test was passed at the level of significance of 0.001. An increase in the activity of the use of big data and analytics by one point leads to an increase in the success of the fight against tax evasion (de-shadowing of the economy) by 0.2690 points.

The residual test (Durbin–Watson test) was performed based on the data on residuals that are given in Table A1: 735.8002/328.7042 = 2.2385. Since the test statistics 2.0879 did not exceed the critical value (at the level of significance of 0.01 at n = 330 and m(k) = 7), there is no correlation between residuals, i.e., the residuals are independent. Therefore, the assumption was confirmed, and the Durbin–Watson test was successfully passed.

A structural break test (the Chow test) was performed in Table 8, where the values of the coefficients of regression before the pandemic (in 2019) and during the COVID-19 pandemic and crisis (in 2020) are shown.

Table 7. Regression dependence of tax evasion on the risks for companies, digital management measures of risk management, and the measures of state regulation.

Regression statistics						
Multiple R	0.7878					
R-square	0.6206					
Adjusted R-square	0.6124					
Standard error	1.0104					
Observations	330					
ANOVA						
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	7	537.7296	76.8185	75.2517	5.292×10^{-64}	
Residual	322	328.7042	1.0208			
Total	329	866.4339				
	Coefficients	*Standard error*	*t-Stat*	*p-Value*	*Lower 95%*	*Upper 95%*
Constant	−1.5057	0.4496	−3.3489	0.0009	−2.3903	−0.6211
DGT_1	−0.1706	0.0856	−1.9917	0.0473	−0.3390	−0.0021
DGT_2	0.2690	0.1149	2.3407	0.0199	0.0429	0.4951
DGT_3	0.0961	0.1272	0.7550	0.4508	−0.1543	0.3464
DGT_4	0.0134	0.0029	4.6538	4.77×10^{-6}	0.0077	0.0190
GOV_1	0.6611	0.0582	11.3508	2.42×10^{-25}	0.5465	0.7756
GOV_2	0.1229	0.0414	2.9686	0.0032	0.0414	0.2043
RISK	0.0001	0.0000	1.3221	0.1871	0.0000	0.0002
Chow test						
	Before the pandemic (2019)		During the pandemic (2020)			
	Coefficients	*p-Value*	*Coefficients*	*p-Value*		
Constant	−1.5184	0.1420	−1.3761	0.2388		
DGT_1	−0.2966	0.1482	−0.1070	0.6548		
DGT_2	0.2019	0.5661	0.1564	0.6769		
DGT_3	0.3414	0.3618	0.0095	0.9804		
DGT_4	0.0169	0.0448	0.0183	0.0344		
GOV_1	0.6412	0.0000	0.7830	0.0000		
GOV_2	0.0845	0.4101	0.0291	0.7839		
RISK	0.0001	0.6040	0.0001	0.5248		

Source: Calculated and compiled by the authors.

According to Table 8, coefficients in the considered regression model are approximately equal for different time periods—the period before the pandemic (in 2019) and that during the COVID-19 pandemic and crisis (in 2020). This is a sign of the absence of structural breaks.

The performed analysis of F-statistic and its comparison with the critical value (F-table = 16.4298) at the selected level of significance (α = 0.0000000001, i.e., 0.00000001%) showed that the observed F-statistic is below the critical level (F-observed in 2019 was 14.2800, and that in 2020 was 14.3165). Therefore, there is no significant difference in the coefficients between the two regression models or sub-groups that are compared. This is a sign of the absence of a structural break or insignificant difference in the ties between variables in time or sub-groups. Thus, we confirmed the null hypothesis of the Chow test on the absence of a significant difference between the coefficients of the two regression models.

An increase in the level of digital transformation in companies by one point leads to an increase in the success of the fight against tax evasion (de-shadowing of the economy) by 0.0961 points. An increase in the number of mobile broadband subscribers by 1% leads to an increase in the success of the fight against tax evasion (de-shadowing of the economy) by 0.0134 points. An increase in the measures of protectionism by one point leads to an

increase in the success of the fight against tax evasion (de-shadowing of the economy) by 0.661 points.

Table 8. The Chow test for the resulting variable $ECON_2$.

Coefficients	Values of the Coefficients	
	Before the Pandemic (in 2019)	**During the COVID-19 Pandemic and Crisis (in 2020)**
Constant	−1.5184	−1.3761
DGT_1	−0.2966	−0.1070
DGT_2	0.2019	0.1564
DGT_3	0.3414	0.0095
DGT_4	0.0169	0.0183
GOV_1	0.6412	0.7830
GOV_2	0.0845	0.0291
RISK	0.0001	0.0001
Level of significance (α)	0.0000000001 (0.00000001%)	
F-table at the level of significance α	16.4298 At $k_1 = m = 7$; $k_2 = n - m - 1 = 55 - 7 - 1 = 47$	
F-observed	14.2800	14.3165

Source: authors.

An increase in the development of the healthcare infrastructure by one point leads to an increase in the success of the fight against tax evasion (de-shadowing of the economy) by 0.1229 points. Improvement in business indicators (i.e., reduction in risks) of listed domestic companies by one leads to an increase in the success of the fight against tax evasion (de-shadowing of the economy) by 0.0001 points. Third is the dependence of the government budget deficit on tax evasion. Its characteristics are demonstrated in detail in Table 9.

The results obtained in Table 9 show that the state budget surplus increased by 17.32%, determined via the success of the fight against tax evasion (de-shadowing of the economy). The F-test was passed at the level of significance of 0.005.

The residual test (the Durbin–Watson test) was performed based on the data on residuals that are given in Table A1: 5182.6456/4452.1147 = 1.1641. Since the test statistics, 2.0879, did not exceed the critical value (at the level of significance of 0.01 at n = 330 and m(k) = 1), there is no correlation between the residuals, i.e., the residuals are independent. Therefore, the assumption is confirmed, and the Durbin–Watson test was successfully passed.

A structural break test (the Chow test) was performed in Table 10, where the values of the regression coefficients are shown for before the pandemic (in 2019) and during the COVID-19 pandemic and crisis (in 2020).

As shown in Table 10, the coefficients in the considered regression model are approximately equal for different time periods—the period before the pandemic (in 2019) and that during the COVID-19 pandemic and crisis (in 2020). This is a sign of the absence of structural breaks.

The performed analysis of F-statistic and its comparison with the critical value (F-table = 7.1386) at the selected level of significance (α = 0.01, i.e., 1%) showed that the observed F-statistic is below the critical level (F-observed in 2019 was 4.7260, and that in 2020 was 0.8955). Therefore, there is no significant difference in the coefficients between the two regression models or sub-groups that are compared. This is a sign of the absence of a structural break or insignificant difference in the ties between variables in time or sub-groups. Thus, we confirmed the null hypothesis of the Chow test on the absence of a significant difference between the coefficients of two regression models.

Table 9. Regression dependence of the government budget deficit on tax evasion.

Regression statistics						
Multiple R	0.1732					
R-square	0.0300					
Adjusted R-square	0.0270					
Standard error	3.6842					
Observations	330					
	ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*	
Regression	1	137.7124	137.7124	10.1457	0.0016	
Residual	328	4452.1147	13.5735			
Total	329	4589.8272				
	Coefficients	*Standard error*	*t-Stat*	*p-Value*	*Lower 95%*	*Upper 95%*
Constant	−4.9940	0.6135	−8.1404	8.3×10^{-15}	−6.2009	−3.7872
GOV_2	0.3987	0.1252	3.1852	0.0016	0.1524	0.6449
Chow test						
	Before the pandemic (2019)		During the pandemic (2020)			
	Coefficients	*p-Value*	*Coefficients*	*p-Value*		
Constant	−3.4038	0.0026	−8.2518	0.0000002		
GOV_2	0.4759	0.0342	0.2598	0.3483		

Source: Calculated and compiled by the authors.

Table 10. The Chow test for the resulting variable GBD.

Coefficients	**Values of the Coefficients**	
	Before the Pandemic (in 2019)	**During the COVID-19 Pandemic and Crisis (in 2020)**
Constant	−3.4038	−8.2518
GOV_2	0.4759	0.2598
Level of significance (α)	0.01 (1%)	
F-table at the level of significance α	7.1386 At $k_1 = m = 1$; $k_2 = n - m - 1 = 55 - 1 - 1 = 53$	
F-observed	4.7260	0.8955

Source: authors.

An increase in the success of the fight against tax evasion (de-shadowing of the economy) by one point leads to an increase in the state budget surplus by 0.3987%—i.e., budget deficit decreases. Fourth is the dependence of the health infrastructure on the totality of the digital management measures of risk management. Its characteristics are demonstrated in detail in Table 11.

The results obtained in Table 11 show that the development of the health infrastructure increased by 56.09%, determined via the totality of the digital management measures of risk management. The F-test was passed at the level of significance of 0.001.

A structural break test (the Chow test) was performed in Table 12, where the values of the regression coefficients are shown before the pandemic (in 2019) and during the COVID-19 pandemic and crisis (in 2020).

As shown in Table 12, the coefficients in the considered regression model are approximately equal for different time periods—the period before the pandemic (in 2019) and that during the COVID-19 pandemic and crisis (in 2020). This is a sign of the absence of structural breaks.

Table 11. Regression dependence of the health infrastructure on the totality of the digital management measures of risk management.

Regression statistics						
Multiple R	0.5609					
R-square	0.3146					
Adjusted R-square	0.3062					
Standard error	1.6555					
Observations	330					
ANOVA						
	df	SS	MS	F	Significance F	
Regression	4	408.8924	102.2231	37.2994	1.134×10^{-25}	
Residual	325	890.6983	2.7406			
Total	329	1299.5907				
	Coefficients	*Standard error*	*t-Stat*	*p-Value*	*Lower 95%*	*Upper 95%*
Constant	−2.0686	0.7154	−2.8916	0.0041	−3.4760	−0.6612
DGT_1	0.6197	0.1354	4.5758	6.76×10^{-6}	0.3533	0.8861
DGT_2	−0.0785	0.1882	−0.4170	0.6769	−0.4488	0.2918
DGT_3	0.3723	0.2047	1.8189	0.0699	−0.0304	0.7751
DGT_4	0.0284	0.0044	6.5004	3.01×10^{-10}	0.0198	0.0369
Chow test						
	Before the pandemic (2019)		During the pandemic (2020)			
	Coefficients	*p-Value*	*Coefficients*	*p-Value*		
Constant	−1.5917	0.3690	−2.0232	0.2983		
DGT_1	0.5591	0.1195	0.7792	0.0553		
DGT_2	0.3510	0.5722	−0.4699	0.4683		
DGT_3	−0.1369	0.8367	0.5107	0.4419		
DGT_4	0.0384	0.0064	0.0290	0.0386		

Source: Calculated and compiled by the authors.

Table 12. The Chow test for the resulting variable GOV_2.

Coefficients	**Values of the Coefficients**	
	Before the Pandemic (in 2019)	**During the COVID-19 Pandemic and Crisis (in 2020)**
Constant	−1.5917	−2.0232
DGT_1	0.5591	0.7792
DGT_2	0.3510	−0.4699
DGT_3	−0.1369	0.5107
DGT_4	0.0384	0.0290
Level of significance (α)	0.0001 (0.01%)	
F-table at the level of significance α	7.3301 At $k_1 = m = 1$; $k_2 = n - m - 1 = 55 - 1 - 1 = 53$	
F-observed	5.7474	5.2092

Source: authors.

The performed analysis of F-statistic and its comparison with the critical value (F-table = 7.3301) at the selected level of significance (α = 0.0001, i.e., 0.01%) showed that the observed F-statistic is below the critical level (F-observed in 2019 was 5.7474, and that in 2020 was 5.2092). Therefore, there is no significant difference in the coefficients between the two regression models or sub-groups that are compared. This is a sign of the absence of a structural break or insignificant difference in the ties between variables in time or

sub-groups. Thus, we confirmed the null hypothesis of the Chow test on the absence of a significant difference between the coefficients of the two regression models.

An increase in the development of digital/technological skills by one point leads to an increase in the level of the development of health infrastructure by 0.6197 points. Growth in the level of digital transformation in companies by one point leads to a growth in the level of the development of health infrastructure by 0.3723 points. Growth in the coverage of mobile broadband subscribers by 1% leads to an increase in the level of the development of health infrastructure by 0.0284 points.

The reliability of econometric model (2) is confirmed via the successfully passed F-test, the Augmented Dickey–Fuller test, the Durbin–Watson test, and the Chow test for all regression equations. The performed tests proved the regression model and confirmed its expedience, guaranteeing the reliability and precision of the analysis.

For a better understanding of the cause-and-effect relationships in the context of this research, we performed a correlation analysis, calculating the coefficients of cross-correlation (Table 13).

Table 13. Coefficients of cross correlation.

Correlation	DGT_1	DGT_2	DGT_3	DGT_4	GOV_1	GOV_2	RISK	$ECON_1$	$ECON_2$	GBD
DGT_1	1.00	0.62	0.68	0.25	0.46	0.46	0.12	0.16	0.40	0.19
DGT_2	0.62	1.00	0.82	0.29	0.38	0.37	0.16	0.22	0.45	0.04
DGT_3	0.68	0.82	1.00	0.19	0.44	0.39	0.17	0.14	0.45	0.20
DGT_4	0.25	0.29	0.19	1.00	0.21	0.41	0.19	0.19	0.39	−0.12
GOV_1	0.46	0.38	0.44	0.21	1.00	0.66	0.00	0.00	0.72	0.24
GOV_2	0.46	0.37	0.39	0.41	0.66	1.00	0.14	0.08	0.63	0.18
RISK	0.12	0.16	0.17	0.19	0.00	0.14	1.00	0.67	0.12	−0.31
$ECON_1$	0.16	0.22	0.14	0.19	0.00	0.08	0.67	1.00	0.16	−0.27
$ECON_2$	−0.04	0.05	0.09	0.11	−0.09	−0.03	−0.03	−0.02	1.00	0.16
GBD	0.19	0.04	0.20	−0.12	0.24	0.18	−0.31	−0.27	0.17	1.00

Source: authors.

The correlation analysis (Table 13) allowed for performing a test on the multicollinearity of variables, which has been successfully passed—the duplicating variables are absent in econometric model (2). Based on the results from Table 1, the bidirectional nature of the cause-and-effect relationship of the studied indicators is determined.

Digital/technological skills (DGT_1) demonstrated the closest bidirectional connection and catalytic effect with digital transformation in companies (DGT_3, correlation: 0.68) and with the use of big data and analytics (DGT_2, correlation: 0.62). This could be explained via the growth in demand for digital personnel in the labour market in the course of the development of digital business and the corresponding expansion of opportunities for the digitalisation of business in the course of an increase in its provision with the necessary digital personnel.

Also, we revealed a rather close bidirectional relationship with protectionism (GOV_1, correlation: 0.46): digital personnel support import substitution. Protectionism, in turn, raises the demand for digital personnel as a production factor of digital business. The revealed close bidirectional relationship with health infrastructure (GOV_2, correlation: 0.46) shows that the development of digital healthcare based on the telecommunication infrastructure motivates employees and consumers to master digital skills, and better mastering of these skills, in its turn, expands on opportunities for the development of digital healthcare.

We also revealed a weak negative connection (inhibiting effect) with tax evasion ($ECON_2$, correlation: −0.04). It could be explained by the fact that the shadow economy reduces the motivation of employees in mastering digital skills due to the impossibility to obtain returns on investments into training. At that, the development of digital skills increases the sellers' power in the labour market and allows employees to influence em-

ployers, requiring social guarantees and fighting the shadow economy, i.e., overcoming tax evasion.

The use of big data and analytics (DGT_2) demonstrated the closest bidirectional connection and catalytic effect with digital transformation in companies (DGT_3, correlation: 0.82). This means that the higher the level of digitalisation, the more actively big data and analytics are used, which causes further digital development, which takes place in a cyclical manner.

Digital transformation in companies (DGT_3) demonstrated the closest bidirectional connection and catalytic effect with protectionism (GOV_1, correlation: 0.44) and health infrastructure (GOV_2, correlation: 0.39), which is largely predetermined by the pandemic and crisis context. Thus, digitalisation supports import substitution due to the growth of digital competitiveness of domestic businesses and allows for developing digital healthcare. Accordingly, protectionism and digital healthcare (including the fight against COVID-19 during the pandemic) support the digitalisation of businesses.

Mobile broadband subscribers (DGT_4) demonstrated the closest bidirectional connection and catalytic effect with health infrastructure (GOV_2, correlation: 0.41). Thus, mobile communication facilitates the development of telemedicine, while digital healthcare stimulates consumers to more actively use mobile communications for the use of telemedicine services.

At that, we revealed a weak negative connection (inhibiting effect) with government budget surplus/deficit (GBD, correlation: -0.12). It can be explained by the fact that a budget deficit hinders investments in the development of mobile communications and reduces its accessibility. In turn, the development of mobile communications and an increase in the activities of their use raise economic activity (support economic growth and increase the taxation base), facilitate the development of digital finance, and contribute to the fight against the shadow economy.

Protectionism (GOV_1) demonstrated the closest bidirectional connection and catalytic effect with health infrastructure (GOV_2, 0.66). This means that protectionism was implemented and, at the same time, the healthcare infrastructure was developed, for the fight against the COVID-19 crisis. A developed healthcare infrastructure supports import substitution. Protectionism allows for starting import substitution in healthcare and developing its infrastructure. At that, there is a weak negative connection (inhibiting effect) with tax evasion ($ECON_2$, correlation: -0.09). It can be explained by the fact that the shadow economy hinders import substitution, and import substitution facilitates the fight against the shadow economy.

Health infrastructure (GOV_2) demonstrated a weak negative connection (inhibiting effect) with tax evasion ($ECON_2$, correlation: -0.03). It can be explained by the fact that the shadow economy causes a deficit in revenues of the state budget, reducing the effectiveness of institutes and thus hindering the financing of the development of healthcare infrastructure. Under the conditions of the COVID-19 pandemic and crisis, the development of healthcare infrastructure ensured the fight against the shadow economy.

The listed domestic companies (RISK) demonstrated a weak negative connection (inhibiting effect) with tax evasion ($ECON_2$, correlation: -0.03) and government budget surplus/deficit (GBD, correlation: -0.31). It can be explained by the fact that overcoming the shadow economy reduces business risks. A reduction in business risks eliminates the necessity for the shadow economy and facilitates its overcoming.

Gross domestic product, GDP ($ECON_1$), demonstrated a weak negative connection (inhibiting effect) with tax evasion ($ECON_2$, correlation: -0.02) and government budget surplus/deficit (GBD, correlation: -0.27). It can be explained by the fact that the shadow economy reduces the official GDP, decreases the tax base, and causes a budget deficit. Accordingly, overcoming the shadow economy causes a reverse process: an increase in the official GDP, growth in the tax base, and growth in the state budget revenues.

These steps address the concern raised about the potential bidirectional or feedback dynamics in real-world relationships. The bidirectional nature of the cause-and-effect

relationship was studied with the help of correlation coefficients, which demonstrate the character (inhibiting each other with the negative sign of the correlation coefficient and catalysing each other with the positive sign of the correlation coefficient) and tightness (the closer the value of the correlation coefficient to 1, the tighter the connection) of the connection between the indicators.

The cause-and-effect relationships are systemically shown in the model of structural equations (SEM) in Figure 4.

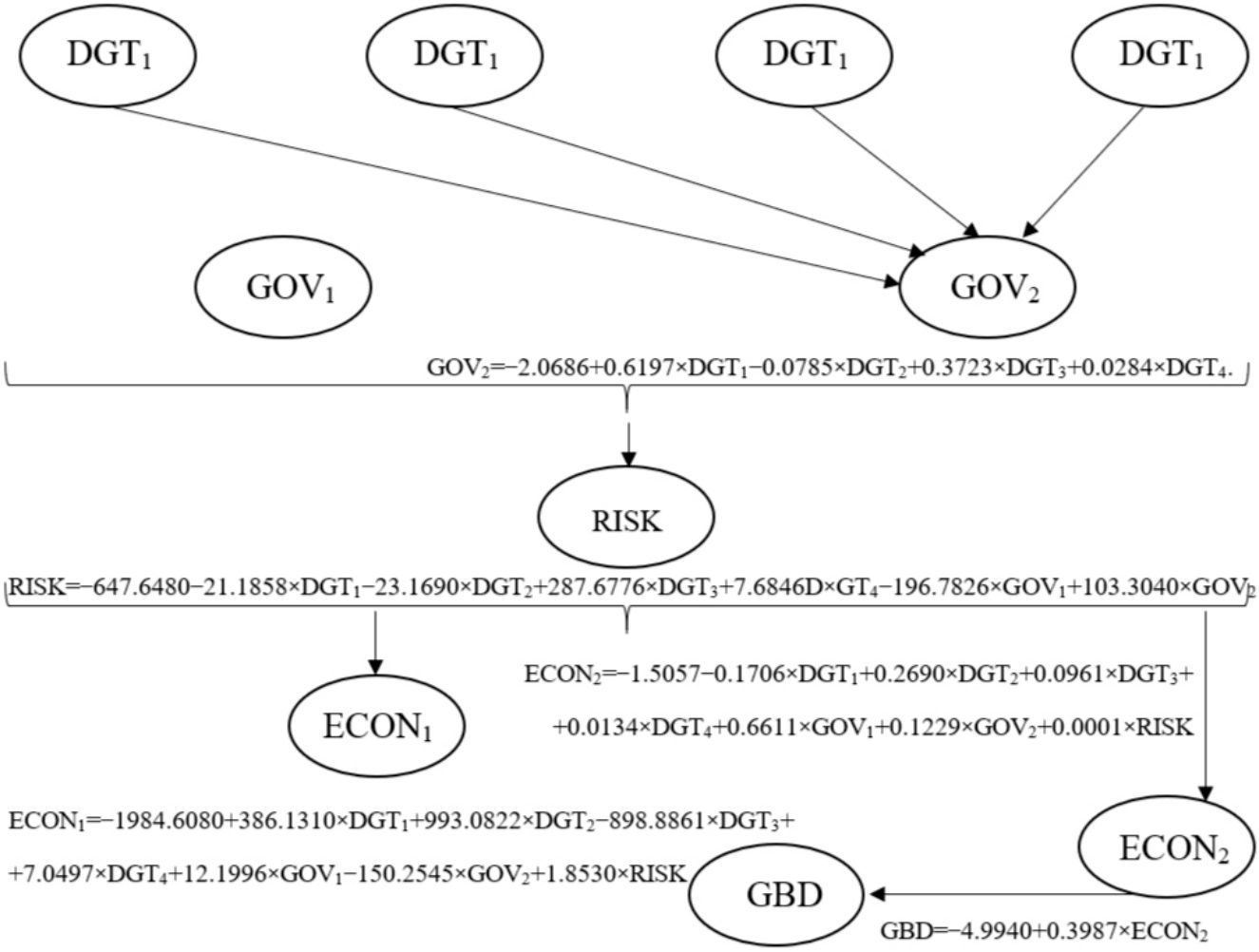


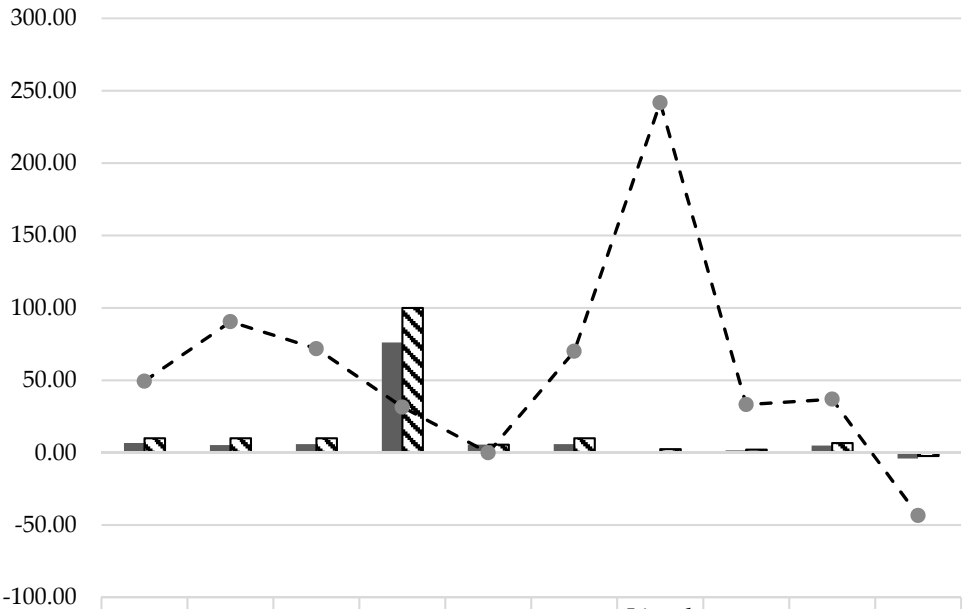
Figure 4. Model of structural equations (SEM). Source: authors.

Thus, the obtained results showed that the totality of the digital management measures of risk management makes a significant contribution not only to the improvement in business indicators (reduction in risks) of listed companies but also to the development of healthcare infrastructure and the fight against tax evasion (de-shadowing of the economy).

Moreover, the digital measures of risk management play a much more important role in the reduction in the risks for companies than alternative measures of state regulation, aimed at reducing the risk burden on business (protectionism and the development of healthcare infrastructure). A reduction in risks for companies supports economic growth (ensuring an increase in GDP) and improves the results of the fight against tax evasion (de-shadowing of the economy), thus reducing the state budget deficit.

4.3. Potential of Digital Management of Risks for Companies under the Conditions of a Crisis of a Non-Economic Nature via the Example of the COVID-19 Pandemic

To solve the third task and to determine the potential of digital management of risks for companies under the conditions of a crisis of a non-economic nature via the example of the COVID-19 pandemic, we used the method of foresight and inserted into econometric model (2) the maximal values of the digital management measures of risk management. With the help of the method of trend analysis, we assessed the growth rate of the indicators' values (Figure 5).



	Digital /Technological skills	Use of big data and analytics	Digital transformation in companies	Mobile Broadband subscribers	Protectionism	Health infrastructure	Listed domestic companies, тыс. шт.	GDP, USD trillion	Tax evasion	Government budget surplus/deficit (%)
Factual value in 2022 (world average)	6.69	5.25	5.82	76.06	5.55	5.83	0.73	1.58	4.86	−4.13
Value by foresight	10.00	10.00	10.00	100.00	5.55	9.90	2.48	2.11	6.66	−2.34
Growth rate (trend) of the value by foresight, %	49.40	90.46	71.84	31.48	0.00	70.01	241.72	33.22	36.95	−43.40

Figure 5. The potential of the digital management of risks for companies under the conditions of a crisis of a non-economic nature via the example of the COVID-19 pandemic. Source: authors' foresight.

Following the authors' foresight (Figure 5), to fully unlock the potential of digital management of risks for companies under the conditions of a crisis of non-economic nature via the example of the COVID-19 pandemic, it is recommended that a set of measures be implemented: increase digital/technological skills by 49.40%, increase the activity of the use of big data and analytics by 90.46%, raise the level of digital transformation in companies by 74.84%, and increase the coverage of mobile broadband subscribers by 31.48%.

Due to this, the business indicators of the listed domestic companies will grow, and their risks will reduce by 241.72% (their number grows from 0.73 thousand in 2022 to 2.48 thousand). Also, the development of health infrastructure by 70.01% (from 5.83 points in 2022 to 9.90 points) is achieved. Following the authors' foresight, the implementation

of digital measures of risk management of companies ensures the following advantages for the economy: an increase in GDP by 33.22% (from USD 1.58 trillion in 2022 to USD 2.11 trillion), improvement in the results of the fight against tax evasion (de-shadowing of the economy) by 36.95% (from 4.86 points in 2022 to 6.66 points), and reduction in the budget deficit by 43.40% (from −4.13% of GDP in 2022 to −2.34% of GDP).

5. Discussion

This paper's contribution to the literature consists of the development of scientific provisions of the concept of risks for companies through a clarification of the specifics of risks and risk management of companies during the COVID-19 crisis. Due to this, this paper filled the literature gap and provided answers to all posed RQs, which are given—in comparison with the existing literature—in Table 14.

Table 14. Obtained answers to the posed RQs compared with those in the existing literature.

Research Questions (RQs)	Answers in the Existing Literature	New Answers that Were Received in This Paper
RQ_1: What is the level of risks for companies during the COVID-19 crisis (in 2020): higher or lower than the pre-crisis level (2019)?	Risks for companies were very high during the COVID-19 crisis (Moreno Ramírez et al. 2022; Tan et al. 2022; Zhou and Li 2022)	Risks for companies during the COVID-19 crisis increased slightly compared with those at the pre-crisis level
RQ_2: Which countries experienced the highest risks for companies during the COVID-19 crisis: developed or developing nations?	Companies faced large risks during the COVID-19 crisis in developing countries (Abdullah et al. 2022; Dohale et al. 2023)	Companies faced large risks during the COVID-19 crisis in developed countries
RQ_3: What are the consequences of risks for companies during the COVID-19 crisis for the economy: increase or reduction in crisis phenomena in the economy?	Due to the unpreparedness of companies for the COVID-19 crisis, the risks for them increased the economic decline (Mezghani et al. 2021; Yamen 2021)	Due to successful adaptation, the risk management of companies mitigated manifestations of the COVID-19 crisis in the economy
RQ_4: How (and with what measures) can we manage risks under the conditions of a crisis of a non-economic nature given the experience of the COVID-19 crisis: measures of state or corporate management?	To reduce the risk burden on business during the COVID-19 crisis, there is a need for external (state) management with the help of standard measures of protectionism (Phang et al. 2023; Salami et al. 2022; Velayutham et al. 2021) and special measures of the development of healthcare infrastructure (Abdel Fattah et al. 2022)	Companies managed—independently and successfully (internal corporate management)—their risks during the COVID-19 crisis with the help of measures of the digitalisation of businesses

Source: authors.

As shown in Table 14, first, a new answer to RQ_1 was obtained. Unlike Moreno Moreno Ramírez et al. (2022), Tan et al. (2022), and Zhou and Li (2022), it was substantiated that the risks for companies during the COVID-19 crisis increased only slightly (not much) compared with those at the pre-crisis level. Hypothesis H_1 was proved, confirming the work of Hohenstein (2022) and Tingey-Holyoak and Pisaniello (2021).

Second, a new answer to RQ_2 was obtain. Unlike Abdullah et al. (2022) and Dohale et al. (2023), it was substantiated that companies faced large risks during the COVID-19 crisis, not in developing countries but in developed countries. Hypothesis H_2 was proved, confirming the work of Kukoyi et al. (2022) and Metwally and Diab (2023)

Third, a new answer to RQ_3 was obtain. Unlike Mezghani et al. (2021) and Yamen (2021), it was substantiated that the risks for companies did not increase the economic decline, but on the contrary, due to successful adaptation, risk management of companies mitigated the manifestations of the COVID-19 crisis in the economy. Hypothesis H_3 was proved, confirming the work of Inshakova et al. (2021), Leung et al. (2023), and Ngo et al. (2023).

Fourth, a new answer to RQ_4 was received. Unlike Abdel Abdel Fattah et al. (2022), Phang et al. (2023), Salami et al. (2022), and Velayutham et al. (2021), it was substantiated that companies managed their risks independently and much more successfully during the COVID-19 crisis with the help of measures of the digitalisation of businesses. That is, internal corporate management is preferable to external (state) management with the help of standard measures of protectionism and special measures of the development of healthcare infrastructure to reduce the risk burden for businesses during the COVID-19 crisis. Hypothesis H_4 was proved, confirming the work of Attaran (2023), Busco et al. (2023), Cui et al. (2022), and Türk (2022).

6. Conclusions

Thus, as a result of the performed research, a systemic risk profile of companies during the COVID-19 crisis was formed; it reflects their cause-and-effect relationships and risk management. In particular, the following results were received. First, via the example of companies from "Global-500", it was discovered that companies in developing countries faced a much lower level of risk during the COVID-19 crisis than companies in developed countries.

Thus, we determined the significant risks faced by companies in developed countries during the COVID-19 crisis: the position (rank) of companies listed in the Fortune (2023) ranking during the COVID-19 crisis deteriorated (growth rate: 0.99), and the profits of these companies reduced (growth rate: 0.96). Unlike them, in developing countries, the profits of companies during the COVID-19 crisis (in 2020 compared with 2019) did not change, and their revenues grew (growth rate: 1.01), and the position (rank) of companies listed in the ranking of Fortune (2023) improved significantly (growth rate: 1.03).

Second, based on the experience of the top 55 most competitive digital economies of the world (IMD 2023) in 2017–2022, we compiled an econometric model, which disclosed the cause-and-effect relationships of the change in and digital management of risks for companies during the COVID-19 crisis. The model showed that, due to successful adaptation, risk management of companies mitigated the manifestations of the COVID-19 crisis in the economy.

Thus, digital measures of risk management improve the business indicators (reduce risks) for listed companies, facilitate the development of healthcare infrastructure and support the fight against tax evasion (de-shadowing of the economy). A reduction in the risks for companies supports economic growth (ensures an increase in GDP) and improves the results of the fight against tax evasion (de-shadowing of the economy), thus reducing the state budget deficit.

Third, it was proved that digital measures of risk management play a much more important role in the reduction in risks for companies than alternative measures of state regulation, aimed at reducing the risk burden for business (protectionism and the development of healthcare infrastructure). The key conclusion of this research is that, under the conditions of a crisis of a non-economic nature (e.g., the COVID-19 crisis), companies manage—independently and successfully—their risks with the help of measures of the digitalisation of businesses—i.e., internal corporate risk management with limited state intervention is preferable.

The theoretical significance lies in the fact that the authors' conclusions rethought the risks for companies under the conditions of a crisis given the special context of a crisis of non-economic nature (via the example of the COVID-19 crisis). Unlike a crisis of an economic nature (e.g., the 2008 global financial and economic crisis), crises of an economic nature (e.g., the COVID-19 crisis in 2020) (1) cause less vivid risks for companies; (2) cause larger risks for companies in developed countries, creating opportunities for improvement in the business indicators of companies in developing countries; (3) require the management of risks at the level of companies, not at the level of the state; and (4) cause a preference for digital risk management.

The practical significance of the authors' results is that the developed novel approach to risk management of companies during the COVID-19 crisis, which is based on digitalisation, allows, with high effectiveness, for managing the risks of companies during a crisis of a non-economic nature. For this, a set of digital management measures of risk management was proposed, which include an increase in digital/technological skills, an increase in the activity of the use of big data and analytics, growth in the level of digital transformation in companies, and an increase in the coverage of mobile broadband subscribers.

The managerial significance of the authors' recommendations is connected to the fact that, under the conditions of future crises of a non-economic nature (caused by reasons related to epidemics/pandemics and environmental disasters), they will allow for improving business indicators of listed domestic companies and reducing risks down to 241.72% (as the authors' foresight showed).

The proposed recommendations' economic policy implications are that their implementation by companies during future crises of a non-economic nature will ensure advantages for the economy in the form of the development of health infrastructure up to 70.01%, an increase in GDP up to 33.22%, improvement in the results of the fight against tax evasion (de-shadowing of the economy) up to 36.95%, and a reduction in budget deficit down to 43.40% (as the authors' foresight showed).

As for the limitations of the performed research, it should be noted that it is based on the unique experience of the COVID-19 crisis, unparalleled in the 21st century, which does not allow for generalisation of the results obtained and for their application to all crises of a non-economic nature. This is a limitation of the authors' conclusions; to overcome it, future studies should elaborate on the experience of future crises of a non-economic nature (caused by reasons connected to epidemics/pandemics and environmental disasters) and should identify common regularities of the risks for companies under the conditions of all crises of the non-economic nature.

Summing up, it is necessary to point to weaknesses of the research design and approach, which are connected with the predominant consideration of economic reasons and consequences of the risks of companies during the COVID-19 crisis with a focus on the digital economy. At that, non-economic aspects belong to an error of the compiled econometric model and remained beyond the limits of this research. Thus, prospects for future studies lie in the elaboration on these non-economic aspects.

In particular, attention should be paid to socio-psychological and cultural aspects, which are connected to social distancing and social isolation during the lockdown. They could have played an important role in the practical implementation of risks of companies during the COVID-19 crisis. It is recommended that they be studied in future work as a continuation of this paper.

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Appendix A

Table A1. Residuals.

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
1	437.1073	−341.1073	791.6584	−148.0301	2.7052	−0.5473	−4.1337	−2.5596	3.7562	0.6122
2	486.1902	1526.8098	674.6055	706.7617	5.9143	−0.6024	−2.8763	0.9344	5.4648	1.7526
3	778.1272	−711.1272	1400.8041	−983.5428	4.8576	1.1906	−2.5828	1.7667	5.4595	2.5886
4	615.0006	−499.0006	540.4818	−37.7171	5.4934	−1.3463	−3.3407	2.6569	5.3307	3.4155
5	628.6902	−293.6902	360.6878	1702.8269	2.4056	0.4787	−3.8441	−3.9216	4.4742	−2.6522
6	194.9956	121.0044	−861.2992	920.4997	2.8857	0.1698	−3.7759	5.3981	5.2176	−1.6621
7	731.9983	2546.0017	1751.1808	−69.3935	5.4563	1.2878	−2.3053	2.1950	5.9359	1.4594
8	262.2065	−50.2065	351.7989	−74.7230	5.7205	1.4999	−2.1155	−0.5053	5.6087	−0.9754
9	1063.8207	2421.1793	2204.2606	10,106.2299	4.1081	0.1894	−3.2807	−0.5406	6.4867	−1.4950
10	203.6079	−136.6079	104.9160	206.9678	2.6844	−0.6154	−4.1692	1.6737	3.4651	−1.2897
11	477.7187	−322.7187	756.1133	−699.8989	2.7334	0.8952	−3.5474	4.3005	4.4508	0.6635
12	−171.1790	245.1790	−1046.4973	1069.3677	3.6188	0.9923	−3.1557	5.0549	4.0659	0.6563
13	532.1477	−509.1477	442.5295	−223.5934	4.9032	−0.1862	−3.1135	4.6128	5.5232	1.4580
14	811.7080	−795.7080	492.8692	−465.9443	5.7064	−0.8867	−3.0726	2.5972	5.9931	−0.7144
15	757.3294	−292.3294	567.4872	2027.6639	4.9505	−0.2642	−3.1257	0.1673	5.6213	2.6559
16	496.5550	−46.5550	421.8043	3260.7981	5.1465	0.9171	−2.5766	3.9157	4.8295	3.4353
17	242.7985	−46.7985	251.4477	−47.8593	2.9031	−1.3406	−4.3711	4.9399	5.0438	−1.3295
18	691.5918	−650.5918	997.0235	−855.5129	3.2056	−0.3222	−3.8445	1.3576	4.9029	−1.9893
19	493.8904	5121.1096	667.2530	1958.3447	3.8713	−1.1790	−3.9207	−1.9109	5.1087	−1.6472
20	494.5051	71.4949	347.6521	667.8898	3.8687	0.1705	−3.3837	0.7801	4.1824	0.8176
21	243.6591	−202.6591	455.3019	−119.6386	5.9084	1.3257	−2.1100	1.8164	5.9752	−1.4645
22	1254.3717	−823.3717	2809.3310	−2456.6631	4.2682	0.6652	−3.0272	1.0740	7.1099	−0.0877
23	331.6749	37.3251	−472.2995	2434.0959	4.7687	−2.7427	−4.1863	1.7672	4.2783	2.3061
24	979.0276	2618.9724	−185.6586	5116.4960	5.1107	1.8893	−2.2033	−1.1136	5.1413	2.2929
25	535.6489	−341.6489	1350.9353	−1310.2268	3.8782	0.0117	−3.4432	0.8556	4.4907	1.0833
26	551.6202	−461.6202	1430.6992	−1263.8933	4.4791	−0.1650	−3.2741	−0.9914	4.6249	0.7194
27	1387.3952	726.6048	1087.0913	535.9829	4.0816	−0.7322	−3.6587	5.8468	6.9298	0.3321
28	795.6294	−768.6294	945.2202	−914.7364	4.2871	−1.7743	−3.9922	3.2110	6.6328	−2.5302
29	960.1246	−932.1246	2033.6945	−1985.9358	3.5409	−0.7478	−3.8805	4.2977	6.6867	−1.2040
30	775.5562	−747.5562	776.0356	−710.3232	5.0945	1.2784	−2.4533	3.8202	5.6712	2.2271
31	1061.6701	−171.6701	2091.3720	−1772.2628	4.4083	0.1102	−3.1926	0.2544	5.6780	1.7109
32	138.2176	2.7824	181.3832	976.8459	4.0418	−1.3233	−3.9103	2.8472	4.1839	−0.7993

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
33	2.6507	215.3493	−1296.4555	1307.9363	2.4824	0.1843	−3.9309	0.1654	3.4327	−1.2355
34	905.9958	−803.9958	1200.2668	−367.6376	5.9331	0.4971	−2.4305	3.7487	6.8642	1.9149
35	188.6269	−24.6269	−208.8377	412.5625	6.2963	0.6057	−2.2424	3.5144	4.5643	2.5557
36	975.4821	−795.4821	1929.2461	−1530.8521	5.6669	1.1528	−2.2752	7.2743	6.8743	1.6831
37	24.9844	193.0156	−536.6038	750.7570	3.1744	−1.0474	−4.1461	1.3120	3.2342	−0.7263
38	541.9590	−277.9590	341.3416	−12.8609	2.9077	−0.2814	−3.9470	3.5750	4.4843	−0.3833
39	532.7044	328.2956	819.6529	−314.9938	3.4145	−0.1514	−3.6931	2.1416	5.4206	−2.2627
40	640.6952	−597.6952	−400.9076	622.2655	4.0752	−0.0895	−3.4050	0.4490	5.4741	1.8974
41	985.0466	−940.0466	2641.7800	−2480.6809	5.9641	0.2619	−2.5119	0.0238	6.6908	0.4278
42	128.1210	−42.1210	657.2064	−445.5105	3.1699	−0.7844	−4.0430	1.4076	5.0973	−2.8563
43	389.2393	−159.2393	415.6918	1158.5068	2.8628	0.2057	−3.7707	2.3018	5.0142	−1.0416
44	616.8316	−428.8316	1474.5720	−785.9859	4.8957	−0.1589	−3.1056	−6.1305	5.4265	0.8828
45	1048.7074	−565.7074	1977.9357	−1634.7485	5.6425	2.0924	−1.9103	4.2021	6.8961	1.2520
46	829.7674	−722.7674	1623.2816	−1527.8891	2.9909	−0.6958	−4.0790	3.0967	4.8581	−0.7926
47	710.4776	−675.4776	1887.5003	−1838.9116	4.5560	−1.0597	−3.6001	3.5360	6.7800	−2.0245
48	115.1602	178.8398	280.6484	68.6197	3.8536	0.4912	−3.2619	−1.1204	3.7223	−0.2135
49	655.7578	2454.2422	401.6783	910.8609	4.8244	−1.2053	−3.5512	0.4479	5.3119	2.8310
50	1059.9551	−831.9551	1950.1581	−1245.3862	5.9404	1.4784	−2.0363	3.1514	7.0131	2.1835
51	693.8135	−5.8135	622.0959	−165.7391	4.7893	−0.0496	−3.1044	2.6862	4.9650	1.3775
52	795.5029	−421.5029	1280.5963	−421.6077	4.4685	−0.6440	−3.4693	1.2867	6.1114	0.4243
53	1021.0167	−894.0167	2468.1169	−2082.5485	6.7789	0.4126	−2.1270	0.4464	7.3127	0.4581
54	601.4743	1082.5257	1228.0495	1434.5233	5.3069	0.8486	−2.5400	0.1222	6.1980	−0.9314
55	952.2794	3383.7206	3028.5767	16,514.4028	4.7479	1.4291	−2.5314	−2.0852	6.8501	−1.0822
56	487.6461	−394.6461	281.2045	243.6154	2.9755	−0.5895	−4.0428	−1.3983	3.7344	0.9674
57	792.4713	1211.5287	1401.9965	13.1110	6.0862	−1.1542	−3.0278	2.4945	6.0354	1.3626
58	874.9428	−807.9428	1070.2815	−615.1133	5.5345	0.4234	−2.6188	2.7888	5.3604	3.1028
59	791.5333	−680.5333	429.1374	114.1364	5.4203	−1.6942	−3.5086	2.6387	5.4995	3.1672
60	515.7988	−181.7988	164.6722	1752.2618	3.0174	0.3499	−3.6516	−3.3077	4.4175	−2.4288
61	189.3884	101.6116	−360.9752	427.3368	3.7544	0.6456	−3.2399	4.9672	5.6600	−3.3933
62	812.4578	2517.5422	1894.8550	−168.8348	5.6727	0.5160	−2.5268	2.8865	6.4930	1.2052
63	354.9452	−149.9452	188.6310	109.6001	5.4246	1.4845	−2.2396	0.7714	5.9184	−1.1407
64	1258.2058	2325.7942	2527.9652	11,366.9419	4.5598	0.4052	−3.0146	−1.2526	7.0095	−1.3172
65	246.6397	−180.6397	379.0904	−44.8922	2.4559	−0.5621	−4.2390	−0.4286	3.7482	−1.2257
66	521.7323	−394.7323	449.4775	−387.2296	2.8224	0.3370	−3.7345	3.7047	4.6813	−0.1306
67	−42.4716	133.4716	−799.0110	824.5350	3.3720	0.7232	−3.3614	−0.2702	3.8211	0.7979

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
68	594.5839	−571.5839	146.4659	102.7830	5.7818	0.0643	−2.6633	3.5549	5.9424	1.3268
69	787.4924	−769.4924	667.9899	−637.5000	6.1517	−1.6205	−3.1875	2.6321	6.3419	−0.1856
70	540.5973	−83.5973	833.7283	1957.2285	5.6426	−0.9503	−3.1233	0.8344	6.1130	1.9452
71	468.8869	−3.8869	168.6975	3808.5919	5.0648	0.4894	−2.7797	4.6930	4.1480	4.1050
72	613.0593	−430.0593	1153.4987	−941.2493	3.1791	−1.8541	−4.4658	5.3972	5.7367	−1.6617
73	693.0180	−650.0180	1082.3192	−924.4363	3.7609	−0.2053	−3.5765	1.4283	5.2047	−2.1066
74	616.3022	4448.6978	926.8075	1847.1924	4.2808	−1.4441	−3.8631	−1.9495	5.2941	−1.0084
75	771.9200	−152.9200	591.9062	450.2670	4.1154	0.3164	−3.2272	1.0305	4.8492	0.1054
76	344.9839	−301.9839	163.5314	219.1427	5.6152	0.9448	−2.3787	2.5241	6.0844	−1.8044
77	1326.8385	−906.8385	2534.8241	−2161.1828	5.1192	−0.0460	−2.9715	0.0741	7.6469	−1.0127
78	422.2689	−23.2689	−93.1939	2185.1262	4.5264	−2.6734	−4.2553	2.0691	4.5356	2.3681
79	981.2331	2670.7669	589.7953	4448.0400	5.1170	1.0163	−2.5488	0.0766	5.6430	2.3066
80	631.0638	−436.0638	2032.8602	−1989.9278	4.7578	−1.6238	−3.7446	1.3563	5.6508	0.6228
81	544.1948	−447.1948	1022.6742	−843.3343	4.2094	−0.0844	−3.3495	5.9291	4.5957	0.0293
82	1581.0703	604.9297	1810.6111	−85.2377	4.6443	−1.0640	−3.5667	6.1297	6.9884	0.7366
83	603.1790	−579.1790	1327.1652	−1292.7362	4.7145	−1.5062	−3.7150	2.8746	6.4924	−2.9605
84	869.7252	−841.7252	2267.5290	−2213.7781	3.8244	0.0544	−3.4477	3.9848	6.7221	−1.1463
85	571.4936	−544.4936	785.8581	−714.5734	5.6883	1.6260	−2.0780	5.0643	5.2610	2.6819
86	1004.3769	−102.3769	2113.3407	−1754.5518	4.7515	0.3152	−2.9741	−0.7133	5.6961	1.1706
87	357.8798	−217.8798	298.1347	925.2242	3.6963	−1.4785	−4.1098	1.9137	4.5925	−1.1865
88	60.5249	155.4751	−851.5278	864.7059	2.2349	0.6136	−3.8584	6.7127	3.4003	−1.1849
89	1002.0882	−899.0882	1520.1650	−606.8467	6.0812	0.5855	−2.3362	3.7668	7.0639	1.4428
90	161.4946	−30.4946	−342.7317	552.1158	5.8771	1.1573	−2.1896	3.4413	4.8544	1.0294
91	985.6543	−799.6543	1606.0306	−1169.0309	6.3664	0.9039	−2.0956	9.9591	6.9506	1.8439
92	6.5612	204.4388	−329.9797	555.3854	3.6807	−1.2389	−4.0205	2.0585	3.7731	−1.2382
93	489.0184	−225.0184	585.1044	−238.2625	2.5764	0.4236	−3.7980	2.2455	3.9762	−0.1657
94	374.0492	448.9508	968.3543	−380.9452	3.9980	0.4918	−3.2041	2.9593	5.6716	−2.6512
95	469.4999	−426.4999	−230.1836	472.4967	4.9137	0.1874	−2.9603	2.6113	5.8065	1.2721
96	1116.4272	−1070.4272	2971.9395	−2788.6046	6.1112	−0.1988	−2.6369	8.2407	7.2724	0.4667
97	267.3436	−182.3436	897.2571	−655.8007	3.2621	−0.9287	−4.0638	1.2232	5.7576	−3.6909
98	410.9344	−189.9344	174.3220	1483.0068	2.5941	0.7046	−3.6789	6.6022	4.8378	−1.0975
99	716.3317	−516.3317	871.5920	−55.0133	4.8907	0.3623	−2.8998	−2.7544	5.5527	0.3759
100	1047.0055	−565.0055	1671.5931	−1294.6066	5.8051	1.8126	−1.9571	2.6137	7.0317	0.9978
101	110.4857	−7.4857	1519.8752	−1414.2624	3.1656	−1.3851	−4.2842	3.2722	5.3191	−3.0021
102	790.4793	−759.4793	1966.4756	−1912.3123	4.7262	−0.5106	−3.3133	4.0486	6.9630	−2.3888

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
103	208.4564	80.5436	−146.8161	551.6574	3.5842	−0.4874	−3.7594	0.0233	3.7765	−0.0716
104	719.5717	2259.4283	468.3278	952.6664	5.2328	−1.3504	−3.4462	0.8513	5.5679	2.6204
105	1112.6708	−876.6708	1994.3967	−1258.8636	5.7756	1.3050	−2.1712	3.4441	6.9286	2.0390
106	809.2043	−105.2043	738.6682	−231.9141	4.9287	−0.2508	−3.1290	3.1923	5.1713	1.0321
107	718.8156	−341.8156	1367.1009	−588.6242	4.8693	−1.2154	−3.5373	−0.1972	6.2097	0.3672
108	1150.6587	−1020.6587	1979.0209	−1556.6928	6.4219	1.0003	−2.0350	3.1568	7.2694	0.5973
109	665.9359	1007.0641	2210.4023	690.5830	5.4214	0.5147	−2.6274	0.4682	6.1920	−0.1275
110	1105.8308	3291.1692	3214.4267	17,312.7321	5.1000	1.0818	−2.5295	−2.9091	7.0896	−0.7112
111	524.5183	−433.5183	803.9233	−351.1048	3.2913	−0.9246	−4.0505	−0.3445	4.5070	0.1371
112	607.8430	1344.1570	1664.1141	−277.9890	6.5927	−0.7177	−2.6518	2.6167	6.0699	1.4620
113	741.7190	−670.7190	991.0111	−545.9988	5.5021	1.0254	−2.3917	3.0020	5.4940	2.9016
114	516.0622	−408.0622	1120.4275	−585.1388	5.8334	−1.3857	−3.2208	1.2682	5.4308	3.1961
115	652.7548	−328.7548	802.3887	1070.8995	2.2643	1.7097	−3.4097	−2.3982	4.3372	−2.1934
116	618.8076	−356.8076	2211.6540	−2142.7404	2.6973	−0.1008	−3.9589	6.0779	5.6189	−2.7768
117	861.3342	2496.6658	1954.9159	−186.0828	5.8465	0.3535	−2.5223	2.5265	6.4763	0.8487
118	58.9066	144.0934	477.5511	−195.2330	4.8868	0.8878	−2.6918	0.0013	5.5744	−1.3490
119	1145.9901	2631.0099	2560.8575	11,719.1110	5.2564	−0.1897	−2.9741	−3.1537	7.1807	−1.2400
120	325.9018	−259.9018	515.4729	−192.3633	2.6554	−0.0412	−3.9518	0.4701	4.2991	−1.1967
121	421.1450	−302.1450	961.2311	−898.9849	3.1993	0.4183	−3.5518	3.7867	4.5332	−0.4463
122	−273.6192	369.6192	−545.7965	571.5556	3.4488	0.1512	−3.5588	4.8356	3.8694	0.0806
123	567.1229	−544.1229	1344.4224	−1091.8022	5.1192	0.3324	−2.8206	3.1090	5.6538	0.7656
124	525.7816	−507.7816	530.5266	−499.4813	5.2159	−0.3159	−3.0405	3.1624	5.4430	−0.1430
125	505.0980	−51.0980	848.9980	1879.8723	5.4272	−1.7481	−3.5273	0.4627	5.7696	2.6501
126	105.7261	364.2739	−48.0290	3936.3558	5.5651	0.6755	−2.5061	3.9772	3.8959	4.3025
127	466.6245	−290.6245	1329.5232	−1124.1959	2.6650	−0.6962	−4.2091	5.3563	5.1591	−1.2529
128	617.6935	−573.6935	1105.0236	−944.0564	3.9123	0.2572	−3.3318	1.2126	4.9083	−1.5237
129	542.7019	4611.2981	1272.0711	1616.2775	4.6135	−1.1044	−3.5950	−3.5300	5.8403	−1.2867
130	957.3152	−289.3152	2094.2042	−975.1130	4.4293	0.3268	−3.0979	1.2283	5.4568	0.3951
131	101.8632	−58.8632	1007.8094	−608.6876	6.1741	1.2953	−2.0162	2.4998	6.0738	−2.1988
132	1252.6979	−838.6979	3090.7022	−2692.7676	4.8484	0.2627	−2.9564	−0.7231	7.5148	−1.6036
133	379.4899	34.5101	386.2206	1625.0652	4.4128	−2.2867	−4.1464	2.6062	4.3474	2.4994
134	816.4930	2887.5070	179.7704	4943.5477	4.8903	1.0772	−2.6150	−0.4153	4.8250	2.4147
135	741.4089	−550.4089	2156.0721	−2111.5693	4.8557	−1.1634	−3.5220	0.1736	5.6242	0.3098
136	574.6556	−480.6556	1761.1885	−1579.5213	4.8415	−2.2541	−3.9625	3.3930	4.8173	0.0639
137	1640.0858	621.9142	2066.5937	−415.1708	4.2048	−0.0421	−3.3344	3.7062	7.0625	0.3561

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
138	384.3835	−363.3835	1231.1255	−1196.8168	4.9977	−1.6227	−3.6485	3.0808	6.6686	−2.7103
139	850.0265	−821.0265	2489.8287	−2435.1313	4.3185	−0.5471	−3.4905	3.9641	6.8928	−0.9786
140	468.8703	−440.8703	538.2755	−468.0800	5.8406	1.3816	−2.1147	4.4144	5.1554	2.8165
141	1053.7496	−134.7496	2581.8556	−2216.5767	5.2523	−0.0627	−2.9250	−0.4783	6.4885	0.9353
142	412.3537	−273.3537	950.9342	307.3503	2.6650	0.5231	−3.7230	1.3745	4.1001	−0.7733
143	320.2542	−121.2542	143.9051	−129.6988	1.4567	0.9845	−4.0208	4.9152	3.4006	−1.2536
144	797.6335	−694.6335	2080.1409	−1173.1426	6.7741	−0.0144	−2.2991	4.0263	7.3081	1.2110
145	505.5336	−382.5336	1146.8861	−935.9998	5.7922	0.9331	−2.3128	−0.1570	5.6626	0.8869
146	981.5285	−795.5285	2020.3191	−1615.3777	6.0471	1.1421	−2.1279	8.7116	7.0300	0.8349
147	−49.4561	245.4561	−391.0747	621.9621	3.4797	−0.8050	−3.9277	2.5498	3.7981	−2.0149
148	437.7307	−172.7307	784.3168	−407.4934	3.6608	−0.4282	−3.7053	2.0474	4.6208	−0.5976
149	627.0237	170.9763	1850.1446	−1252.8601	3.9296	0.5778	−3.1970	2.4600	5.5820	−2.6123
150	354.4497	−311.4497	676.1894	−436.2025	4.2165	−0.0498	−3.3329	3.4482	5.4949	1.1908
151	1207.2293	−1160.2293	3171.9089	−2996.0714	6.5279	−0.6719	−2.6594	7.2437	7.6503	0.3180
152	632.5845	−551.5845	1859.3084	−1609.4283	2.5888	0.6576	−3.6998	−0.6498	5.5035	−2.4020
153	431.2340	−218.2340	1389.4170	303.6980	3.4236	0.6304	−3.3778	5.3074	4.7684	−1.2009
154	734.8808	−530.8808	1673.1824	−869.5662	5.5029	0.0833	−2.7670	−1.6184	6.5621	−0.5162
155	1001.8981	−531.8981	2196.0992	−1820.6150	6.4107	1.1028	−1.9986	2.1636	7.3038	1.1557
156	767.8319	−670.8319	2240.8475	−2135.5631	1.8537	0.6463	−3.9973	2.7014	5.7144	−2.5674
157	919.7612	−890.7612	2526.6768	−2472.4976	4.8344	−0.7158	−3.3520	3.7810	7.2380	−1.6787
158	268.8538	5.1462	1362.6444	−974.7106	2.8889	0.8853	−3.4894	−1.2277	3.7457	−0.6812
159	613.8385	2256.1615	1114.3249	278.7212	4.9620	−0.5409	−3.2315	0.1684	5.7476	2.4103
160	848.7126	−611.7126	2164.0740	−1432.2581	6.3787	1.0638	−2.0269	3.3510	7.0321	1.8797
161	835.9006	−110.9006	1270.4199	−726.3390	5.0439	0.0149	−2.9772	2.1657	5.6008	0.8698
162	952.0725	−574.0725	1893.7428	−1132.7409	3.6934	−0.4341	−3.6946	−1.0542	6.0318	0.8941
163	1125.9117	−995.9117	3107.5916	−2690.3760	7.2448	0.9608	−1.7227	2.1586	7.6835	0.5969
164	472.7708	1194.2292	1991.7360	886.9379	5.5475	−0.2236	−2.8715	0.6621	5.9560	0.4155
165	958.7020	3775.2980	3449.8599	17,922.7224	4.8914	1.3451	−2.5077	−3.2206	7.0397	−1.5774
166	1062.6934	−971.6934	2044.7632	−1655.1719	2.0447	−0.4360	−4.3527	−4.2728	5.0810	−0.5032
167	664.0992	1237.9008	1885.3246	−532.3949	6.4902	−0.3538	−2.5476	−1.7913	6.4222	1.1005
168	727.6856	−659.6856	1251.1728	−817.9138	6.1919	1.0303	−2.1147	−5.9305	5.8912	3.2755
169	558.5586	−450.5586	1342.2520	−820.3912	5.9741	−1.7279	−3.3012	−5.7427	5.7445	2.8709
170	623.4588	−278.4588	1088.8957	359.6700	3.3224	0.5582	−3.4469	−10.1501	4.7751	−1.5662
171	758.7580	−499.7580	2174.3994	−2104.5115	3.3841	1.1492	−3.1867	−0.7964	6.2942	−2.6053
172	1027.4720	2894.5280	2775.5467	−1049.8610	6.2990	0.4307	−2.3111	−8.5210	7.1817	0.3588

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
173	10.0673	183.9327	363.4542	−110.5142	5.8294	0.5474	−2.4518	−4.6822	5.7331	−1.1361
174	1342.5768	2811.4232	3495.4431	11,192.3004	5.4906	0.1888	−2.7298	−8.0906	7.6548	−1.2273
175	421.8690	−356.8690	1143.6858	−873.3859	2.7659	0.0508	−3.8711	−3.1045	4.3688	−1.1824
176	601.7665	−497.7665	1060.8185	−1003.6147	3.0687	0.4796	−3.5794	−3.7446	5.2867	−0.4534
177	309.9527	−217.9527	419.4815	−394.7895	4.1078	0.8922	−3.0007	−2.7561	4.9027	1.1358
178	950.6490	−927.6490	2078.9672	−1833.5362	4.8343	−0.2306	−3.1586	−2.6206	6.1448	0.3080
179	730.4836	−712.4836	661.8090	−631.1581	5.7293	−0.8818	−3.0615	−2.5346	5.8626	0.6374
180	524.0082	−73.0082	1511.6599	1118.6579	5.3439	−0.0733	−2.8928	−6.0323	5.8921	1.6317
181	104.3187	333.6813	254.7594	3591.6545	5.9228	0.3139	−2.5076	−1.8055	4.1920	4.2485
182	449.2219	−278.2219	754.8781	−566.0434	4.1893	−1.6461	−3.9801	−6.1732	5.3308	−0.0468
183	634.8819	−589.8819	1400.7719	−1245.7590	3.4424	0.7462	−3.3241	−4.5527	5.2803	−2.3660
184	574.7761	4640.2239	1545.0108	1084.1510	4.7118	−0.9303	−3.4864	−10.0385	6.0712	−1.3653
185	980.7250	−267.7250	2207.3175	−1148.8937	4.4218	−0.4643	−3.4163	1.4257	5.6718	−0.0159
186	470.3106	−427.3106	1147.0881	−721.1985	6.1885	0.6865	−2.2531	−2.8773	6.1827	−1.3911
187	1262.7405	−836.7405	3431.5731	−3024.4722	4.8424	0.5723	−2.8354	−6.7093	7.0168	−1.1144
188	323.2984	90.7016	372.4051	1520.1690	4.9163	−2.9343	−4.2039	−5.3933	4.7835	2.3415
189	740.1004	3013.8996	94.4189	4945.6888	4.8704	1.5227	−2.4452	−6.5064	4.7477	2.5173
190	824.0553	−645.0553	2341.6947	−2297.9975	5.0007	−1.7661	−3.7045	−3.3285	6.0077	0.0416
191	598.4461	−504.4461	1846.8102	−1675.7279	4.8230	−1.7572	−3.7718	−3.2651	5.1177	−0.7756
192	1757.9704	560.0296	3154.2534	−1516.3579	4.9027	−1.9298	−3.8088	1.5670	7.4879	0.5121
193	870.0694	−852.0694	2039.1291	−2005.5112	4.7237	−0.9904	−3.5056	3.0572	6.7296	−1.9296
194	869.0247	−842.0247	2451.7501	−2395.2032	4.6516	−0.3928	−3.2961	−3.9854	6.9905	−1.1552
195	511.3141	−482.3141	306.6891	−233.3361	5.9055	1.4660	−2.0552	−1.3648	5.3889	2.6397
196	1134.9336	−207.9336	2484.6914	−2147.6839	4.8919	−0.1766	−3.1142	−3.0728	6.4870	0.8115
197	655.6299	−515.6299	1799.4553	−723.2920	2.5149	0.2660	−3.8853	−0.5838	5.1189	−1.9733
198	530.4277	−338.4277	552.6710	−539.3580	1.9187	0.8929	−3.8731	−5.3625	3.6020	−0.4136
199	888.7154	−785.7154	2198.9987	−1286.4982	6.7721	−0.2147	−2.3798	−1.3236	7.4929	0.8186
200	145.5856	−23.5856	357.2969	−147.0973	5.9019	1.8608	−1.8992	−2.1345	5.1566	0.9450
201	1096.4768	−910.4768	2720.1027	−2357.9044	6.3696	0.1637	−2.3894	−0.2252	7.3212	0.9121
202	214.9676	−15.9676	91.0444	114.2233	3.8503	−0.8366	−3.7925	−4.5401	4.4447	−2.2193
203	584.3196	−316.3196	1491.8706	−1130.3812	3.6693	−0.1804	−3.6031	−2.1299	4.9970	−0.8172
204	761.1296	20.8704	2461.6271	−1865.0092	4.2568	0.6048	−3.0559	−3.8930	6.0680	−2.5055
205	508.1199	−465.1199	611.8938	−383.3545	4.1888	−0.1156	−3.3702	−2.4694	5.6514	1.2023
206	1281.0201	−1234.0201	3658.0520	−3513.6407	6.8455	−0.7380	−2.5591	3.5900	7.8516	0.5397
207	413.0221	−332.0221	1523.2166	−1273.7048	2.9635	0.4827	−3.6201	−5.6889	5.5189	−2.5189

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
208	277.0542	−64.0542	1653.7460	−165.4243	3.7459	0.6141	−3.2558	−0.7457	4.9203	−1.0011
209	1030.5755	−823.5755	1857.4852	−1154.1175	5.8241	0.3188	−2.5450	−8.7189	7.0700	0.5532
210	1054.2914	−595.2914	2750.3769	−2405.0914	6.7729	0.9902	−1.8991	−8.9251	7.5803	1.2731
211	732.0948	−639.0948	2774.2420	−2669.0697	1.5390	0.4013	−4.2205	−1.2478	5.5317	−3.2631
212	783.0058	−756.0058	2395.7792	−2342.1896	5.2605	−0.6494	−3.1557	−5.1411	6.9786	−1.5393
213	183.1656	80.8344	590.9739	−255.5319	2.7398	0.1593	−3.8382	−5.8967	3.2121	−0.5084
214	708.8498	2002.1502	1412.8730	−131.3883	4.4471	−0.3945	−3.3784	−6.8895	5.5877	2.4470
215	892.1540	−656.1540	2263.8983	−1511.7491	6.6203	0.8425	−2.0188	−0.8006	7.1987	1.7101
216	1148.2591	−405.2591	1893.3962	−1393.7141	4.8005	0.1067	−3.0377	−1.7438	6.1249	1.3803
217	1158.2142	−787.2142	2312.3086	−1592.2105	4.4404	−0.4040	−3.3848	−1.7064	6.6627	0.3191
218	1228.8664	−1098.8664	2913.8990	−2556.6805	6.7935	1.1039	−1.8455	−3.3716	7.6055	0.5227
219	781.2840	885.7160	2322.6674	434.2329	5.5607	0.3217	−2.6489	−10.1118	6.8432	−0.8726
220	959.3801	3143.6199	3380.6825	17,513.0630	5.1239	0.5320	−2.7392	−11.7525	7.3812	−2.2725
221	1115.5037	−1024.5037	2017.0918	−1525.5993	1.5798	0.7138	−4.0796	−0.4749	4.4082	−0.6101
222	926.0551	975.9449	1943.5231	−311.5171	5.6887	−1.3705	−3.2725	−2.9045	6.3145	1.0037
223	1219.2642	−1151.2642	2126.4402	−1649.3582	5.2393	0.6866	−2.6315	−3.2862	5.9178	2.9217
224	666.3840	−558.3840	1151.9832	−552.9564	6.1308	−2.1308	−3.3993	−2.1223	6.0271	2.4993
225	912.4096	−567.4096	1390.5064	218.4749	2.7617	1.2205	−3.4065	−1.0139	4.9655	−1.5601
226	621.8992	−362.8992	1719.3569	−1639.0896	2.9044	0.0086	−3.8327	−0.2599	5.6445	−2.1662
227	1006.2113	2915.7887	2771.9115	−700.0846	5.9106	−0.1459	−2.6958	−1.8274	7.1406	−0.1112
228	557.8372	−363.8372	1221.5747	−904.5162	5.2611	−0.4442	−3.0737	−4.4443	6.2745	−1.0914
229	1285.9756	2868.0244	3072.7276	14,661.4033	5.6035	−0.1616	−2.8245	−3.0763	7.5183	−0.8051
230	503.6747	−438.6747	681.6681	−367.3458	3.0456	−0.6639	−4.0445	−2.7879	4.2953	−0.2023
231	888.1194	−784.1194	1794.9750	−1727.1372	2.8060	0.0318	−3.8627	0.9798	5.6518	−1.4626
232	470.1443	−378.1443	349.4053	−321.7848	3.9980	0.4835	−3.2074	1.5425	5.0321	1.1944
233	1104.4658	−1081.4658	2053.1676	−1770.6337	5.0566	−0.5142	−3.1831	−2.6848	6.5264	0.5402
234	722.3520	−704.3520	1137.7297	−1101.4669	5.2563	−0.1220	−2.9471	0.5942	5.6849	0.8524
235	729.0355	−278.0355	1307.5277	1629.9451	5.3583	−0.1083	−2.9010	−3.5778	6.2904	1.1455
236	361.2792	76.7208	297.2191	3925.8971	5.3042	0.7551	−2.5784	−1.1312	4.4396	3.6197
237	533.8466	−362.8466	1195.0617	−978.8213	4.4665	−0.9978	−3.6111	−3.8215	5.6392	−0.1154
238	804.9002	−759.9002	1500.1387	−1317.8571	3.6419	0.2376	−3.4474	−3.3264	5.4777	−1.9356
239	901.3082	4313.6918	2219.1234	921.4782	4.7277	−0.8011	−3.4286	−6.3821	6.3989	−1.7567
240	969.4231	−256.4231	1239.9670	−53.8740	4.7703	−0.3649	−3.2377	−2.6924	5.7850	−0.3255
241	289.4693	−246.4693	1041.7522	−543.1929	5.8754	0.8704	−2.3047	0.3805	6.2822	−1.6721
242	1365.2783	−939.2783	3465.7381	−2984.1470	4.9178	−0.3687	−3.1805	−0.7421	7.0713	−0.0313

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
243	460.7369	−46.7369	988.9260	1110.9528	5.1729	−3.2979	−4.2465	−2.9814	5.2862	1.3745
244	811.2145	2942.7855	157.7346	4779.6882	4.8665	2.1070	−2.2139	−5.4028	4.6344	2.0559
245	829.5364	−650.5364	2739.3990	−2694.1553	6.0295	−1.7271	−3.2788	−2.1099	6.6991	−0.2108
246	818.5377	−724.5377	2422.5255	−2231.7113	5.0402	−1.8510	−3.7226	−0.3733	5.4753	−0.6935
247	1658.3290	659.6710	2509.1721	−710.6276	5.0293	−2.6439	−4.0431	3.4039	7.0472	1.0996
248	738.9701	−720.9701	2640.9173	−2601.9855	4.8100	−0.9433	−3.4525	2.7173	6.6978	−1.7644
249	816.1794	−789.1794	2254.2713	−2188.8355	4.4006	−0.5272	−3.4498	2.4474	6.8838	−1.1370
250	733.8969	−704.8969	1160.1920	−1073.4806	5.9217	1.3482	−2.0957	2.9821	6.0697	1.9303
251	1456.9610	−529.9610	2702.2236	−2329.5220	4.5065	−0.1922	−3.2740	−3.1226	6.8106	0.6179
252	907.8267	−767.8267	2036.3910	−743.3537	2.1205	1.4372	−3.5757	−0.2265	5.1851	−2.4008
253	731.4857	−539.4857	−250.8989	265.9969	1.5826	1.3139	−3.8393	0.3822	4.0687	−1.3669
254	997.4641	−894.4641	2309.2309	−1318.9849	6.7313	−0.3274	−2.4410	−0.1733	7.8162	0.4338
255	364.3307	−242.3307	973.9638	−726.3453	5.8609	1.6553	−1.9975	−2.9461	5.9795	−0.5041
256	1286.5939	−1100.5939	2588.2322	−2105.7952	6.5547	0.0739	−2.3514	11.4365	7.9456	0.3973
257	331.8499	−132.8499	694.5950	−469.8906	3.1048	−0.6798	−4.0272	1.4193	4.1353	−2.1603
258	628.1121	−360.1121	1473.7015	−1080.0893	3.4896	−0.7277	−3.8929	−2.5712	4.8985	−1.2062
259	742.3919	39.6081	2165.5600	−1491.5146	3.1518	0.6525	−3.4773	1.5947	5.2676	−2.5564
260	689.2796	−646.2796	785.0013	−534.8978	3.7567	0.0033	−3.4950	0.6684	5.8637	1.1496
261	1282.0912	−1235.0912	3374.2752	−3194.7044	6.6407	−0.2475	−2.4452	6.5397	7.7995	0.5564
262	420.5460	−339.5460	1669.4686	−1385.3822	2.9332	0.3334	−3.6917	−3.4133	5.3901	−2.6234
263	357.3876	−144.3876	1841.0687	−65.2700	3.8555	−0.4332	−3.6297	4.3497	4.6129	0.0316
264	1229.2552	−1022.2552	2108.7358	−1275.1946	5.3228	−0.2978	−2.9907	0.5450	7.1425	0.3325
265	1285.6237	−826.6237	2710.0041	−2313.0123	6.0650	1.1515	−2.1170	1.1883	7.7617	0.8363
266	471.9769	−378.9769	2412.7288	−2297.8587	2.7155	1.4967	−3.3148	−2.8353	5.6217	−3.0679
267	816.0655	−789.0655	2139.0329	−2077.5068	4.5360	−0.7162	−3.4712	−1.7288	6.7885	−1.8956
268	324.1251	−60.1251	1270.1676	−850.2212	2.0986	0.3373	−4.0229	−2.3590	3.5602	−0.8935
269	848.8677	1862.1323	1571.4536	−146.1770	4.3309	0.1894	−3.1919	−3.6807	5.7866	1.8663
270	985.9124	−749.9124	2376.5150	−1563.6481	6.5149	0.6933	−2.1203	0.1857	7.5011	1.4236
271	1220.4578	−477.4578	2212.3077	−1706.3260	5.1282	−0.1371	−3.0042	−4.7613	6.2930	1.5654
272	1187.3204	−816.3204	2493.8017	−1680.7735	3.2996	−0.7038	−3.9592	0.4793	6.1456	0.7906
273	1267.9883	−1137.9883	3077.3716	−2671.9039	7.0205	0.5836	−1.9624	2.2926	7.9718	0.5282
274	1003.5070	663.4930	2762.5154	424.3443	5.5003	0.6938	−2.5246	−5.4607	7.0477	−0.2128
275	1133.6456	2969.3544	3473.6297	19,523.8706	5.6163	0.1950	−2.6772	−7.5012	7.5084	−1.1656
276	1140.0177	−1049.0177	2380.8006	−1889.3081	1.5878	0.8898	−4.0063	−0.5483	4.4990	−0.5899
277	670.6594	1231.3406	1883.0665	−251.0605	6.5920	−0.8120	−2.6897	−3.4873	6.4242	0.4958

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
278	1013.8753	−945.8753	1534.9497	−1057.8678	5.3197	0.4611	−2.6894	−3.2283	5.7831	3.1058
279	662.5581	−554.5581	1720.5095	−1121.4828	5.8683	−0.4215	−2.8225	−2.6991	5.7383	2.3922
280	866.4770	−521.4770	1171.0121	437.9692	3.2211	0.9673	−3.3242	−1.0961	4.8316	−0.9766
281	572.6354	−313.6354	1877.8379	−1797.5706	3.3855	−0.6189	−3.8910	−0.2016	5.9699	−2.5600
282	1154.7931	2767.2069	3105.7536	−1033.9266	5.8136	0.4396	−2.5011	−2.0221	7.1413	−0.2806
283	658.5666	−464.5666	1443.3692	−1126.3107	4.6432	0.4315	−2.9709	−4.5471	6.2983	−1.9347
284	1423.0522	2730.9478	3734.4679	13,999.6630	5.4601	0.1506	−2.7572	−3.1436	7.6839	−1.1704
285	507.1595	−442.1595	1398.8047	−1084.4823	2.8161	0.5784	−3.6407	−3.1916	4.1074	−0.6074
286	924.7529	−820.7529	1877.5529	−1809.7151	4.0230	0.1588	−3.3268	0.4440	6.4165	−1.6286
287	348.5751	−256.5751	1204.0089	−1176.3884	4.0425	0.6658	−3.1169	1.4521	4.9323	1.3656
288	945.0308	−922.0308	1995.8869	−1713.3529	6.1275	−0.4949	−2.7484	−3.1195	6.9460	0.5234
289	794.3239	−776.3239	1162.9685	−1126.7057	6.1037	0.1993	−2.4812	0.1283	5.7840	0.9736
290	585.6957	−134.6957	1433.8686	1503.6042	5.8491	−0.8390	−2.9966	−3.4821	6.2938	0.7567
291	252.6750	185.3250	251.0435	3972.0727	5.7950	1.0505	−2.2649	−1.4447	4.5009	3.3378
292	562.4055	−391.4055	448.9213	−232.6809	4.2649	−1.2226	−3.7812	−3.6514	5.2577	−0.2999
293	765.3357	−720.3357	1416.7989	−1234.5173	4.2946	0.2690	−3.1746	−3.5992	5.6516	−1.6155
294	1029.1262	4185.8738	2415.5144	725.0872	5.1567	−0.6901	−3.2133	−6.5974	6.7367	−1.5589
295	999.6145	−286.6145	1805.6580	−619.5650	4.8117	−0.6636	−3.3403	−2.5898	5.8256	−0.1713
296	508.2797	−465.2797	1569.5370	−1070.9777	6.0338	0.9832	−2.1966	0.2724	6.0606	−1.4165
297	1429.9848	−1003.9848	3525.3835	−3043.7923	4.9982	0.6762	−2.7318	−1.1907	7.0872	0.2616
298	534.5751	−120.5751	1021.5132	1078.3655	5.4042	−3.2663	−4.1417	−3.0862	5.1621	2.0563
299	791.3000	2962.7000	−14.7000	4952.1227	4.8297	1.6748	−2.4009	−5.2158	4.3827	2.1082
300	919.6271	−740.6271	2593.1536	−2547.9100	5.3421	−1.1114	−3.3073	−2.0813	6.3814	−0.3029
301	935.9100	−841.9100	2282.7490	−2091.9348	4.8735	−1.5168	−3.6558	−0.4401	5.7019	−0.7842
302	1521.9452	796.0548	2058.0311	−259.4866	5.1369	−2.8660	−4.0887	3.4496	6.4969	1.1662
303	910.6914	−892.6914	2614.0482	−2575.1164	5.0451	−0.4260	−3.1525	2.4173	6.6563	−1.3706
304	911.4966	−884.4966	2374.1070	−2308.6712	4.5376	0.6139	−2.9403	1.9378	7.1394	−1.6848
305	640.1449	−611.1449	477.9226	−391.2111	5.4383	0.8694	−2.4793	3.3656	5.4043	2.3393
306	1379.0786	−452.0786	2727.0338	−2354.3321	4.1284	0.3382	−3.2133	−3.1833	6.3851	0.3260
307	778.6827	−638.6827	1903.2700	−610.2327	2.3624	0.9154	−3.6873	−0.1149	5.1559	−2.2961
308	504.3446	−312.3446	182.0085	−166.9104	1.8120	1.3810	−3.7211	0.2640	3.5046	−1.2239
309	1016.9491	−913.9491	2642.3744	−1652.1284	6.9386	−0.0765	−2.2583	−0.3560	7.8015	0.4054
310	184.5967	−62.5967	903.1924	−655.5740	5.2810	2.1556	−2.0292	−2.9144	5.0257	−0.6877
311	1319.2631	−1133.2631	2981.4559	−2499.0189	6.1413	0.6769	−2.2758	11.3609	7.8010	−0.3010
312	693.1938	−494.1938	877.6593	−652.9549	2.5930	0.4768	−3.7702	1.1622	4.2265	−1.6618

Table A1. *Cont.*

Observation	RISK		$ECON_1$		$ECON_2$		GBD		GOV_2	
	Predicted RISK	Residuals	Predicted $ECON_1$	Residuals	Predicted $ECON_2$	Residuals	Predicted GBD	Residuals	Predicted GOV_2	Residuals
313	771.2069	−503.2069	1454.4554	−1060.8432	3.5321	−0.7285	−3.8763	−2.5878	5.3645	−1.3464
314	899.5969	−117.5969	1679.0247	−1004.9793	3.1325	1.0700	−3.3186	1.4359	4.9509	−2.4193
315	534.1591	−491.1591	596.9042	−346.8007	4.0130	0.5999	−3.1550	0.3284	5.4485	1.2289
316	1304.9273	−1257.9273	3277.6254	−3098.0546	6.8051	−1.2169	−2.7661	6.8606	7.8581	0.4191
317	560.9506	−479.9506	1781.1512	−1497.0648	3.1969	0.1781	−3.6485	−3.4565	5.5613	−2.1863
318	358.4625	−145.4625	1839.8832	−64.0844	3.8556	−0.4356	−3.6306	4.3506	4.6123	0.0277
319	1231.3459	−1024.3459	1669.6136	−836.0724	6.3464	−0.8201	−2.7908	0.3451	7.8390	−0.4969
320	1105.5497	−646.5497	2835.9983	−2439.0064	6.5617	1.2597	−1.8758	0.9472	7.5913	0.5873
321	790.1959	−697.1959	2343.4596	−2228.5895	3.2014	1.3820	−3.1668	−2.9833	5.8473	−1.9584
322	840.0349	−813.0349	2441.5782	−2380.0520	4.8102	−0.5395	−3.2914	−1.9085	6.7661	−1.8939
323	507.7302	−243.7302	1539.1219	−1119.1755	2.8341	1.1958	−3.3874	−2.9944	3.7476	−0.0935
324	831.5757	1879.4243	1804.0855	−378.8090	4.6605	−0.3480	−3.2747	−3.5978	5.8447	2.2022
325	953.4211	−717.4211	2382.5877	−1569.7207	6.7041	0.8691	−1.9748	0.0402	7.2097	1.6626
326	1161.8996	−418.8996	2269.4337	−1763.4519	5.0935	−0.0044	−2.9651	−4.8004	5.9994	1.3868
327	1147.8397	−776.8397	2175.1083	−1362.0801	4.1516	−1.7213	−4.0251	0.5452	5.8946	0.0295
328	1178.3826	−1048.3826	2851.9926	−2446.5249	6.0110	1.8461	−1.8616	2.1917	7.4739	0.1690
329	1058.5042	608.4958	2848.5497	338.3100	5.4294	0.4040	−2.6684	−5.3169	6.9157	−1.0586
330	1042.0847	3060.9153	3727.2900	19,270.2102	5.9385	0.1668	−2.5600	−7.6184	7.3934	−1.8828

Source: authors.

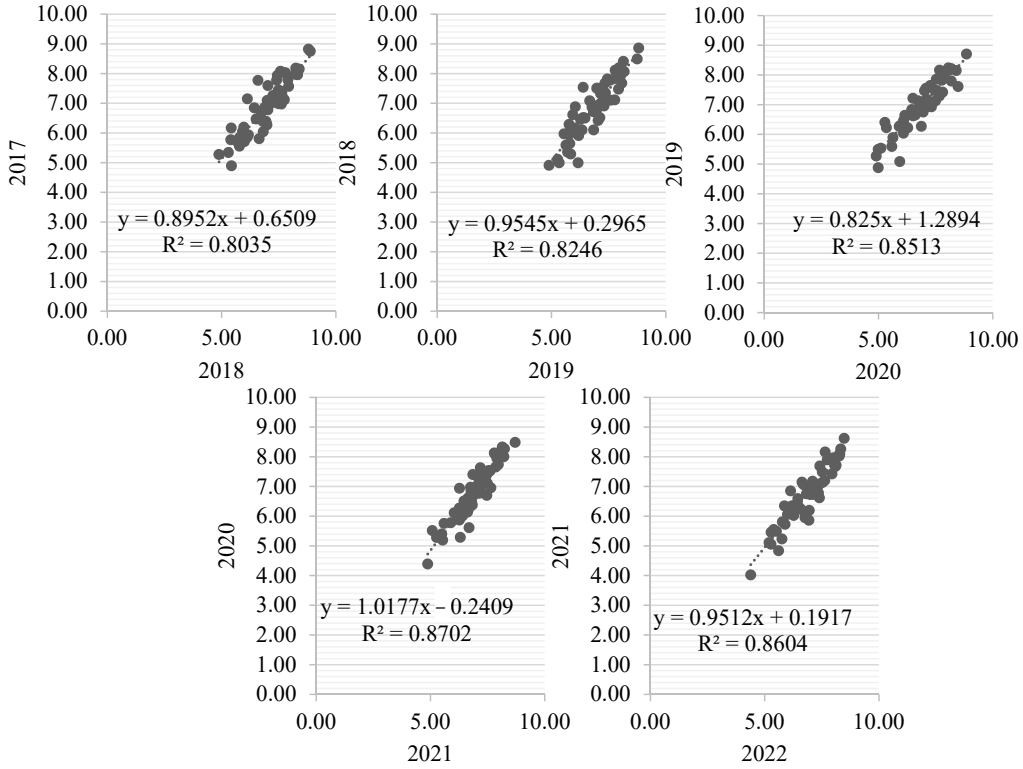

Figure A1. Stationarity test (the augmented Dickey–Fuller test, ADF) for digital/technological skills (DGT_1). Source: authors.

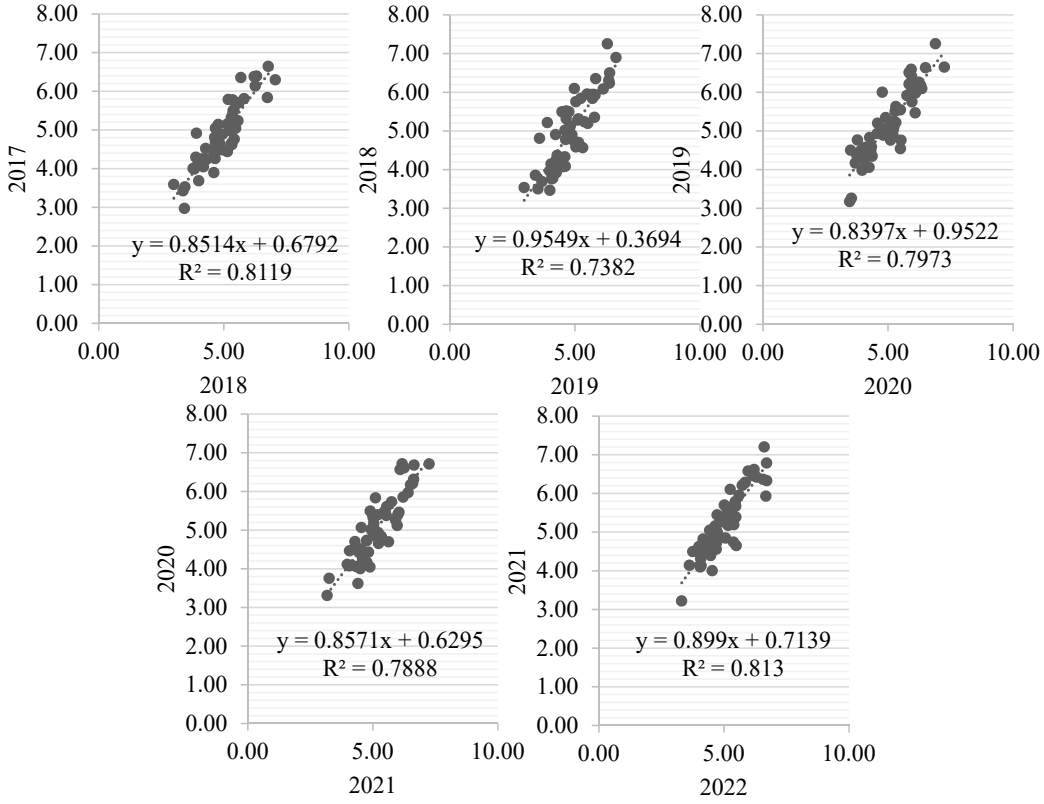

Figure A2. Stationarity test (the augmented Dickey–Fuller test, ADF) for use of big data and analytics (DGT_2). Source: authors.

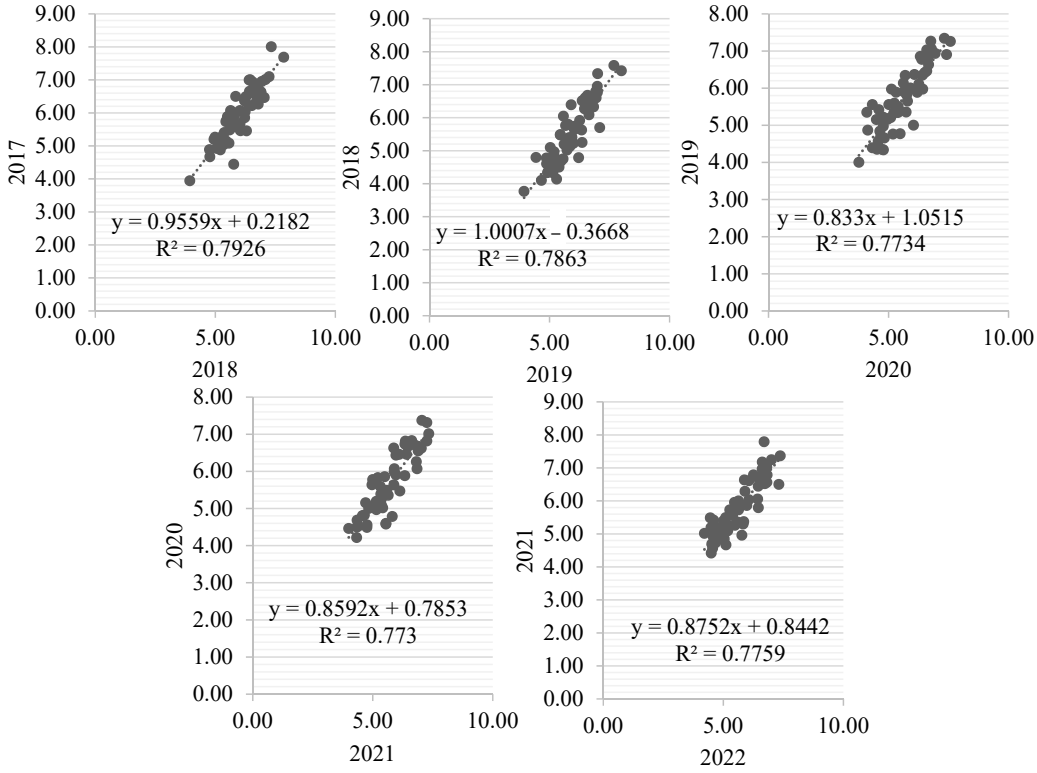

Figure A3. Stationarity test (the augmented Dickey–Fuller test, ADF) for digital transformation in companies (DGT_3). Source: authors.

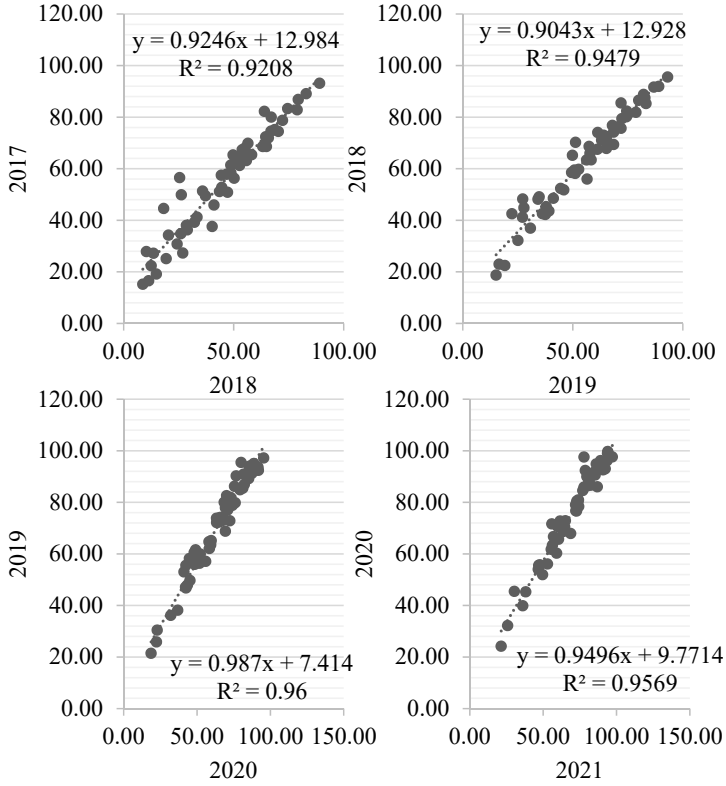

Figure A4. Stationarity test (the augmented Dickey–Fuller test, ADF) for mobile broadband subscribers (DGT_2). Source: authors.

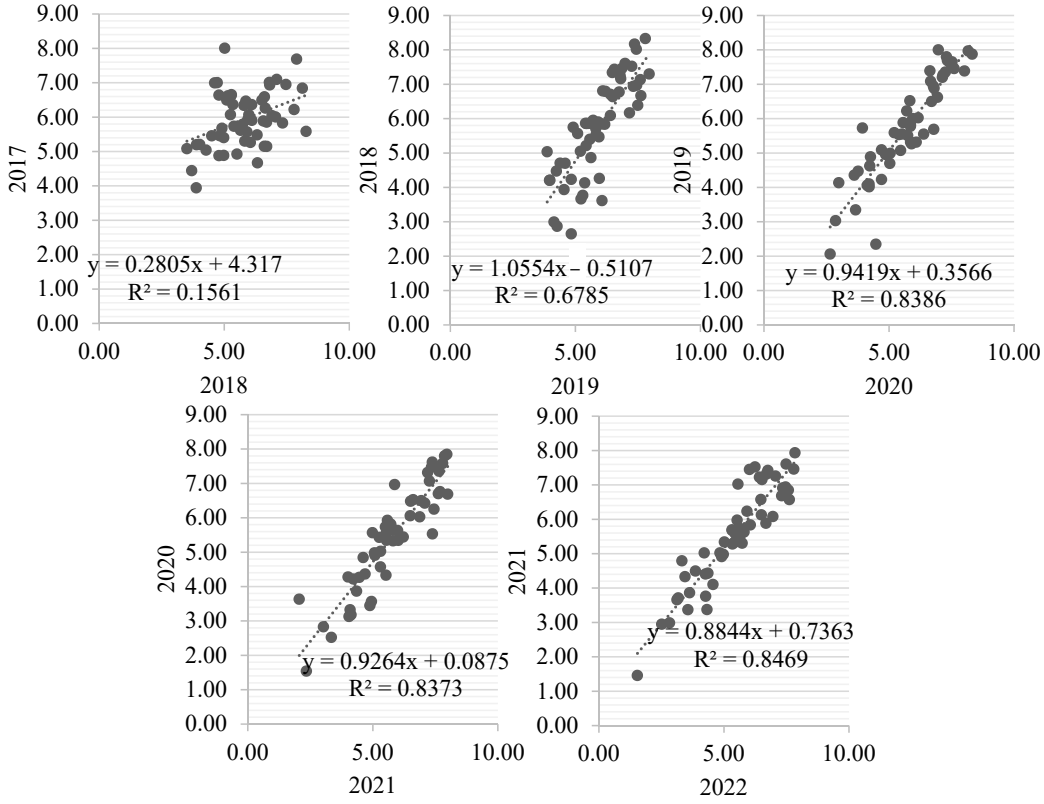

Figure A5. Stationarity test (the augmented Dickey–Fuller test, ADF) for protectionism (GOV_1). Source: authors.

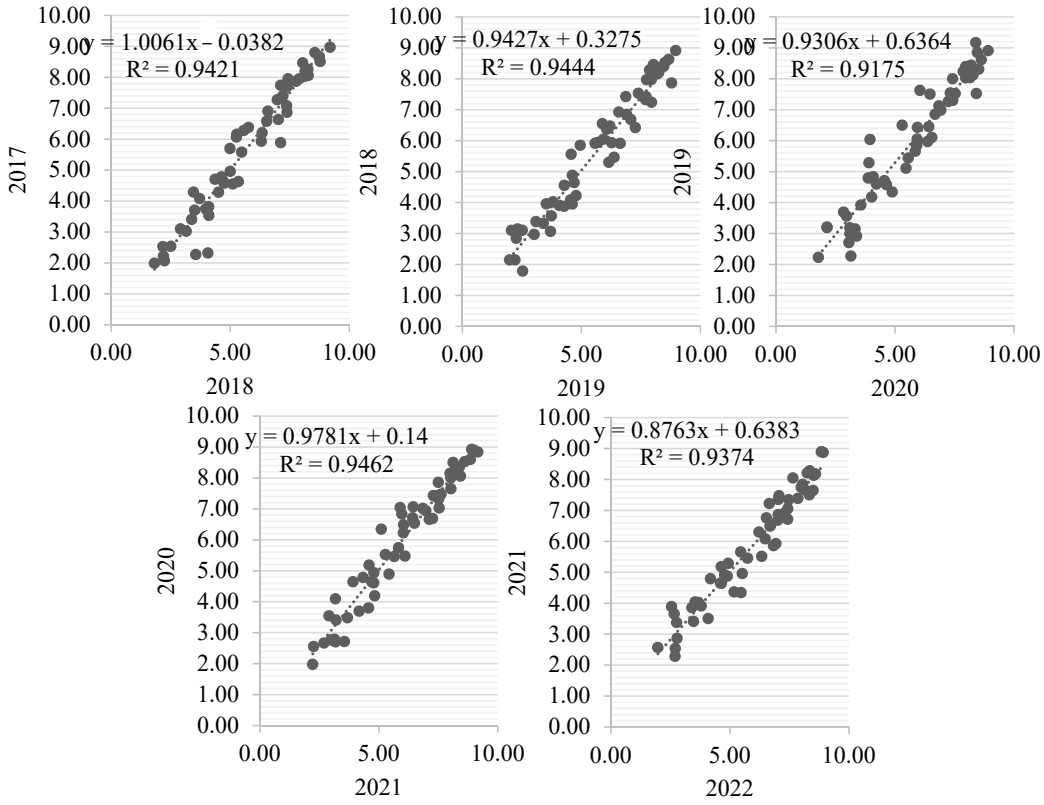

Figure A6. Stationarity test (the augmented Dickey–Fuller test, ADF) for health infrastructure (GOV_2). Source: authors.

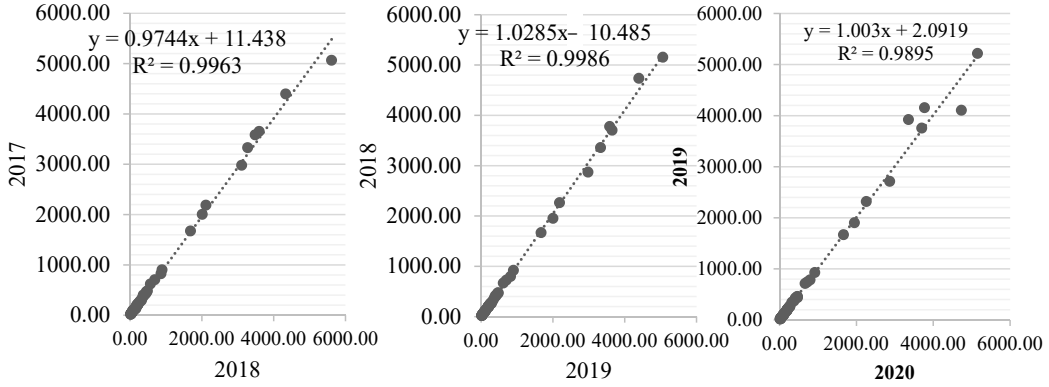

Figure A7. Stationarity test (the augmented Dickey–Fuller test, ADF) for "listed domestic companies" (RISK). Source: authors.

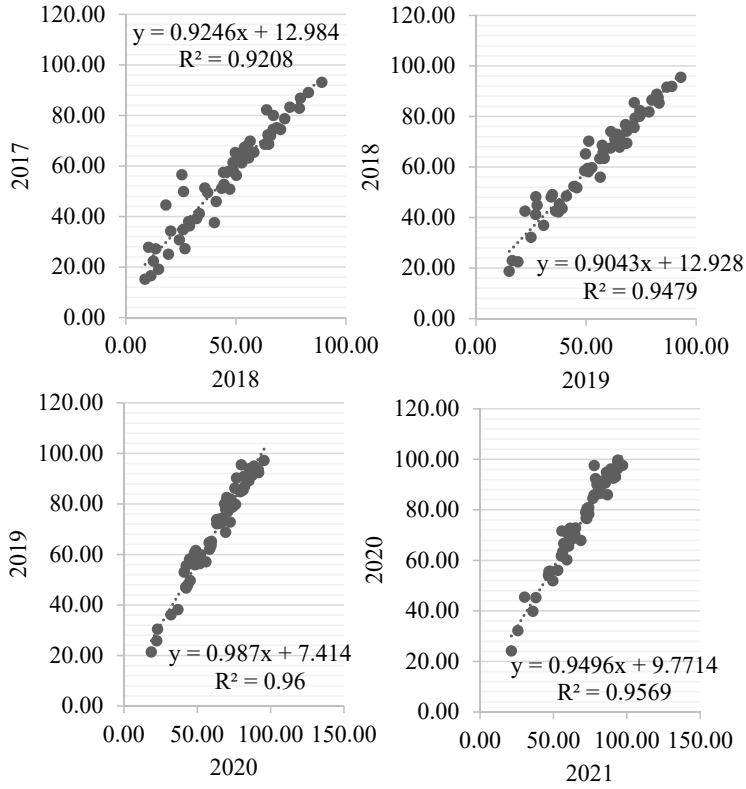

Figure A8. Stationarity test (the augmented Dickey–Fuller test, ADF) for GDP ($ECON_1$). Source: authors.

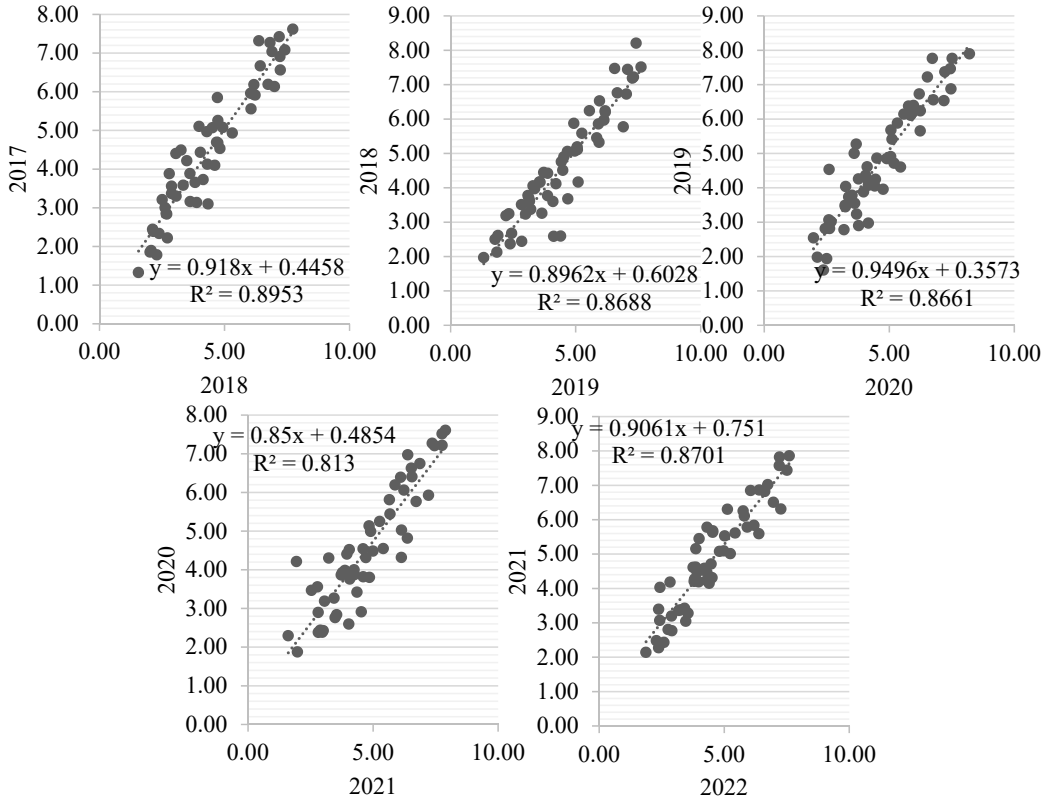

Figure A9. Stationarity test (the augmented Dickey–Fuller test, ADF) for tax evasion ($ECON_2$). Source: authors.

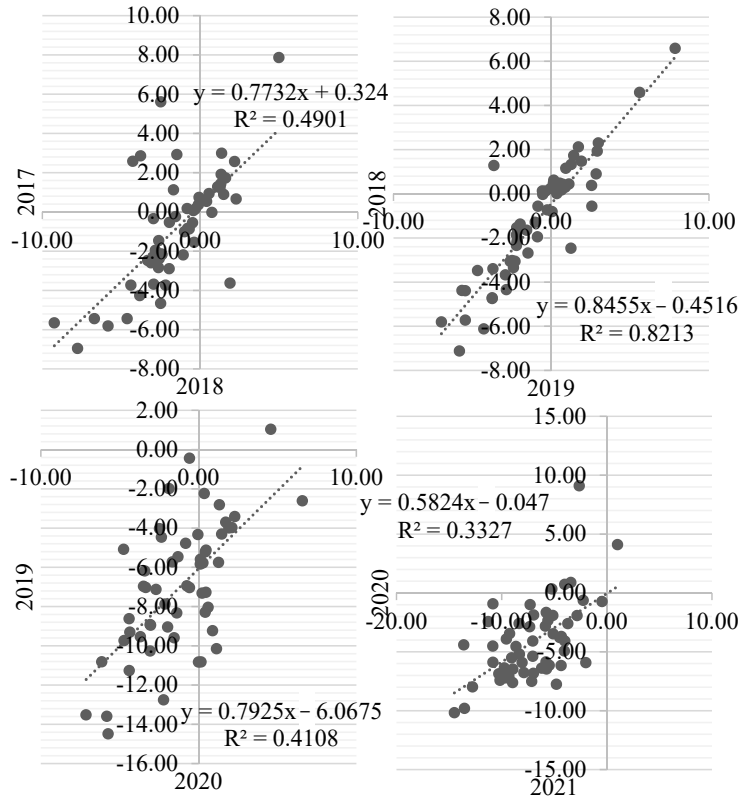

Figure A10. Stationarity test (the augmented Dickey–Fuller test, ADF) for government budget surplus/deficit (GBD). Source: authors.

References

Abakah, Emmanuel Joel Aikins, Aviral Kumar Tiwari, Imhotep Paul Alagidede, and Shawkat Hammoudeh. 2023. Nonlinearity in the causality and systemic risk spillover between the OPEC oil and GCC equity markets: A pre- and post-financial crisis analysis. *Empirical Economics* 65: 1–77. [CrossRef]

Abdel Fattah, Fadi Abdel Muniem, Khalid Abed Dahleez, Abdul Hakim H. M. Mohamed, Mohammad Khaleel Okour, and Abrar Mohammed Mubarak AL Alawi. 2022. Public health awareness: Knowledge, attitude and behaviours of the public on health risks during COVID-19 pandemic in sultanate of Oman. *Global Knowledge Memory and Communication* 71: 27–51. [CrossRef]

Abdelwahed, Nadia Abdelhamid Abdelmegeed, and Bahadur Ali Soomro. 2023. The COVID-19 Crises: The Threats, Uncertainties and Risks in Entrepreneurial Development. *Risks* 11: 89. [CrossRef]

Abdi, Yaghoub, Xiaoni Li, and Xavier Càmara-Turull. 2023. Firm value in the airline industry: Perspectives on the impact of sustainability and COVID-19. *Humanities and Social Sciences Communications* 10: 294. [CrossRef]

Abdullah, Dahlan, S. Susilo, Ansari Saleh Ahmar, R. Rusli, and Rahmat Hidayat. 2022. The application of K-means clustering for province clustering in Indonesia of the risk of the COVID-19 pandemic based on COVID-19 data. *Qual Quant* 56: 1283–91. [CrossRef]

Attaran, Mohsen. 2023. The impact of 5G on the evolution of intelligent automation and industry digitization. *Journal of Ambient Intelligence and Humanized Computing* 14: 5977–93. [CrossRef]

Busco, Carolina, Felipe González, and Michelle Aránguiz. 2023. Factors that favor or hinder the acquisition of a digital culture in large organizations in Chile. *Frontiers in Psychology* 14: 1153031. [CrossRef]

Chow, Gregory C. 1960. Tests of Equality Between Sets of Coefficients in Two Linear Regressions. *Econometrica* 28: 591–605. [CrossRef]

Cui, Yong, Saba Fazal Firdousi, Ayesha Afzal, Minahil Awais, and Zubair Akram. 2022. The influence of big data analytic capabilities building and education on business model innovation. *Frontiers in Psychology* 13: 999944. [CrossRef]

Davidson, Russell, and James G. MacKinnon. 1993. Estimation and inference in econometrics. *Econometric Theory* 11: 631–35. [CrossRef]

De Gooijer, Jan G., and Rob J. Hyndman. 2006. 25 Tears of Time Series Forecasting. *International Journal of Forecasting Twenty Five Years of Forecasting* 22: 443–73. [CrossRef]

Dohale, Vishwas, Priyanka Verma, Angappa Gunasekaran, and Priya Ambilkar. 2023. COVID-19 and supply chain risk mitigation: A case study from India. *The International Journal of Logistics Management* 34: 417–42. [CrossRef]

Erer, Deniz, Elif Erer, and Selim Güngör. 2023. The aggregate and sectoral time-varying market efficiency during crisis periods in Turkey: A comparative analysis with COVID-19 outbreak and the global financial crisis. *Financial Innovation* 9: 80. [CrossRef] [PubMed]

Fortunato, Francesca, Roberto Lillini, Domenico Martinelli, Giuseppina Iannelli, Leonardo Ascatigno, Georgia Casanova, Pier Luigi Lopalco, and Rosa Prato. 2023. Association of socio-economic deprivation with COVID-19 incidence and fatality during the first wave of the pandemic in Italy: Lessons learned from a local register-based study. *International Journal of Health Geographics* 22: 10. [CrossRef]

Fortune. 2023. Global 500. Available online: https://fortune.com/ranking/global500/2022/search/?fg500_industry=Telecommunications (accessed on 6 June 2023).

Garcia, Ronald, and Andrew Lumsdaine. 2005. MultiArray: A C++ library for generic programming with arrays. *Software Practice and Experience* 35: 159–88. [CrossRef]

Hean, Oudom, and Nattanicha Chairassamee. 2023. The effects of the COVID-19 pandemic on U.S. entrepreneurship. *Letters in Spatial and Resource Sciences* 16: 1. [CrossRef] [PubMed]

Hohenstein, Nils-Ole. 2022. Supply chain risk management in the COVID-19 pandemic: Strategies and empirical lessons for improving global logistics service providers' performance. *The International Journal of Logistics Management* 33: 1336–65. [CrossRef]

IMD. 2023. World Competitiveness Online. Available online: https://www.imd.org/centers/wcc/world-competitiveness-center/rankings/world-competitiveness-ranking/ (accessed on 6 June 2023).

Inshakova, Agnessa O., Anastasia A. Sozinova, and Tatiana N. Litvinova. 2021. Corporate Fight against the COVID-19 Risks Based on Technologies of Industry 4.0 as a New Direction of Social Responsibility. *Risks* 9: 212. [CrossRef]

Kanamura, Takashi. 2023. An impact assessment of the COVID-19 pandemic on Japanese and US hotel stocks. *Financial Innovation* 9: 87. [CrossRef]

Kolchin, Sergey, Nadezda Glubokova, Mikhail Gordienko, Galina Semenova, and Milyausha Khalilova. 2023. Financial Risk Management of the Russian Economy during the COVID-19 Pandemic. *Risks* 11: 74. [CrossRef]

Kukoyi, Patricia Omega, Fredrick Simpeh, Oluseyi Julius Adebowale, and Justus Ngala Agumba. 2022. Managing the risk and challenges of COVID-19 on construction sites in Lagos, Nigeria. *Journal of Engineering Design and Technology* 20: 99–144. [CrossRef]

Leung, Wilson K. S., Man Kit Chang, Man Lai Cheung, and Si Shi. 2023. VR tourism experiences and tourist behavior intention in COVID-19: An experience economy and mood management perspective. *Information Technology & People* 36: 1095–125. [CrossRef]

Litvinova, Tatiana N. 2022. Risks of Entrepreneurship amid the COVID-19 Crisis. *Risks* 10: 163. [CrossRef]

Loughran, Tim, and Bill McDonald. 2023. Management disclosure of risk factors and COVID-19. *Financial Innovation* 9: 53. [CrossRef]

McMillan, Michael. 2014. *Data Structures and Algorithms with JavaScript*. Sebastopol: O'Reilly Media, pp. 30–32.

Metwally, Abdelmoneim Bahyeldin Mohamed, and Ahmed Diab. 2023. An institutional analysis of the risk management process during the COVID-19 pandemic: Evidence from an emerging market. *Journal of Accounting & Organizational Change* 19: 40–62. [CrossRef]

Mezghani, Taicir, Fatma Ben Hamadou, and Mouna Boujelbène Abbes. 2021. The dynamic network connectedness and hedging strategies across stock markets and commodities: COVID-19 pandemic effect. *Asia-Pacific Journal of Business Administration* 13: 520–52. [CrossRef]

Moreno Ramírez, Denise, Shannon Gutenkunst, Jenna Honan, Maia Ingram, Carolina Quijada, Marvin Chaires, Sam J. Sneed, Flor Sandoval, Rachel Spitz, Scott Carvajal, and et al. 2022. Thinking on your feet: Beauty and auto small businesses maneuver the risks of the COVID-19 pandemic. *Frontiers in Public Health* 10: 921704. [CrossRef] [PubMed]

Ngo, Vu Minh, Hiep Cong Pham, and Huan Huu Nguyen. 2023. Drivers of digital supply chain transformation in SMEs and large enterprises—A case of COVID-19 disruption risk. *International Journal of Emerging Markets* 18: 1355–77. [CrossRef]

Phang, Soon-Yeow, Christofer Adrian, Mukesh Garg, Anh Viet Pham, and Cameron Truong. 2023. COVID-19 pandemic resilience: An analysis of firm valuation and disclosure of sustainability practices of listed firms. *Managerial Auditing Journal* 38: 85–128. [CrossRef]

Popkova, Elena G., and Bruno S. Sergi. 2021. Dataset Modelling of the Financial Risk Management of Social Entrepreneurship in Emerging Economies. *Risks* 9: 211. [CrossRef]

Salami, Babatunde A., Saheed O. Ajayi, and Adekunle S. Oyegoke. 2022. Coping with the Covid-19 pandemic: An exploration of the strategies adopted by construction firms. *Journal of Engineering, Design and Technology* 20: 159–82. [CrossRef]

Sozinova, Anastasiya A., and Elena G. Popkova. 2023. Dataset Analysis of Pandemic Risks and Risk Management Prospects Based on Management and Marketing in Conditions of COVID-19 Recession. *Risks* 11: 37. [CrossRef]

Tan, Xiaoyu, Shiqun Ma, Xuetong Wang, Chao Feng, and Lijin Xiang. 2022. The impact of the COVID-19 pandemic on the global dynamic spillover of financial market risk. *Frontiers in Public Health* 10: 963620. [CrossRef] [PubMed]

Tang, Hongfei, Kangzhen Xie, and Xiaoqing Eleanor Xu. 2023. COVID-19 Pandemic and Bond ETF Valuation Discount. *Journal of Fixed Income* 32: 83–155. [CrossRef]

Tingey-Holyoak, Joanne Louise, and John Dean Pisaniello. 2021. The need for accounting-integrated data streams for scenario-based planning in primary production: Responding to COVID-19 and other crises. *Sustainability Accounting Management and Policy Journal* 12: 898–912. [CrossRef]

Türk, Abdullah. 2022. Digital leadership role in developing business strategy suitable for digital transformation. *Frontiers in Psychology* 13: 1066180. [CrossRef]

Velayutham, Ajantha, Asheq Razaur Rahman, Anil Narayan, and Michael Wang. 2021. Pandemic turned into pandemonium: The effect on supply chains and the role of accounting information. *Accounting Auditing & Accountability Journal* 34: 1404–15. [CrossRef]

Vogl, Markus. 2022. Quantitative modelling frontiers: A literature review on the evolution in financial and risk modelling after the financial crisis (2008–2019). *SN Business & Economics* 2: 183. [CrossRef]

World Bank. 2023. GDP Growth (Annual %). Available online: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?view=chart (accessed on 1 August 2023).

Yamen, Ahmed Emadeldin. 2021. Tax evasion, corruption and COVID-19 health risk exposure: A cross country analysis. *Journal of Financial Crime* 28: 995–1007. [CrossRef]

Yelikbayev, Kuanysh, and Inna Andronova. 2022. The Interaction of the EEU Member States and Risks of Their Mutual Trade during the COVID-19 Pandemic: Implications for the Management of Corporate Social Responsibility. *Risks* 10: 27. [CrossRef]

Yeşildağ, Eser. 2019. Financial Risks and Derivative Use of Non-financial Companies in Turkey. *Frontiers in Applied Mathematics and Statistics* 5: 64. [CrossRef]

Yuan, Duanyang, Jingwei Yue, Xuefeng Xiong, Yibi Jiang, Peng Zan, and Chunyong Li. 2023. A regression method for EEG-based cross-dataset fatigue detection. *Frontiers in Physiology* 14: 1196919. [CrossRef] [PubMed]

Zhou, Haiyang, and Shuping Li. 2022. Effect of COVID-19 on risk spillover between fintech and traditional financial industries. *Frontiers in Public Health* 10: 979808. [CrossRef] [PubMed]