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The New Era of Business Digitization through the Implementation of 5G Technology in Romania

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Abstract: The main objective of the present research is to identify the advantages and benefits that the use and implementation of 5G technology has on the development and evolution of the Romanian business environment. The study is based on a theoretical documentation regarding existing information in the field and a descriptive analysis of the evolution of the technology in Romania and worldwide. The research method chosen is a survey based on an opinion poll (questionnaire) to find out the availability of economic entities regarding the implementation of 5G technologies, the foreseen expectations and those realized by the business environment regarding the effects of 5G technologies on the economic activities and the benefits that 5G networks offer them. The analysis of the results of the questionnaire, through the correlations and contingency tables determined, allowed the validation of the research hypotheses, and the results show availability and interest for the implementation of 5G technology (over 69% agree with the 5G implementation over a period of up to 5 years), conditioned by the costs, the high degree of cyber security, and the competitive advantages it can generate. Competition, low productivity, and even external pressures are the main decisive factors in the implementation of 5G. Thus, it can be considered useful to extend the research by identifying possible viable solutions or alternatives, customized for the implementation of 5G technologies for economic entities from different sectors, as well as the analysis of the implementation costs and the potential economic benefits.

Keywords: 5G; Industry 4.0; artificial intelligence; machine learning; virtual reality; big data analytics; internet of things

1. Introduction

Combining emerging technologies (Artificial Intelligence (AI), Machine Learning, Virtual Reality (VR), Big Data Analytics, Internet of Things (IoT)) with improved 5G connectivity will significantly contribute to the metamorphosis of society and the economy to the 4th industrial revolution or Industry 4.0. Artificial intelligence, automation processes, Big Data, the cloud, algorithms, and 5G technology contribute to machine activation and industries such as food, retail, and banking becoming more digitalized. Computer systems take information, analyze patterns from it, and ultimately produce results based on a previously learned function. These results have many characteristics of human thought processes and are therefore referred to as intelligent. Automation means teaching a machine several repetitive operating steps and the machine repeats these over and over again. AI, on the other hand, is suitable for processes that are more complex and cannot be described in clearly sequential steps. Artificial intelligence describes the ability of machines to execute tasks autonomously based on algorithms and to react adaptively to unknown situations. Their behavior is thus similar to that of humans: they not only perform repetitive tasks, but also learn from success and failure and adapt their behavior accordingly. In the future, artificial intelligence machines (AIM) should also be able to think and communicate like humans. The Big Data solution is a new opportunity for today's business. Big Data offers the ability to store and transfer information and files within the business. Big Data is an artificial intelligence solution used in many fields; therefore, most operating systems such as Linux®, UNIX®, and Windows® (LUW) already contain high-value data and drive critical transaction processes for various missions. Through Big Data, we can monitor data and fast-moving operations from most sources, meaning we can act immediately to optimize performance, protect information, and especially prevent fraud [1–4]. The convergence of these technologies allows the industrial sector to respond to both customer requirements (personalization, increased safety, and comfort), as well as environmental requirements for energy efficiency and rationalization of resource use [5,6]. 5G is the fundamental element of the future digital economy, which will contribute to job creation and sustainable global growth [7–9]. 5G era-specific communication networks will also have significant social roles by connecting people, machines, and things on a massive scale, facilitating the provision of personalized healthcare, and also contributing to optimizing transportation and logistics and increasing access to culture and education [10,11]. According to studies conducted by Price Waterhouse Coopers (PwC) in 2016, approximately one third of economic entities have a high level of digitization and industrial digitization is expected to increase from 33% to 72% over the next 5 years [12]. A significant number of companies develop new products and services with digital features that cover the entire product life cycle [13].

The business environment considers mobile connectivity to be essential, and the implementation of 5G technology generation will contribute to improving the consumer experience and increasing business utility through faster data transmission and more reliable connectivity [14–16]. It is estimated that, around the world, will be 550 million 5G subscriptions and a population coverage of 10% by the end of 2022, and by 2024 an increase in mobile subscriptions has been estimated to exceed 60% [17–19]. The 5G radio interface brings transfer speeds of up to 20/10 Gbps DL/UL, which means 2 to 3 times the performance improvement and ensures 5 to 100 times energy efficiency with a bit cost of 10 or lower [20]. In addition to broadband services, 5G technology, by providing higher bandwidth and ultra-low latency, will help accelerate the digitization of economic sectors and public systems (auto industry, utilities, public safety, manufacturing, health system, media, gaming) [9,21,22]. Business digitization can help increase the productivity of economic entities and increase consumer satisfaction [23–25]. The materialization of 5G benefits globally is forecast for the 2035 time horizon 2035 when the annual output of 5G-enabled products and services will be valued at USD 12.3 trillion [7,8]. At the same time, advanced data analysis and prediction techniques allow economic entities to perform advanced segmentation of markets and consumers, as well as the prediction of consumption habits, thus maximizing the value added per customer [26]. The 5G data point compilation and managing ability is accelerated by edge computer science, the functionality helps particular characteristics of sophisticated data evaluation and digitization [27–29].

The study conducted by the European Commission on identifying and quantifying key socioeconomic data to support strategic planning for the introduction of 5G in Europe shows that the installation and use of 5G networks in Europe will have significant direct, indirect (multiplication), and induced (training) effects, respectively: (i) the effects of multiplication throughout the EU are estimated at 142 billion euros and 2.4 million jobs; (ii) the estimated training effects for four sectors (motor vehicles, transport, utilities and health) show benefits of 62.5 billion euros per year, at the EU level [6]. At the same time, the evolution of artificial intelligence is supported by the management of large amounts of digital data that can be analyzed to generate perspectives and predictions of behaviors by using algorithms, as well as by the advanced processing power of the computer [30,31]. It has been estimated that technology using artificial intelligence has the potential to generate an additional global economic output of approximately USD 13 trillion by 2030 [32].

As far as Romania is concerned, the multiplier effects in the economy of 5G adoption are estimated to be 4.7 billion euros, which means an increase of over 252,000 jobs [33]. To stimulate the development of 5G in Romania, some concrete aspects must be taken into account: availability in 2019, an important quantity of radio spectrum representation, for territorial coverage and capacity; introduction of new rights in the frequency bands suitable for coverage in January 2020; interventions regarding the authorization regime for construction works; and pilot projects for testing and validating 5G performance. Regarding the trust of digital technologies for SMEs, in DESI 2019, Romania ranks 27th among the countries in the EU; thus, 11% of Romania's economic maintenance can offer an opportunity to provide a large volumetric data analysis (big data), 9% of them use social networks, 7% use cloud services, and another 8% of all SMEs for online sales (while 2% of them can make cross-border online sales) [5,6]. 5G is expected to be launched in Romania in 2020, testing and analyzing having been ongoing for 3 years now. Unlike existing technologies, 5G is designed for a fusion of internet consumption, with the aim of bringing innovative solutions and greater performance to the industrial sectors [34–36]. In this context, the objective of this paper is to investigate the availability regarding the implementation of 5G technologies; we do so by envisaging its business environment, to establishing potential 5G technologies, to activating new activities and reviewing the benefits of 5G networks. Based on the available information, we carried out variable analyses looking for correlations to validate our research hypotheses that were the basis of this work: H1—the use of 5G technology is absolutely necessary for the Romanian business environment; H2—the implementation of 5G technology in economic transactions is influenced by scope, size, and form of ownership; H3—5G technology innovations bring economic and social benefits for social enterprises. Our research structure of analyzing the main studies in the literature regards the new digital business for the implementation of 5G technologies, materials, and methodology applied to the tracking of the results and the conclusions of the research. Our research structure of analyzing the main studies in the literature regards the new digital business for the implementation of 5G technologies, materials, and methodology applied to the tracking of the results and the conclusions of the research.

2. Review of the Literature on the New Era of Business Digitization through the Implementation of 5G Technology

5G technology represents the evolution of radio access networks that meet future data transmission requirements, but also a revolution in network architecture, to develop cost-effective flexible networks [37,38]. The 5G network will give the user infinite internet perception, or infinite network capacity, which means that there will always be sufficient capacity available for any kind of data transfer required [39]. Due to the flexibility of the configuration and distribution of limited resources/capacity both in time and in space, the network will be able to react to the local data demand by giving sufficient capacity to meet the needs of the services in real time. 5G will integrate new radio access networks with previous generation radio access technologies (3G, 4G, Wi-Fi) [40,41]. Thus, 5G represents a convergence of previous generations of technologies, being for the first time a new generation of technologies that integrates previous generations into a new integrated and dynamic radio access network, through connectivity management mechanisms [42–46].

To ensure connectivity for a diverse range of applications that have new features and diversified requirements, the capabilities of 5G wireless access must extend beyond the capabilities of previous generations of mobile communications [47]. The 5G targets in terms of general technical performance are: 10 to 100 times higher data usage rate, obtaining 1 Gbit/s to 20 Gbit/s for dense urban clusters; 1000 times higher volume of mobile data per area, reaching traffic density values $\geq$ 10 Tb/s/km^2; 1000 times more connected devices, reaching a density of $\geq$ 1 M terminals/km^2; 10 years of battery life for large M2M devices (sensors, actuators, smart meters, etc.); ultra-low cost for M2M devices; increased coverage for M2M devices; ultra-fast response, reaching a latency of 1 ms for vehicle-to-vehicle communications and 5 ms for tactile Internet; ultra-high reliability in achieving packet losses of 1 in 100 million transmitted; and very strong security [48]. These goals can be achieved by adopting new efficient radio communication and system architecture techniques, which will utilize a variety of radio frequency bands, starting from traditional frequency bands for mobile communications (below 3 GHz) and up to frequency bands from the millimeter wave range (over 20 GHz). The radio spectrum requirements to support the development of 5G technologies represent a combination of frequency bands in the spectrum below 1 GHz, between 1 and 6 GHz and above 6 GHz, which have different characteristics but offer different advantages [49]. At the European level, the Radio Spectrum Policy Group (RSPG) has identified as priority bands [50] for the early introduction of 5G mobile communications systems in the 700 MHz band of the European Union (694–790 MHz), 3400–3800 MHz band and 26 GHz band (24.25–27.5 GHz), features shown in Table 1.

Table 1. Frequency band characteristics.

No.	Frequency Bands	Characteristics
1.	700 MHz	This is suitable for ensuring efficient coverage over large areas, as well as for improved coverage inside buildings, due to the propagation of radio waves over longer distances and better penetration inside buildings than those of higher frequency bands; The spectrum available in the 700 MHz band (in addition to the 800 MHz band) offers MFCN networks the opportunity to provide cost-effective coverage in rural areas; Like other bands below 1 GHz, it is suitable for the provision of narrowband IoT services, which require extensive coverage area and very good penetration within buildings and/or constructions; It will extend the spectrum below 1 GHz already used for the provision of broadband mobile communications services using LTE technology and will facilitate the implementation of 5G networks and the widespread introduction of innovative digital services.
2.	3400–3800 MHz	This is considered a primary bandwidth suitable for the introduction of 5G services before 2020, as it offers relatively large bandwidths and a good compromise between coverage and capacity, ensuring a significant increase in capacity and supporting enhanced broadband communications as well as applications that need low latency and high reliability, such as applications for critical missions (industrial automation and robotics)
3.	26 GHz	This is a pioneering band for early 5G harmonization in Europe, by 2020, as it offers over 3 GHz of continuous spectrum and allows the provision of dense high capacity networks over short distances, and revolutionary 5G applications and services, which entail transfer speeds very large data, high capacity, and very low latency.

(source: [42–44]).

Additional technological components for 5G radio access include [51,52]: advanced multiantenna, MIMO, and 3D beamforming technologies; ultralean transmissions to reduce interference caused by common signal resources and to maximize resource efficiency; flexible duplex in certain deployments of isolated local networks (dynamic FDD and/or TDD); access/backhaul integration, where fixed or wireless access uses the same technology and global spectrum; RAN virtualization, which contributes to the improvement of network efficiency and performance, making it possible to centralize Virtual Network Functions (VNF) on a common platform that supports both 4G and 5G; smart connectivity (5G and 4G coverage areas overlap), allowing the network to intelligently target data based on application requirements and the validity of network resources, enhancing the combined data transfer of 4G and 5G resources; and reducing the latency for shortening access procedures and changing the framework structure for instant access to the network.

5G will be used for [7,8,53]: (i) Enhanced Mobile Broadband (eMBB), which has two facets of function—expanding cellular coverage across a wider range of structures, including buildings offices, industrial parks, shopping centers, etc., and the improved ability to manage a significant number of devices using large volumes of data, especially in localized areas; (ii) Massive Internet of Things (MIoT)—5G will provide deeper and more flexible coverage, which will result in significantly lower costs within MIoT settings for applications targeting asset tracking, industry, agriculture and smart cities, monitoring from distance, interconnected factories, etc.; and (iii) Mission Critical Services—5G will support applications that require high reliability, ultra-low latency connectivity, strong security and availability used for autonomous vehicles, drones, smart grids, telemedicine. These considerations will lead to the adoption and creation of value in the 5G economy. Initial 5G deployments will focus on eMBB applications that focus primarily on human needs, but will also include new application areas that have requirements for improved performance, which require very high data traffic capacity and more efficient data transmission, but with a lower bit cost for data transmission [4].

The Internet of Things (IoT) represents the next major innovation from an economic and social point of view, after connectivity [54]. Through IoT, any physical or virtual object can be connected to other objects and the Internet, creating a network between objects as well as between people and objects (Figure 1) [17–19,34–36]. IoT can combine the physical and virtual worlds by creating a smart ecosystem that can perceive and effectively analyze the environment and adapt effectively to human needs [5,6]. Ericsson estimates that the number of connected devices to the Internet of Things will average more than 20% annually by 2022, which will be fueled by a wide range of usage scenarios and price reductions for connected devices/things [17–19,42–44]. At the same time, the existing coverage of mobile networks puts their operators in a favorable position to provide the necessary connectivity for emerging IoT applications [42–44].

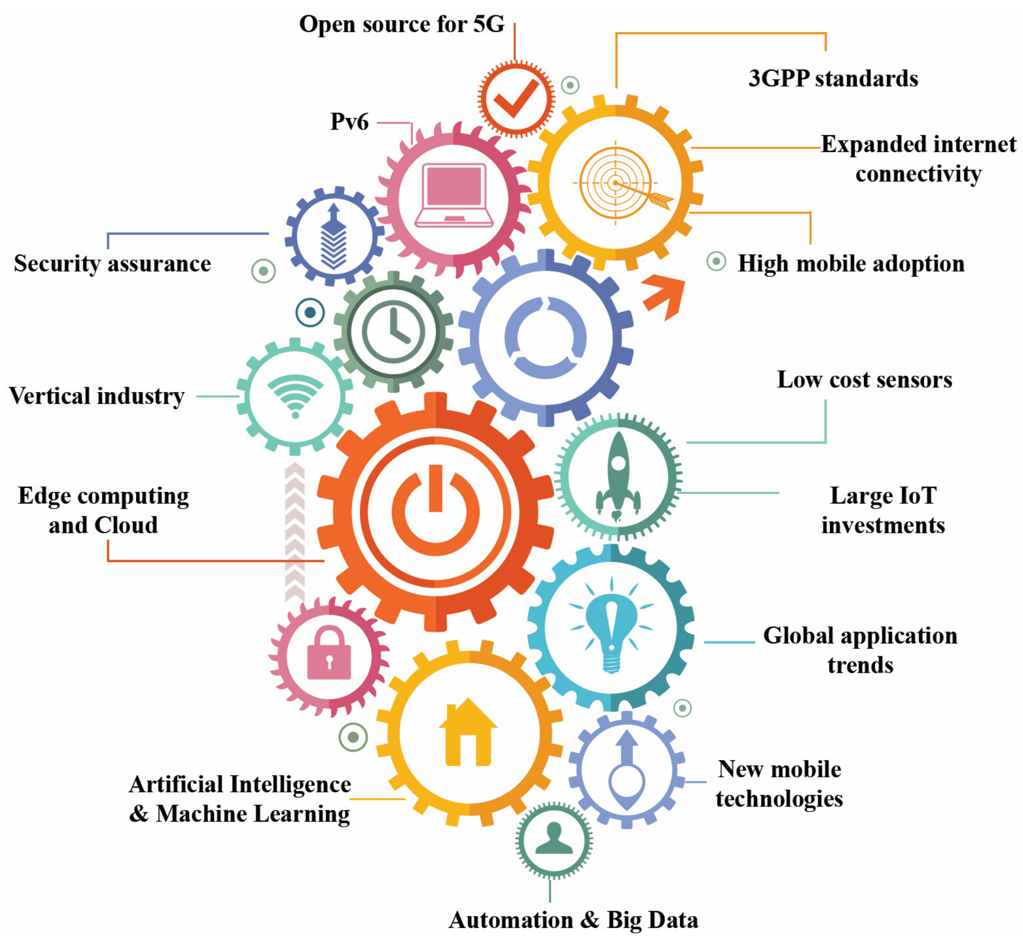

Figure 1. IoT and 5G technologies.

Currently, alternative technologies, including 4G services upgrades, are sufficient to meet the medium-term demand for IoT [55,56]. 5G brings reliability, low latency, scalability, security, and mobility, components that can support the massive proliferation of IoT ecosystems [17]. 5G will serve consumers, businesses and lead the Internet of Things to the next level: to MIoT [18]. The effect of 5G on productivity growth will be due to the evolution of production factors, inputs and outputs, as a result of the integration of 5G technologies [34–36,57]. The effects of 5G on production include: (i) increasing the efficiency of production processes by monitoring the use of raw materials in order to improve energy consumption, as well as safety and quality (zero defects); (ii) increasing the quality of products through quality control based on augmented reality, which contributes to the identification and resolution of faults in real time; (iii) real-time process automation, through the use of collaborative robots; (iv) robotics in the cloud; (v) inventory management automation; (vi) navigation and assisted navigation within an installation or outside it using augmented reality; and (vii) streamline product distribution [58,59]. Worldwide, 5G is expected to make a significant contribution to industrial production in 2035, with 5G's largest contributions being generated in information and communications technology, public services, agriculture, forestry, and fisheries, transport and logistics, hotel industry, construction, finance, insurance, and public utilities [8].

Efficient use of capital and labor may also result from increased machine-to-machine (M2M) technology that enables network devices to perform actions and exchange information without human guidance in real-time using 5G Internet [35]. At the same time, production systems that are based on connectivity and computing infrastructure contribute to achieving the primary objectives of Industry 4.0, namely flexibility, versatility, resource efficiency, cost efficiency, support for workers, quality of industrial production and logistics [27,28]. Smart factories are characterized by the implementation of flexible modular production systems, which have versatile production assets and use efficient wireless communication services [60]. The materialization of the benefits derived from the implementation and use of 5G technology, respectively, the productivity increases in the economic and social sectors, the creation of new jobs, etc. require massive investments, time, and a favorable environment for the development of comprehensive digital ecosystems, both in private and public areas [42–44]. At the same time, 5G implies the evolution and emergence of new stakeholders presented in Figure 2.

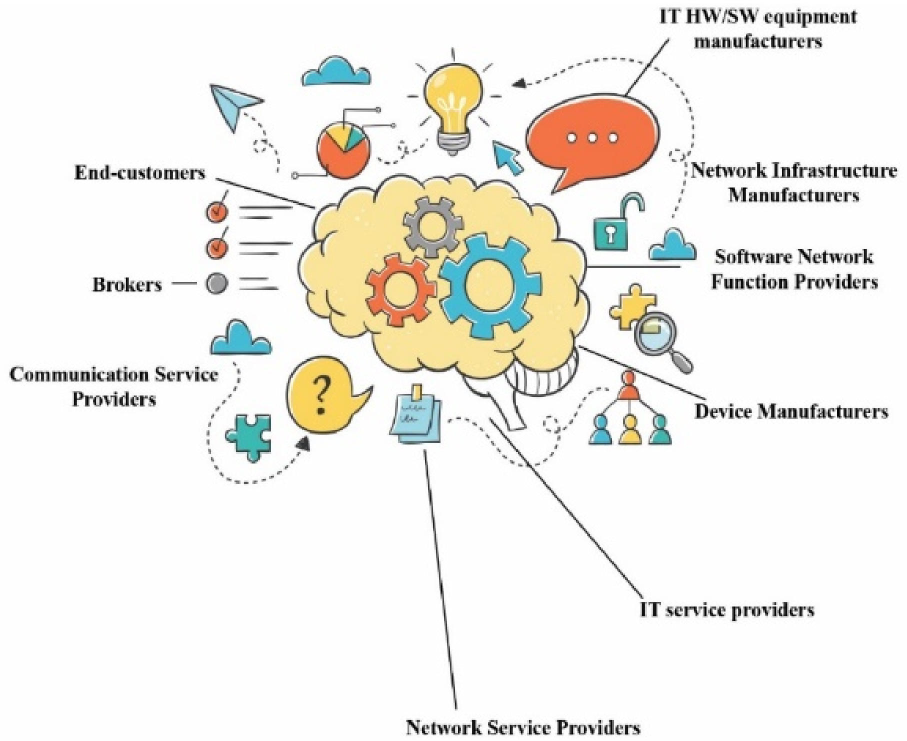

Figure 2. Stakeholders in the 5G era.

The benefits of exploiting on 5G implementation are [61]: (i) immediate advantages for users of 5G customer services, resulting from their approach to enhanced outcomes and customer services (in conditions of costs, value, knowledge, security, etc.); (ii) the considered advantages of vertical businesses, achieved over the better condition of data on manufacture chains, domestic processes, marketplace attributes, separation, consumption practices, etc., refereed by the usage of 5G services; (iii) operative assistances: increasing the production of vertical industries, as a outcome of actual capitalization of data on internal processes; and (iv) benefits for end-to-end or tertiary segments ensuing from the usage of the progressive techniques of real-time data handling interceded by 5G. There are also benefits for the commercial environment: introduction of new corporate models [62], arbitrated by the use of 5G diversity competences; and economic and social assistances, i.e., the cumulative economic output of companies and creating new jobs.

The value capabilities proposed by 5G for vertical industries (Figure 3) are: (i) 5G aims to enable a ubiquitous video experience through virtual media, augmented reality, holograms and other immersive technologies that will allow real-time interaction; (ii) 5G will cause the Smart Office revolution, as all office equipment will be wirelessly connected and integrated, being accessible from anywhere using a screen and a user interface; (iii) 5G aims to deliver 50 Mbit/s anywhere, ensuring a high quality of services; (iv) 5G innovation, especially in the basic network, will allow the possibility of creating a user's own network; (v) 5G flexible architecture will allow the relocation of resources to increase the network's ability to serve a large number of users; (vi) 5G supports the evolution of the transport systems towards a higher level of speeds; (vii) the entire 5G system is designed to provide very large scale support to M2M/IoT networks; (viii) 5G will allow an ultra-reliable network for critical applications, for supporting the demands of current applications, as well as for future vertical industry specific applications; and (ix) 5G will make possible the realization of the tactile Internet that will use new user interface technologies, such as augmented reality and remote robotics [63,64].

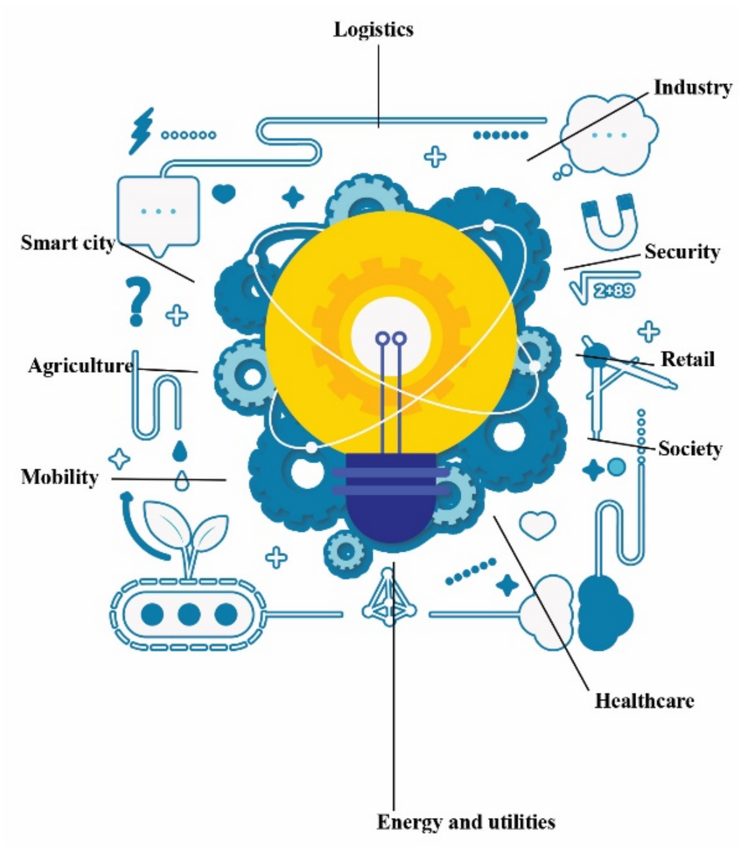

Figure 3. Vertical industries.

In addition to the new corporate models facilitated by the digitization of the economic sectors [65], the expansion of 5G progress may be related with the modification of elements in traditional models of delivering facilities and infrastructure networks and the emergence of new positions in the value-producing chain [66]. The characteristics with substantial possibilities are: (i) diversity of customer services, which, across virtualization and automation, network separation, etc., can lead to an increase in the demand for mobile connectivity, but also to the involvedness of the tariff models; (ii) expansion of connectivity requests: produced by the development and application of IoT technologies, in combination with their aptitude to be linked to alternative networks (5G private networks, or Wi-Fi), determining the appearance and expansion of new charging models, as well as the development of the position on the cost chain; (iii) new downstream intercessors: 5G opens mediation chances in the facility of services, for example connectivity collectors for certain products, multinational industrial sectors; (iv) compression of networks and intermediaries upstream: this might determine new chances for mediation, upstream of traditional communication network providers, i.e., companies specialized in the acquisition, installation or operation of sites in well–defined areas, hot spots with very high density, which provide wholesale connectivity services to providers of nationally covered mobile networks; and (v) fixed-mobile convergence–public safety services and disaster intervention [61].

The digitization at the level of an economic entity concerns its key processes: distribution, sales, financial, production, communication, etc. At the same time, digitization also involves the transfer of administrative or promotional and marketing practices in the digital environment (electronic invoicing, electronic signature, electronic archiving, cloud storage, Facebook page, company website, etc.). Digitalization also involves the use of digital services in key processes, such as: Enterprise Resource Planning (ERP) for integrated management of all processes and operations within an entity within a single information platform; Customer Relationship Management (CRM) for efficiently managing the demand and supply of goods and services in order to improve the customer relationship; Advanced Planning & Scheduling (ARP) for production planning; and Business Intelligence (BI), etc. [67,68]. Thus, to date, industrial digitization has focused on improving operational efficiency, facilitating quality control, and reducing costs, and the use of sensors, integrated software and communications technology, etc., in manufacturing have determined that physical products become smarter. The evolution of 5G technology proposes the development of (new) smart data-based services, and value creation is based on new customer-centric experiences that come from the combination of smart products and smart services [69–72]. The potential contributions of 5G technology to key economic sectors is reflected in Table 2.

5G involves supplementary investment and budgets to build the physical infrastructure of the networks; thus, at the European Union rank, 5G is projected to require 56–58 billion euros of financing by the year 2025. Radio frequencies directly influence the prices of 5G application, through the price spectrum as well as the funds required to “accommodate” facilities at various frequencies, bringing into account transmission types [5–8,42–44].

In 4.0 industries, the use of 5G connectivity is grounded on appliance-type infrastructures that board both manufacturing developments achieved within closed-loop economic companies and their incorporation amid diverse economic companies, such as: (i) devices installed on a manufacturing line that robotically interconnect with controller units, guaranteeing important flexibility and effectiveness of manufacturing cycles; (ii) autonomous vehicles used to transport goods securely and competently within the factory; (iii) automation of the technical procedures, accomplished by the application of a large quantity of sensors and actuators that interconnect and obtain directions from control units, contributing to the intensification of effectiveness and the decrease of inventories; (iv) perpetual chase contributes to the optimization of the flow of goods in different periods of processing, from the raw material to the finished product and until the delivery to the customer; (v) remote assistance and control of robots to perform tasks, measurements, etc.; and

(vi) augmented reality promotes the development of the physical environment necessary for protection procedures or employee coaching [73,74,76–78].

Table 2. Potential contribution of 5G technology to key sectors.

No.	Sector	5G Use Cases	Impact of 5G Use
1.	Automotive Industry	autonomous vehicles	execution of functions such as crash prevention, difficulty decelerating, smart systems, platooning, and fulfilling V2V connections outside the field of vision, centered on enhanced location, etc.; enhanced security;
		infotainment services	on-demand performance, tourism assistance services and roadside support, road traffic managing, local weather conditions or road assistance, etc.
		data collection	producing substantial volumes of telemetry information begins up chances for new assurance types;
		remote monitoring and predictive maintenance	effectiveness developments;
		remote monitoring of car condition and predictive maintenance	enhanced protection.
2.	Media and entertainment industry	encouraging superior quality data facilities	allow users to connect with media facilities at significant issues;
		immersive media	encourage the development of collaborative media and enhanced, immersive video;
		new allocation tools	permits discovering the application of multicast and broadcast types over wireless linkages;
		cooperative/off-site media production	improves to eliminate fabrication from supply-heavy, on-site, beyond transmission units to a main position, hypothetically creating budget savings and further effective usage of assets.
3.	Manufacturing industry	cell automation	devices in a construction field and power divisions transmit wirelessly and impact the growth of the flexibility and productivity of the manufacture;
		automated guided vehicle	autonomous automobiles utilized to transport goods to manufacturing works improve security and productivity;
		process automation	a high amount of low-protection sensors that can transmit wirelessly with controller elements improve effectiveness and flexibility of technological practices;
		logistics tracking	following the movement of goods from raw resources to transport support to improve effectiveness, reducing budget and schedule;
		remote assistance and robot control	distant control of machine to execute tasks such as dimensions, mining, and so on, take the lead to enhance the superiority of manufactured goods and practices;
		augmented reality	live direct or indirect point of view of a natural ecosystem for teaching and maintenance, improve effectiveness, employee fulfillment.

Table 2. *Cont.*

No.	Sector	5G Use Cases	Impact of 5G Use
4.	Logistics	IoT-driven smart inventory management	use of pallet labelling, cameras, sensors, robotics to accomplish damage recognition, real-time visibility, and precise inventory control might improve depot effectiveness and safeguarding assistance value;
		optimal asset utilization	linking equipment and vehicles to a main structure to screen all resources in real time and to facilitate prognostic maintenance, decrease errors and improve workers productivity;
		fleet and asset management	application of sensors and wireless connectivity to generate swift productivities take the lead improved routes, enhanced fuel economy, decrease remove miles;
		drone delivery	use of drones to provide packs by utilizing a remote controller method produce a superior transport rate and access to low down inhabitants' areas;
		truck platooning	platooning of delivery automobiles provided with commonly linking intelligent technology produces improved capability and price effectiveness;
		connected ports	devices, machines and humans sharing real-time data to facilitate interfaces to work in a smarter manner produces improvements in exchange and an exact following.
5.	Agriculture	precision farming	use of sensor information to determine harvest yields, humidity levels, and land topography confirms productivity and sustainability, safeguards ecosystem;
		smart irrigation	use of IoT to determine humidity, soil moisture, temperature, etc. Determining accurate water conditions means greater effectiveness of irrigation;
		soil and crop monitoring	use of sensors to screen humidity and detect issues such as infections or insects allow changes to advised agriculture choices, reduce destruction;
		precision livestock farming	Real-time monitoring of manufactures, health, and wellbeing of livestock ensures optimum produce, allows informed farming choices;
		agriculture drones	use of drones to observe crop health, scanning areas produces enhanced security, effective examination, and monitoring.
6.	Energy and utilities	smart metering	use to provide consumers with more data about their energy use in nearby real-time, permitting them to make more economical choices. Also, by notifying the provider of their precise energy use, eliminating the necessity for physical meter evaluations, consumers will obtain more precise invoices and contractors can better handle events and assets created on the enhanced data;
		smart grids	superior controlling of the energy grid, to respond to the challenges of volatile renewable energy creation, and as demand for energy and patterns of use progress as well.
7.	Healthcare	remote monitoring of health or wellness data through wireless devices	offer new openings to examine wellbeing remotely and to offer superior medical information to healthcare providers, incorporating medical data/information;
		assets tracking and management in hospitals	price savings and productivity advantages through enhanced tracing of important resources within the hospital and management of pharmaceuticals e.g., tracing those next to end of expiry data and/or having automated ordering systems in place to restock key items;
		wireless tele-surgery	allow experts to connect with a regional surgeon remotely or permit for hospital to take place for those patients in remote or unsafe places;
		smarter medication connected ambulances	linked with health examining devices, medication might be administered instantly when necessary; permit ambulances to communicate crucial data (telemetric information, high-definition video) to the hospital.

(source: based on [10,42–44,55,73–75]).

The characteristics of Industry 4.0 adapted to the era of 5G technology are the following: interoperability—the ability of machines, devices, sensors, and people to connect and communicate with each other through IoT or IoP; Transparency of information—the ability of computer systems to create a virtual copy of the physical world by integrating and using sensors in factories; technical assistance—the ability of assistance systems to support people by aggregating and visualizing relevant information for informed decision-making and solving real-time urgent problems; decentralized decisions—cyber-physical systems can make decisions on their own and perform their tasks in the most autonomous way possible; cross-solutions—the particularities of different factories are standardized through the Cloud database; modularity—the ability to adapt quickly and smoothly to seasonal changes and market trends [79–81]. The 2030 vision for Industry 4.0 emphasizes the essential characteristics, namely autonomy, interoperability, and sustainability, which are presented in Table 3.

Table 3. Vision 2030 for Industry 4.0.

	Autonomy	
Digital Infrastructure Autonomous and resilient, bringing together all the global requirements and services necessary for the collection, exchange, analysis, and cross-border and cross-sectoral use of the necessary data ecosystems Industry 4.0.	Safety and Security Data protection and information security are a basic condition for Industry 4.0 and cooperation in digital ecosystems.	Technology Development Industry 4.0 requires technology-neutral research, development, and innovation in the basic fields of digital industrial value creation.
	Interoperability	
Standards and Integration Integration of individual solutions to become Industry 4.0 systemic solutions must be achieved by developing standards in accordance with the needs of digital ecosystems.	Regulatory Framework	Decentralized Systems and AI Autonomous, decentralized, and embedded intelligence systems are important in digital ecosystems to create industrial value and allow the development of new business solutions and models by using AI at different levels of industrial practice.
	Sustainability	
Decent Work and Education Industry 4.0 contributes significantly to improving working conditions and increasing the level of education of the workforce through lifelong learning.	Social Participation Industry 4.0 represents a transformation process that encompasses the entire society and involves major changes.	Mitigation of Climate Change Industry 4.0 allows the efficient use of resources through a combination of design-based and process-based approaches to create closed product lifecycles that contribute to environmental protection and mitigate climate change.

(Source: processing after: [71,72]).

Industry 4.0 encompasses four dimensions [82–85]: smart factories (a production environment in which production systems and logistics systems are organized largely without human intervention, based on cyberphysical systems (CPS), which links the physical and virtual worlds through communication through an IoT infrastructure and digital modeling through intelligent data collection, storage, and processing for provision of information and efficient use of resources); intelligent products (result from an automatic, flexible and efficient production in which production processes can be improved and guided autonomously in real time, and the status of the products can be monitored and optimized according to the customer requirements); intelligent operations (Industry 4.0 achieves an integration between enterprises and the physical and virtual world, by using information technologies for production planning and supply chain management systems); data-based services (the objective is to align future business models and improve customer benefit). Industry 4.0 represents the fusion of the physical and virtual worlds, because the first two dimensions (smart factory and intelligent products) refer to the physical world, while the other two dimensions (intelligent operations and data-based services) are the virtual representation of the physical dimensions [86].

3. Materials and Methods

To validate the research results, we carried out empirical research based on an opinion poll (questionnaire). The design of the questionnaire and the formulation of the questions are in accordance with the main objective of this research, namely to observe the degree of use of 5G technology in Romanian economic entities and to observe the impact of this technology on the national business environment (business environment represents the totality of internal and external factors of the economic entity, such as management, employees, customers, suppliers, etc.). The questionnaire consisted of 12 questions with closed answers and 2 questions with precoded answers, structured on a 5-stage Likert scale. 5G technology will be promoted on the market by telecommunications providers, but what we intend to observe through the present research is what 5G technology represents for economic organizations, how 5G technology will affect economic activity, and what are the major benefits that 5G networks have offers to companies? To answer these questions, we have established the following research hypotheses: H1—the use of 5G technology is absolutely necessary for the Romanian business environment; H2—the implementation of 5G technologies within the economic entities is influenced by the activity field, the size and the form of ownership; H3—5G technology innovations bring economic and social benefits to economic entities.

The questionnaire was sent to 440 economic entities from different fields of activity, by email, to facilitate their filling in and retransmission. A random sampling method was used, the target group of the study was represented by Romanian economic entities from related and diverse fields such as the extractive industry, processing industry, energy industry, transport, construction, hotels and restaurants, education, health and other administrative and social services. From the 440 questionnaires sent, we received a response from 362 respondents. Following the verification of the questionnaires received, 36 of them could not be validated, because the answers were not relevant, so we recorded 326 valid questionnaires and a response rate of 74%. After collecting the completed questionnaires and removing the invalid questionnaires, the collected data was centralized and recorded with the help of Microsoft Excel, creating the database needed to interpret the results. Interpretation and statistical analysis of data collected from questionnaires, as well as graphical representations, were made with the help of the IBM SPSS Statistics 20 specialized application. The SPSS application is one of the most used in the statistical analysis of data in various fields starting with marketing, experimental research, education, and ending with health, insurance industry, etc. [87,88].

4. Results

The questionnaire started with five closed questions necessary to know the profile of the respondent. Thus, we observed that the largest share was held by economic entities in the field of commerce 68 (20.90%), followed by economic entities in the field of construction 45 (13.80%), hotels and restaurants 38 (11.70%), the manufacturing industry 35 (10.70%), transportation and storage 31 (9.50%) and the extractive industry 28 (8.60%) (Table 4). Regarding the sample of economic entities according to the field of activity, we observed that it was relatively homogeneous, there was not a very large discrepancy between the number of respondents according to the fields of activity, except in the fields of production and supply of electricity, heat, gas and water, education and health, where the lowest percentage of validated questionnaires was recorded.

From the collected information we can see that most of the economic entities were entities with Romanian private capital, and the largest share was held by large companies with over 250 employees. The economic activity of the economic entities took place mainly in the urban environment 270 (82.80%) compared to only 56 (17.20%) in the rural area. Regarding the profile of the respondents participating in the study, we note that the majority was represented by the members of the financial accounting department, thus: 83 (25.50%) of the respondents belonged to this category, while 81 (24.80%) were members of the analysis and technology development department. Only 39 (12%) of the respondents were in the commercial department, 36 (11%) in the customer relations department, and 35 (10.70%) in the research and development department. On the opposite side, the lowest weight was represented by the members of the board and the management board, only 8% of the respondents. To obtain relevant opinions from the respondents regarding the use and implementation of 5G technology within the economic entity they represent, we used the Likert scale in the classic five-step version. Thus, we obtained the information presented in Table 5.

Regarding the distribution of the economic entities that participate in the study by size and form of ownership, the situation is presented in Figure 4.

Table 4. Classification of economic entities according to the field of activity.

	Field of Activity	Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Extractive industry	28	8.6	8.6	8.6
	Manufacturing industry	35	10.7	10.7	19.3
	Production and supply of electricity, heat, gas and water	7	2.1	2.1	21.5
	Water distribution, sanitation and waste management	15	4.6	4.6	26.1
	Construction	45	13.8	13.8	39.9
	Trade	68	20.9	20.9	60.7
	Transport and storage	31	9.5	9.5	70.2
	Hotels and restaurants	38	11.7	11.7	81.9
	Education	8	2.5	2.5	84.4
	Health and social assistance	4	1.2	1.2	85.6
	Administrative services activities	28	8.6	8.6	94.2
	Other service activities	19	5.8	5.8	100.0
	Total	326	100.0	100.0	

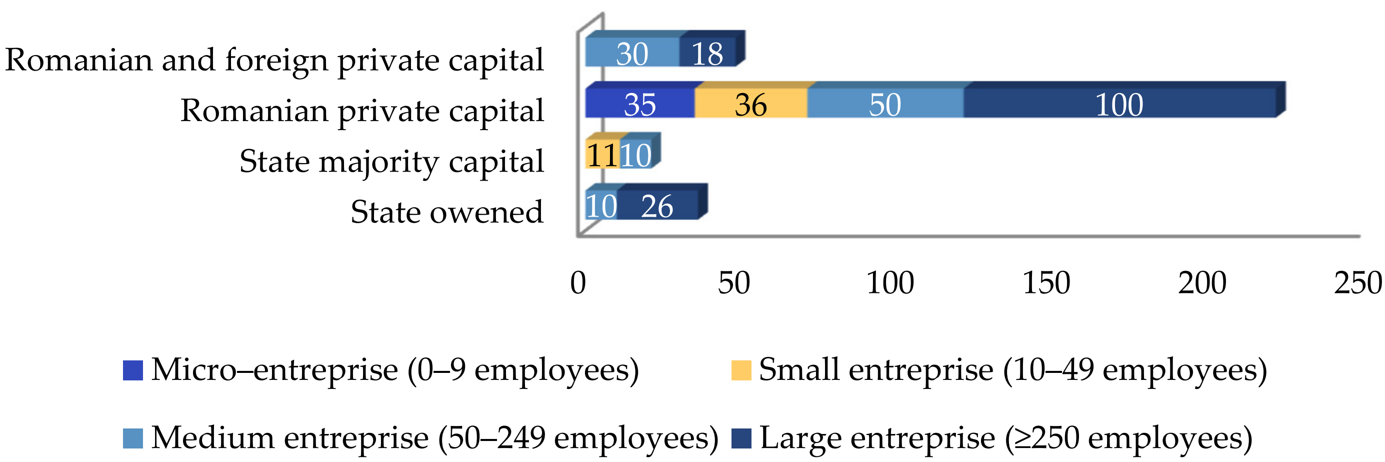

Figure 4. Classification of economic entities according to the form of ownership and the number of employees.

We note that for all the seven characteristics analyzed, the respondents provided varied answers, so regarding the current information solutions, 139 of the respondents did not agree that they can meet the needs of the business environment in the next 5 years, and 137 of the respondents agreed to a small extent with this option. 91 of the study participants agreed that the use of 5G technology is very necessary for the evolution of their business. Regarding the current staff employed, 127 of the respondents did not agree that they are prepared to face the changes of 5G technology, but 120 of the respondents largely agreed with the participation of the staff in trainings/courses/specializations in order to adapt more easily to the process of changing 5G technology. Based on the scores obtained, we observed that three of the characteristics were above average, suggesting that most of the respondents agreed with the information presented to a large and very large extent. The use of 5G technology represents an evolution for 211 (64.70%) of the respondents and an adaptation for 97 (29.80%) of them. Several 18 respondents (5.50%) did not validate any of the variants mentioned, preferring not to respond. Of all the entities participating in the study, 40 (12.30%) consider that they will implement 5G technology as soon as possible, 185 (56.70%) in the next 5 years, 85 (26.10%) in the next 10 years, and 16 (4.90%) did not answer this question. A decisive factor for the implementation and use of 5G technology by Romanian economic entities was the advantages it offers, as well as the knowledge of the factors that could influence its use. Thus, among the factors that influence the use of new technology, competition was the variant most appreciated by respondents at 136 (41.70%), followed by low productivity at 75 (23%), staff dissatisfaction at 42 (12.90%), as well as external pressures in favor of change at 28 (8.60%) or interpersonal or between-group conflicts, also at 28 (8.60%). Also, the social and political context could be another factor influencing the use of 5G technology, but only 17 (5.20%) of the respondents chose this variant. The advantages that 5G technology will offer, as well as the expectations of the participants in this research, are presented in Table 6.

Table 5. Frequency of responses to the use and implementation of 5G technology.

Variable	1	2	3	4	5	Score
The current information solutions can continue to meet the needs of your business over the next 5 years	139	137	42	8	0	1.75
The use of 5G technology is absolutely necessary for the evolution of your business	25	74	70	66	91	3.38
Continuously changing stakeholder requests can influence the use of new 5G technologies	15	121	120	53	17	2.80
Staff is ready to handle the changes of 5G technology	127	93	54	27	25	2.17
Employees are encouraged to actively participate in the change process within the organization in order to use 5G technology	0	111	137	41	37	3.01
Employees are encouraged to participate in trainings/courses/specializations to adapt more easily to the change of 5G technology	0	72	75	120	59	3.51
Changing brought by 5G technology within your organization is a beneficial process	0	9	80	129	108	4.03

Table 6. Expectations versus advantages of using 5G technology.

Expectations	Frequency	Percent	Expectations	Frequency	Percent
Faster connections	58	17.80	Increasing operational efficiency	35	10.70
Higher speed	95	29.10	Increasing the coverage of information in several fields related to the activity	66	20.20
Better support for (IoT)	34	10.4	Increased productivity	59	18.10
Better connectivity	55	16.90	Improved reliability	74	22.70
Higher throughput of transferred data	27	8.30	Increasing cyber security	58	17.80
Low latency	57	17.50	The possibility of fast connection of several devices	34	10.4
Total	326	100	Total	326	100

As with any new activity started, the use of the new technology may have some disadvantages, so 82 (25.20%) of the respondents considered that the implementation of 5G technology involves very high costs, 67 (20.60%) mentioned the negative impact on the environment, 57 (17.50%) considered fear of the unknown again one of the barriers.

Furthermore, the complexity of using 5G services was an option validated by 46 (14.10%) of the respondents, while the negative impact on human health represented a disadvantage for 48 (14.70%) respondents, and 26 (8%) considered that the lack of future benefits perceived at the level of personnel is a limit in the implementation of the new technology.

In an increasingly unstable and uncertain environment, economic entities have no choice but to carry out efficient and sustainable economic activities from an economic and technological point of view. Given that the purpose of any business is to make a profit, we believe that the implementation of 5G technology should not affect the financial situation of the economic entities. Within this subpoint, we present, in a correlated way, the explanation of the relationships between the different variables of the questionnaire in order to obtain relevant conclusions to validate or invalidate the research hypotheses.

Hypothesis 1 (H1). *The use of 5G technology is absolutely necessary for the Romanian business environment. To obtain a relevant result in order to validate this hypothesis, a cross-over analysis (cross-table) is required in which the variable "use of 5G technology" is analyzed together with the variable "impact of 5G technology" (Tables 7 and 8).*

Table 7. Case Processing Summary/Cross-Statulation Use of 5G technology—Impact of 5G technology.

Case Processing Summary							
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
		326	100.0%	0	0.0%	326	100.0%
		Using 5G Technology					Total
		I disagree	I agree to a small extent	I agree to some extent (average)	I agree to a large extent	I agree to a very large extent	
Impact of 5G technology	Evolution	25	63	64	10	49	211
	Adaptation	0	0	6	56	35	97
	I don't know/I don't answer	0	11	0	0	7	18
Total		25	74	70	66	91	326

Table 8. Variable Symmetry Analysis Using 5G Technology—Impact of 5G Technology.

Symmetric Measures					
		Value	**Asymp. Std. Errora**	**Approx. Tb**	**Approx. Sig.**
Nominal by Nominal	Phi	0.733			0.000
	Cramer's V	0.518			0.000
	Contingency Coefficient	0.591			0.000
N of Valid Cases		326			

a. Do not assume the null hypothesis.
b. Using the asymptotic standard error, assume the null hypothesis.
c. Based on a normal approximation.

The statistical index Cramer's V demonstrates the existence of a connection with an intensity of 51.8%, (calculated sig. 0.00% which is well below the allowed level of 5% ensures a degree of confidence of 95% between the two variables), which implies an overdependence between the use of 5G technology and the impact of 5G technology on the Romanian business environment. The use of 5G technology represents an evolution for most of the economic entities analyzed, which helps to validate the research hypothesis.

Hypothesis 2 (H2). *The implementation of 5G technology within the economic entities is influenced by the field of activity, the size, and the environment in which the economic entity activates. To demonstrate whether there are any relations between the field of activity, the size and the environment in which the economic entity activates and the time period in which the new 5G technology will be implemented, as well as the implementation costs that the economic entities participating in the study are willing to use for implementing 5G technology, we apply the Pearson correlation coefficient.*

We notice that, between the five variables analyzed, there is a dependency link (Table 9), especially between the variable domain of activity and time or costs, so we can say that the economic entities operating in a certain domain are willing to implement the 5G technology much faster and to allocate higher costs for this activity (Table 10). Also, between the size of the economic entity and the costs they are willing to pay for the implementation of 5G technology, there is a directly proportional dependency relationship (Table 11), so we can say that large economic entities are willing to pay more for the implementation of the new technology.

Table 9. Pearson rank correlation index for the variables analyzed.

Variables	Field of Activity	Size of the Entity	Environment	Time	Cost
Field of activity	1				
Size of the entity	0.776 **	1			
Environment	0.673 **	0.775 **	1		
Time	0.837 **	0.560 **	0.508 **	1	**
Cost	0.752 **	0.722 **	0.506 **	0.610 **	1
Sig. (2-tailed)	0.000	0.000	0.000	0.000	0.000
N	326	326	326	326	326

** Correlation is significant at the 0.01 level (2-tailed).

Table 10. The result of the cross-analysis of the activity/time/cost domain variables.

Field of Activity	Time				Costs			
	As Soon as Possible	In the Next 5 Years	In the Next 10 Years	I Don't Know/I Don't Answer	5%	5–10%	10–20%	20–30%
Extractive industry	28	0	0	0	28	0	0	0
Manufacturing industry	4	31	0	0	35	0	0	0
Production and supply of electricity, heat, gas and water	0	7	0	0	7	0	0	0
Water distribution, sanitation and waste management	0	15	0	0	15	0	0	0
Construction	0	45	0	0	3	42	0	0
Trade	0	68	0	0	0	18	50	0
Transport and storage	8	19	4	0	8	7	16	0
Hotels and communication	0	0	38	0	2	6	15	15
Education	0	0	8	0	2	6	0	0
Health and social assistance	0	0	4	0	4	0	0	0
Administrative services activities	0	0	28	0	5	16	0	7
Other service activities	0	0	3	16	0	0	0	19
Total	40	185	85	16	109	95	81	41

We note that the economic entities working in the extractive industry desired the fastest implementation of new 5G technologies, but the share of expenses they are willing to bear is only 5%. Most of the economic entities surveyed agreed with the implementation of new technologies as soon as possible or within a maximum period of 5 years (225 of the economic entities analyzed) and regarding the implementation costs, 214 of them agreed with the increase of the expenses to a share of maximum 10% compared to the current technological costs. From the information presented in Table 10, we can conclude that the economic entities in the sphere of services and public administration would agree with an increase of technological costs with a share of more than 10%.

Table 11. Cross-analysis of the variables the size of the entity/costs.

Size	**Costs**				**Total**
	5%	**5–10%**	**10–20%**	**20–30%**	
1–9 employees	35	0	0	0	35
10–50 employees	47	0	0	0	47
51–250 employees	17	56	25	2	100
Over 250 employees	10	39	56	39	144
Total	109	95	81	41	326

Symmetric Measures

		Value	Asymp. Std. Errora	Approx. Tb	Approx. Sig.
Nominal by Nominal	Phi	0.912			0.000
	Cramer's V	0.526			0.000
Interval by Interval	Pearson's R	0.702	0.024	17.756	0.000c
Ordinal by Ordinal	Spearman Correlation	0.724	0.031	18.872	0.000c
	N of Valid Cases	326			

a. Do not assume the null hypothesis.

b. Using the asymptotic standard error, assume the null hypothesis.

c. Based on a normal approximation.

According to the Pearson correlation index and the information in the contingency table, we demonstrate the validation of the dependency relation between the size of the entity and the value of the costs that the entity is willing to use, so we can see that the economic entities with over 51 employees agreed with the use of a share of expenses between 10–30%, with micro-enterprises and small entities opting for a much smaller share of up to 5%. By the information presented in Tables 9–11, we can say that we partially validate the research Hypothesis 2: the implementation of 5G technology within economic entities is influenced by the activity field and the size of the economic entity. Regarding the environment in which the economic entity is active, even though the Pearson coefficient shows a relation between the two variables, we cannot say that this is unanimously valid since many of the economic entities surveyed carry out their main activity in the urban environment, but have secondary offices and in rural areas or have collaborators in this regard.

H3—5G technology innovations bring economic and social benefits to economic entities.

Contingency tables applied to multiple-choice questions in which it was desired to highlight the respondents' opinion about the economic and social benefits based on 5G technology innovations are based on the following hypothesis: H_0: there are no differences of opinion regarding the economic and social benefits offered. 5G technology (H_0: $O_{ij} = E_{ij}$), H_1: There are differences of opinion on the economic and social benefits offered by 5G technology (H_1: $O_{ij} \neq E_{ij}$). The absolute frequencies observed are presented in Table 12.

There are differences between the observed frequencies and the expected frequencies in all subgroups formed by the mentioned benefits. By analyzing these elements, it is emphasized that the respondents believe that the innovations of 5G technology bring economic and social benefits to the economic entities to an average extent, according to the scores obtained scores presented in Figure 5.

Table 12. Frequency of observed responses regarding the benefits of 5G technology.

Expected Benefits	1	2	3	4	5
A. Development of innovative new products and services	0	111	137	41	37
B. Increased productivity	23	125	82	48	48
C. The emergence of new industries	15	51	120	33	47
D. Developing competitive companies worldwide	1	98	132	60	35
E. Development and evolution of SMEs	22	79	142	53	30
F. Promoting economic growth in our country	8	68	125	88	37
G. Operational cost efficiency for your organization	24	60	145	68	29
H. Creating new jobs	33	83	94	78	38
I. Increasing access to telecommunications services	15	125	96	61	29
J. Increasing access to education	48	130	61	70	17
K. Increasing and improving access to medical services	15	143	98	52	18
L. Improving the quality of life	42	127	110	30	17
M. Lower global energy consumption	15	134	120	44	13
N. Improving the safety and security of life	9	72	133	81	31
O. Discovering alternative energies and solutions for environmental protection and reducing climate change	8	29	120	54	15

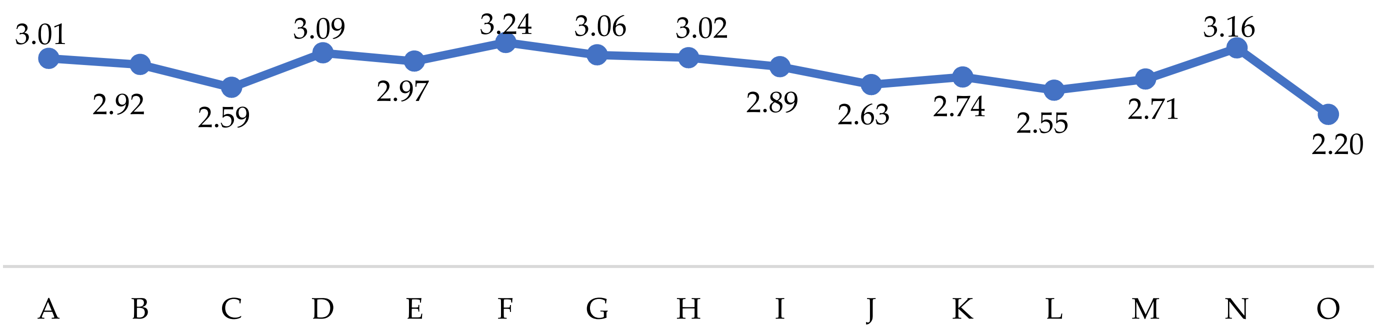

Figure 5. Graphical representation of the scores obtained from the observed responses on the benefits of technology5G.

Following the application of the statistical test, the null hypothesis (H_0) according to which "there are no differences of opinion regarding the economic and social benefits offered by the 5G technology", is not valid, but we validate Hypothesis 3: the innovations of the 5G technology bring economic and social benefits to the economic entities.

5. Conclusions

The development of 5G technology brings significant progress not only in personal life, but also in various business sectors, especially for economic entities active in the field of services. The new era of 5G technology will lead to the development of modern applications for Internet of Things, to new consumer gadgets, and cumulative multiple economic and social benefits for users, because it promises unlimited access to the Internet, in a much faster and more secure manner, with much lower latency, much higher data transfer rate than at present, and more support for Internet of Things [89,90].

Through the statistical analysis started among the 326 economic entities in Romania that responded to the questionnaire, we identified relevant opinions regarding the impact that the use of 5G technology can have on the entity to which they belong. It has been observed that the majority considers the implementation of 5G technology absolutely necessary, especially for the efficient evolution and development of economic activity, and over 69% of these entities agree with the implementation of new technologies as soon as possible or at most in a period of up to 5 years. Competition, low productivity, and even external pressures are the main factors with a decisive role in the implementation of 5G. The determined correlations and contingency tables had as the main result the validation of the research hypotheses (H1–H3) but also the achievement of the initial purpose of the study. Thus, it has been observed that the analyzed economic entities were interested and available to implement 5G technology, but under certain conditions related to the costs that this activity entails and the competitive advantages they offer (such as increased productivity, efficiency, and cybersecurity). Furthermore, the economic and social benefits that innovations in 5G technology have on the Romanian business environment are decisive factors for the use of 5G technology by questioned economic entities. Based on the results obtained, it can be considered useful to extend the research by identifying viable solutions or alternatives, customized for the implementation of 5G technologies at the level of the economic entities from different sectors of activity, as well as the analysis of the implementation costs and the potential economic benefits.

In terms of practical and managerial implications, the study highlights that managers and practitioners should consider adopting AI-related technologies to improve their operations, regardless of the segment of the organization. Therefore, the study indicates the following conclusions: practitioners have always assured us that 5G technology innovation will be in the main interests of users and cannot be easily abandoned, and that we should pay more attention to the influential role of 5G in the development of smart cities such as Smart City. The managerial recommendation is to find solutions to increase the interest in and the desire to use new technologies, especially 5G services. The growth and development of these services refer primarily to the areas in the suburbs, rather than the remote areas where these facilities do not exist. At the same time, practitioners' attention should be directed to Smart City cities and to promote the role and importance of 5G technology. Finally, from this managerial perspective, we believe that the government should take constant steps to encourage people around the world to adopt 5G technology and the new smart technologies offered by digitization.

The study also brings several limitations. The first limitation concerns the COVID-19 pandemic, which brought a short-term acceleration of various technologies in Industry 4.0; however, we had already noticed some delays in this area, which were natural and had an impact on production such as in the automotive industry. Another limitation concerns the research, which was carried out only at the level of Romania and could be extended to the level of developing countries, such as Bulgaria, considering the similarities between the two. Also, given that developed technologies play a key role in addressing current challenges, including waiting times, associated costs, culture, geographical regions, and so on, it would be interesting to analyze these implications of digitization and 5G at the European level.

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