The object of this study is the economic behavior of companies. The study solved the problem of conceptualizing the economic behavior of companies, taking into account the need to adhere to the goals of sustainable development and the use of smart technologies. It has been established that to assess the level of sustainable development of companies, economic, environmental, social, and managerial criteria based on corporate social responsibility are used. It is determined that smart technologies are associated with the introduction into production of cyber-physical systems integrating information and communication technologies into physical processes. To expand the possibilities of assessing the use of smart technologies, it is proposed to collect data on the expenditure of companies for a particular technology and the amount of revenue generated using this technology. The structural model for measuring the relationships between the use of smart technologies, sustainable development, and the economic behavior of companies was calculated using the PLS-SEM method. It has been established that currently, in fact, an increase in the burden on the environment, extensive use of resources for the countries of the European Union and Ukraine activates the economic behavior of companies because the coefficient of the path for load indicators is 0.916. At the same time, increasing the use of smart technologies by 1 will increase economic development indicators by only 0.104. This indicates a lesser power of the link between economic behavior and the use of smart technologies. However, the statistical significance and positive direction of the relationship between economic behavior and the use of smart technologies gives reason to recommend that the management of industrial companies pay special attention to the development of the integration of smart technologies into business processes

Keywords: smart technologies, corporate sustainable development, economic behavior of companies, structural model of relations

UDC 338.3:[330:004+504]
DOI: 10.15587/1729-4061.2023.275731

ASSESSMENT OF RELATIONSHIPS BETWEEN SMART TECHNOLOGIES, CORPORATE SUSTAINABILITY, AND ECONOMIC BEHAVIOR OF COMPANIES

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Received date 07.02.2023
Accepted date 12.04.2023
Published date 30.04.2023

How to Cite: *Popova, O., Chechel, A., Fomina, O., Myroshnychenko, G., Medvedieva, M., Hoholieva, N., Tomashevska, O., Chernyshov, O., Nesterov, Y., Molodchenko, O. (2023). Assessment of relationships between smart technologies, corporate sustainability, and economic behavior of companies. Eastern-European Journal of Enterprise Technologies, 2 (13 (122)), 41–51. doi: https://doi.org/10.15587/1729-4061.2023.275731*

1. Introduction

In the changing world of the XXI century, the problem of solving the contradiction between the need to meet the growing human needs and the inability to do so without destroying the environment has become particularly relevant. The recognition of this problem by the world community has been embodied in the concept of sustainable development.

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Currently, the Sustainable Development Goals formulated by the United Nations (UN) General Assembly in document [1] are a key element of national development strategies of countries. Therefore, there is an active search in the world for effective mechanisms for its implementation.

One of the largest users of resources is companies because, to achieve their goals such as increasing the value of the company, increasing the price of shares, etc., they use significant financial, natural, and human resources. Taking into account the need to monitor the implementation of the sustainable development goals, state authorities, non-governmental organizations, and other interested persons influence companies in order to reduce the burden on the environment. Geopolitical uncertainty, rapid development of technology and low trust in the government and big business determine the main risks that investors pay attention to when making investment decisions. For example, according to the global report [2], already in 2017 investor decisions were most affected by the risks of poor corporate governance, adverse environmental performance, lack of resources, climate change, and human rights violations. This means that, on the one hand, the assessment of the activities of companies that have a significant impact on the environmental, social environment, and the environment is changing.

On the other hand, companies are currently facing challenges that limit their potential for development and growth. These include, in particular, the global pandemic of the COVID-2019 coronavirus, local wars and armed conflicts, which have exacerbated the problems of finiteness of natural resources, reduced purchasing power, and lack of qualified personnel. Under the influence of environmental, social, financial, and industrial factors, there is a blurring of equity, which in the long run can lead to the loss of business capitalization. Therefore, non-compliance with the principles and goals of sustainable development increases the risk of complete disappearance of the company.

One of the main tasks related to sustainable development is the development of new innovative solutions. The accumulation of knowledge and the development of information and telecommunication technologies have all the possibilities and are means that can help in reducing the risks and threats to the sustainability of social ties, the environment, and the economy. Industry 4.0's breakthrough technologies, which include smart technologies in particular, play a key role in changing approaches to achieving sustainable development goals. Smart technology is a generalizing term for describing information, material, and socio-political technologies with advanced intellectual functions [3]. They make it possible to accumulate large amounts of data on production and socio-economic processes for their further improvement. Thus, the IoT technology can collect data on the environment in real time according to certain scenarios. Depending on the scope of application using big data analysis and artificial intelligence technologies, this data is transformed into information for effective management of business processes. If these are production processes, then on the basis of cyber-physical systems, the consumption of material and energy resources is optimized, and the automation of production helps reduce the use of human labor. Intelligent management systems based on information about customer behavior, stakeholder values, market situation, product life cycle, etc. are also becoming widespread. They are key to decision-making and achieving corporate sustainability criteria [4]. Thus, scientific research aimed at solving the problems of corporate sustainable development and the use of related technologies is of direct practical importance. On this basis, companies change the priorities of economic behavior by rethinking the goals of their strategies and the mechanisms for achieving them. Moreover, given the increasing rate of change in the operating environment of companies, the corresponding adjustments to the strategies and behaviors of companies should be continuous.

Thus, the problem of analyzing the economic behavior of companies, taking into account the role of smart technologies in corporate sustainable development processes, is relevant.

2. Literature review and problem statement

The introduction of smart technology in the activities of companies has an impact on their productivity through a number of effects, including reducing costs, conquering new markets, gaining and strengthening competitive advantages.

Thus, work [5] explores the impact of investments in smart technologies, such as big data, cloud computing, cybersecurity, robotics, and the Internet of Things, on the productivity of small and medium-sized enterprises. Productivity is measured using firm revenue, productivity, and profitability. The methodical approach applied in the work is based on taking into account the competitive environment expressed by the number of firms in certain industries and on the concept of the U-inverse relationship between competition and innovation. To identify the influence of the competitive context on the use of technology, a probit model was used, and to calculate the impact on the results of activities – a generalizing method of moments. Based on the results of data analysis on 274 medium and small Spanish enterprises, it was found that the impact depends on what technology is used in the process of activity. Thus, big data technology increases competitive advantages while robotics negatively affects sales growth. In any case, it turned out that for medium and small enterprises, investments in smart technologies do not lead to short-term benefits and do not generate profits by themselves. The main result of the introduction of smart technologies is organizational changes to increase the dynamic capabilities of the enterprise. So, the impact of technology on company behavior is that the latter introduces technology in order to avoid competition. At the same time, the work did not study the sustainable development of companies, which is due to its goals and objectives.

Work [6] focuses on assessing the influence of smart economy factors on the sustainable development of the country. As a result of the study, it was proved that greenhouse gas emissions as an indicator of sustainable development are most affected by gross domestic product (productivity) and energy intensity level. On this basis, it is proposed to choose the development of innovation, smart economy, and green economy as priority strategic directions. But work [6] is focused on the macro level, the study of processes at the enterprise level was not included in the range of tasks. Therefore, the results are useful for understanding the general trend but need clarification for business structures.

This problem is partially solved in [7], which states that digital technologies play a potential role in the development of resource-efficient industrial base by reducing expenditure and increasing the flexibility and sustainability of production systems. However, these positive benefits are not

guaranteed. Therefore, the paper has developed a conceptual framework that explains the potential importance of using digital technologies on the way to efficiency and sustainability. The results of the case study analysis prove that companies expect sustainable development strategies under the influence of digitalization to improve resource efficiency and productivity. At the same time, the fundamental condition is the preservation of energy resources. The unresolved part of the problem in work [7] is the assessment of the relationship between the use of digital technologies and the sustainable development of companies. This may be due to the choice as a method of researching the case study since the example of several enterprises does not yet indicate the presence of certain patterns.

In this context, work [8] focuses on how organizations, using smart technologies, create or improve a sustainable business model (SBM). The research was carried out on the basis of the case study of the Italian provider of aviation navigation services and content analysis of documentation. According to the results of the study, it was found that the value and strategic importance of smart technologies in the process of implementing SBM are underestimated because smart technologies play a minimal role in it. On the other hand, it is shown that the potential of smart technologies lies in the positive experience of their use in corporate communications for external stakeholders. The contribution of smart technologies to such major dimensions of SBM as security and safety, taking into account social and environmental criteria in supply chains may also be significant. The general conclusion of work [8] is that smart technologies play a key role in the development of corporate culture and business models focused on sustainable development, taking into account the rigid regulatory environment and the goals of the organization. On the other hand, the problem of mechanisms of influence of smart technologies on the business models of companies and their behavior, as well as the role of national and cultural environments in these processes, remained unresolved in the work. This is due to the difficulty of obtaining initial data for analysis and the time frame of research of this level.

Instead, paper [9] considers the impact of artificial intelligence on the sustainable development of electronic markets. The aim of the work is to determine how companies form approaches to solving ethical issues related to artificial intelligence. At the same time, the paper emphasizes that artificial intelligence technologies are a threat to sustainable development, as they cause numerous social, ethical, and behavioral problems. These include, in particular, consumer safety and privacy, AI biases, individual independence, well-being, and unemployment issues. In view of this, in [9] it is noted that companies that use artificial intelligence should be socially responsible and pay much attention to the protection of such systems to ensure the sustainable development of countries. To this end, it is proposed to develop official rules and regulations, as well as to introduce appropriate changes in the goals of strategic development of companies. Unresolved in [9] is the issue of evaluating the proposed measures in terms of economic behavior of companies, as well as assessing the impact of technology implementation on the declared measurements of socio-economic life. This is due to the design of the study and the chosen methodology.

The environment for the development of economic systems is characterized by instability and the emergence of a number of emergencies of global and local scale. This has led to changes in the economic behavior of enterprises in the context of the spread of the use of smart technologies and paying more attention to sustainable development.

The aim of [10] is an empirical assessment of the mediating role of corporate strategy between smart technologies and corporate sustainable development. Corporate strategy in [10] is also considered in the context of sustainable development and is defined as the integration of the principles of sustainable development into business processes. That is, the strategy determines the behavior of the company. Corporate sustainable development in [10] is determined on the basis of the triple bottom line approach, when the company's prosperity is dependent on the social environment, the natural environment, and the economy. The social component of sustainable development concerns the maintenance of social capital and social responsibility. The ecological component is associated with the restriction of degradation of natural resources, environmental pollution, and loss of biological diversity. The economic component is presented as a financial assessment of the cost of production resources. It is emphasized that corporate sustainable development involves taking into account the time factor. Smart technologies point to intelligent properties built into previously non-digital devices. The results of study [10] show that corporate strategy completely mediates the relationship between smart technologies and the environmental component, as well as between smart technologies and the social component. Moreover, smart technologies have a direct significant impact on the economic component but this connection is partly mediated by corporate strategy. The disadvantage of [10] is that empirical analysis was carried out on the basis of surveys, which to some extent subjectivizes the results obtained. Also, the chosen approach of cross-sections does not take into account time changes in the studied constructs.

Article [11] explores the contribution of Industry 4.0 technologies to sustainable development. Industry 4.0 technologies in article [11] are understood as additive manufacturing, artificial intelligence, big data, and analytics, blockchain, cloud computing, industrial Internet of Things, virtual reality, simulation and modeling. To this end, article [11] proposes a concept of measurement based on the UN Sustainable Development Goals, which includes economic, environmental and social attributes. In [11], the contribution of each technology to the achievement of sustainable development goals was evaluated separately in different sectors of the manufacturing industry. The measuring model is developed on the basis of fuzzy sets, cumulative perspective theory and VIKOR's multi-criteria decision-making method. As a result of calculations according to this model, ranks are formed that characterize the contribution of a particular technology to the sustainable development goals for each of the studied industries. The results of study [11] indicate the following. Blockchain and mobile technologies account for the largest rank in the economic component of sustainable development, which is explained in terms of reducing product losses and increasing productivity through the proliferation of mobile device use. Sensors and actuators, artificial intelligence, big data analytics, and cloud technologies have proven to be the most influential in the environmental component of sustainability. This is because they provide physical and software infrastructure to improve energy and resource efficiency in production activities. Cloud technologies have proven to be the most important in the social component of sustainable development. The disadvantage

of study [11] is the use of the method of expert assessments, which limits its results. In addition, the work does not take into account the economic behavior of organizations to achieve sustainable development goals.

The purpose of [12] was to analyze the possible impact of the introduction of Industry 4.0 technologies in Brazilian companies on the environmental and social aspects of sustainable development. Industry 4.0 is described through its principles such as interoperability, information transparency, decentralization, virtuality, service orientation, and modularity. On this basis, Industry 4.0 technologies include cyber-physical systems, the Internet of Things, Internet services, autonomous engines, 3D printing, robotics, artificial intelligence, big data, cloud computing, virtual reality, nanomaterials, and sensors. Sustainable development in [12] is considered in the context of social and environmental components. This is explained by the fact that in corporate strategies of digital transformation, the main goals in most cases are set economic goals, and social and environmental ones are not given attention. However, Industry 4.0 technologies affect these aspects of sustainability, which requires additional analysis. The empirical basis of the study was an expert survey of Brazilian scientists. As a result, it was revealed that the main directions of influence of Industry 4.0 technologies on sustainable development are as follows:

– reduction of labor supply for manual and repetitive activities and the emergence of new professions with high added value;

– the emergence of innovative business;

– reduction of accidents at work due to the expanded use of robots in tasks dangerous to humans;

– lack of skilled workers for high-tech industries;

– integration of all activities in value chains, which allows for a better analysis of environmental, social, and economic impacts;

– improvement of physical and cognitive ergonomics through the use of sensors.

The disadvantage of work [12] is its intelligence nature, so the results require more reasonable verification.

Study [13] focuses on the identification of trends regarding the impact of technical, economic, social, and environmental elements of smart technologies on resource efficiency. Smart technologies in the work are understood as cyber-physical production systems, which are the basis of Industry 4.0. Sustainable development is considered as a set of technical, economic, social, and environmental elements. It is revealed that in terms of sustainability, Industry 4.0 technologies have the potential for fundamental improvements. Thus, the network technologies used to manage production make it possible to respond faster to changes in the environment and reduce waste and improve the quality and safety of products. Thanks to intelligent energy management systems and network technologies, renewable energy sources can be used more efficiently. However, a significant drawback of work [13] is its overview nature and lack of empirical confirmation.

In [14], the goal is to analyze the impact of the digital economy on the sustainable development of enterprises and the mechanisms of such impact. The paper proposes an empirical analysis based on measuring the level of the urban digital economy and the level of sustainable development of 280 public companies whose A-shares are traded on Chinese stock exchanges (A-share). As a result of the analysis, it was found that the digital economy can significantly contribute to the sustainable development of enterprises through regional innovation and entrepreneurship. At the same time, the effect of assistance has territorial differences. The disadvantage of [14] is that it actually investigated how the introduction of the digital economy (macro level) affects the sustainable development of companies (micro level) while the impact of digital transformation of enterprises themselves has remained outside the study. In addition, the indicator for measuring sustainable development – total factor productivity (TFP) is quite debatable. This may be due to the limited information base of the study.

So, the results of our review of scientific papers [5–14] prove that unresolved issues in studies of the economic behavior of companies to achieve sustainable development relate to the limited consideration of the use of smart technology in this aspect. This suggests that it is expedient to conduct a study to analyze changes in the economic behavior of companies under the influence of the need to maintain sustainable development and using smart technologies.

3. The aim and objectives of the study

The aim of this study is to identify changes in the economic behavior of companies associated with the need to achieve sustainable development goals due to the introduction of smart technologies. This will make it possible to make informed decisions on the introduction of smart technologies in the strategies of sustainable development of companies.

To accomplish the aim, the following tasks have been set:

– to analyze existing approaches to assessing the level of sustainable development of companies;

– to summarize indicators for evaluating the use of smart technologies in companies;

– to develop a structural model of the company's economic behavior, taking into account sustainable development and the use of smart technologies.

4. The study materials and methods

The object of our study is the economic behavior of companies.

The main hypothesis of the study assumes the existence of a positive link between the proliferation of smart technologies and corporate sustainable development, which determines the economic behavior of companies.

The study accepted the following assumptions:

– sustainable development goals are implemented by companies due to the availability of economic benefits from this;

– the economic behavior of companies reflects their reaction to the current situation on the market.

The simplifications adopted in the study relate to the fact that only such economic behavior of companies is taken into account, which is focused on sustainable development, and is accompanied by the use of smart technologies. This determines the choice of indicators that describe economic behavior and makes it possible to apply mathematical and economic research methods. Due to the use of secondary data available in the public domain, sets of indicators for economic behavior and sustainable development have undergone simplification.

The study consisted of three stages. At the first stage, methods of formal logic, analysis and generalization were applied to identify signs of economic behavior of companies

in order to achieve sustainable development using smart technologies. At the second stage, signs interpreted using appropriate indicators using comparison methods were identified, combined on the basis of a systematic approach into a conceptual model. At the third stage, the relationship evaluation was performed using the PLS-SEM method (modeling of structural equations using the method of partial least squares). The choice of this method is due to several reasons. First, it makes it possible to evaluate any complex model with a large number of designs and indicators. Secondly, it provides sufficient flexibility in relation to the initial data and the specifications of the connection of structures with indicator variables. Thirdly, the PLS-SEM method is a non-parametric statistical method and does not require normalized data distribution [15]. The object of study (that is, the behavior of companies) can be attributed to soft systems that do not have a clearly defined structure, a fixed composition of elements and formalized laws of behavior. This is due to the existence of several simultaneous and incomplete ideas about its characteristics due to the presence in its composition of a social component [16]. Such systems are characterized by the impossibility of using directly measuring their key parameters. For modeling such soft systems, a modeling method based on structural equations was actually developed [17].

We use the technique of analyzing the path with latent variables. Further description is given in accordance with [15, 17]. So, the technique consists in constructing a structural diagram, which depicts latent variables or constructs (Y) in the form of circles or ovals connected by arrows. Arrows mean cause-and-effect relationships. Indicators (x) of latent variables are variables that can be directly observed and that form the original raw data. They are denoted in the form of rectangles, which in the diagram are combined with the corresponding latent variable using arrows. Path model consists of two elements. The first element is a structural model that represents the causal relationships between constructs. The second element is a measuring model that represents the relationship between each construct and the associated indicators.

The reflective measuring model is expressed by equation (1):

$$x = l \cdot Y + e, \quad (1)$$

where x is the observed value of the indicator,

Y is a latent variable,

l – load (regression coefficient that estimates the strength of the relationship between x and Y),

e – random measurement error.

Equation (1) is a bivariant regression, x is a dependent variable, and Y is a factor variable.

The formative measuring model, on the contrary, assumes that a linear combination of observed indicators forms a latent variable.

The problem of modeling the path involves the construction of a model of structural regression to test hypotheses about the existence of dependences between latent variables. These dependences are represented in the following form (2):

$$Y_j = \sum_i \beta_{ij} \cdot Y_i + \varepsilon_j, \quad (2)$$

where β is the coefficient of the path, the value of which allows us to estimate the strength of the relationship between latent variables.

The solution of a system of equations (1) and (2) is carried out by the method of partial least squares [15, 17].

Calculations of structural model indicators using the above PLS-SEM method were performed in the SmartPLS program (FRG).

The initial data for the study were statistical data on performance indicators and sustainable development of companies from 26 countries of the European Union and Ukraine for 2020.

5. Results of the study of changes in the economic behavior of companies to achieve the goals of sustainable development

5. 1. Analysis of existing approaches to assessing corporate sustainable development

The concept of sustainable development is usually applied to macroeconomic systems as a development aimed at meeting current needs, taking into account the needs of future generations. Consequently, economic activity focused on sustainable development involves the creation and maintenance in a viable state of a self-organizing economic system, which includes the economic, social, and environmental component [18]. However, this basic normative and ethical form of the concept of sustainable development does not offer a clear understanding of the strategies, plans or activities that need to be implemented for the appropriate orientation. For this purpose, approaches such as corporate environmental management, corporate social responsibility, and reporting on sustainable development goals have been developed [19]. A feature here are the goals that are laid down in the strategy. Thus, the sustainable development of companies is considered the goal of corporate social responsibility strategies [20]. In particular, the effectiveness of companies in relation to social responsibility can affect such parameters of their behavior as competitiveness, reputation, ability to attract and retain workers and consumers. Of particular influence on the economic behavior of companies in this context are the opinions and decisions of investors, owners, financing organizations, sponsors, and other interested persons who provide campaigns with access to financial resources [20]. In scientific works, for example [21, 22], it is shown that there is a positive relationship between the level of corporate social responsibility and the profitability of the company's securities. This means that taking into account and striving to achieve social and environmental goals in economic behavior strategies is a request from interested individuals who observe the activities of companies.

To assess corporate social responsibility, ratings formed according to environmental, social, and managerial criteria (ESG-rating) are currently used [23]. The list of indicators included in such ESG ratings as S&P Global ESG Scores, CDP Climate, Water & Forest Scores, Sustainalytics' ESG Risk Ratings, MSCI ESG Ratings, Bloomberg ESG Disclosure Scores can be found in works [23–27]. The choice of these ratings for analysis is due to two factors. First, the presence of a detailed methodology in the public domain. Secondly, high assessments of their informativeness on the part of experts and investors [23].

Corporate social responsibility, although based on the goals of sustainable development, reflects the normative position on the moral and ethical code of business. At the same time, the concept of sustainable development involves

the definition of environmental and social boundaries of economic growth [28]. At first glance, for the company, the ideas of sustainable development contradict the goal of maximizing profits [29]. But sustainable development involves meeting needs in a way that conserves resources for future generations. So, this is quite consistent with the task of maximizing profits in conditions of limited resources. In support of this thesis are, in particular, the theory of the triple bottom line (TBL), an approach to building a competitive advantage based on the attributes of sustainable development, a model of the network economy, the theory of property rights and the concept of corporate social responsibility [30]. In this case, the need to comply with the principles of sustainable development requires appropriate changes in the economic behavior of the company.

Consequently, to assess corporate sustainable development, indicators included in ESG ratings can be used, supplemented by indicators of economic performance, selected on the basis of an analysis of scientific papers [31, 32] (Table 1).

From the data given in Table 1, it can be seen that some of the indicators of sustainable development of companies are qualitative indicators. Their measurement is based on the use of assessment scales. The indicators used for measurement relate both directly to the company's activities and to factors external to the company, such as supply chains or the laws of the country of origin. It should also be noted that the initial data for calculating attributive indicators are mainly collected on the basis of companies filling out questionnaires with a large number of questions, therefore they can be subjective.

Table 1

Indicators for assessing corporate sustainability

Direction	Indicators
Economy	
Financial results	Profit, expenses, sales volumes, assets, equity capital, borrowed capital
The results of the use of production factors	Productivity of factors of production, volumes of production of products and services, structure of produced products or services
Financial ratios	Indicators of liquidity, solvency, financial stability, circulation
Ecology	
Carbon emissions	Carbon emissions (direct and associated); emission compensation measures; carbon footprint of the product; use of energy and sources of raw materials; target indicators of pollutant emissions; initiatives to reduce emissions; low carbon products
Waste and environmental pollution	Share of recycled waste and level of recycling; share of hazardous waste; air, water and land pollution; packaging; electronic waste
Aquatic resources	Intensity of use of water resources; water consumption, including per unit of production
Land use	policy in the field of land use, biodiversity, forest protection; activities in areas with an unstable ecological balance in relation to natural ecosystems; activities for the development of new deposits; deforestation activity
Opportunities	Clean technologies; green construction; renewable energy
Society	
Workforce	The company's strategy for diversification and inclusivity; unlocking the potential of employees; employee retention ratio; staff turnover rate; the number of hours of training of one employee; labor relations standards; remuneration of labor; benefits; rewards; employee involvement; the share of workers working under contracts; the share of employees-members of trade unions; participation in ensuring fair and humane standards of labor relations in the value chain
Security management	Frequency and scale of accidents in the workplace; the number of fatal accidents; labor protection and safety; participation in the promotion of safety measures in the value chain
Product liability	Safety and quality of the product; chemical safety; financial protection of consumers; data privacy and security; responsible investments; health insurance and demographic risks
Customer engagement	Trends in satisfaction, retention rate; number of claims; forecasts regarding changes in customer preferences; the ability to ensure the reliability and availability of products; the possibility of misleading customers regarding product characteristics
Communities	Policies towards human rights and social standards in the value chain; interaction with local communities in the areas of direct activity of the company and suppliers, including participation in the life of local communities and their support, including hiring members of local society and charitable activities; propensity for risks associated with war, other conflicts and terrorism
Management	
Structure and supervision	Composition, qualification, term of office, diversification and independence of the governing body; structure and membership of committees; the degree of readiness to perform the duties of members of the board of directors; succession planning and unplanned changes; completeness of supervision by the board of directors; independence of auditors; availability of persons responsible for environmental issues
Norms and values	Business strategy in the field of the environment; completeness of the policy; code of conduct; public statements regarding ethics and values; remuneration and incentive payments for senior executive management
Transparency and reporting	The level and quality of disclosure of information on ESG indicators; publication of a detailed annual sustainability report; tax transparency
Financial and operational risks	Internal control and audit mechanisms; risks associated with financial stability and project implementation; cybersecurity; contingent liabilities; emergency response; general value chain management; processes of identification of risks and opportunities for environmental protection

Note: summarized by authors from [23–27, 30, 31]

5. 2. Determination of indicators for evaluating the use of smart technologies

The chains of effects from the use of smart technologies in the context of sustainable development are complex. The main motive for using smart technology in companies is to reduce energy and resource costs [33]. In general, technology can be defined as a transformational function of an economic system that converts input resources into targeted products or services. On this basis, it can be argued that the technological aspect should also be included in the concept of sustainable development. In addition, the use of digital technologies combines production technology with markets, so their connection with sustainable development is considered very significant [34].

In this context, smart technologies or intelligent technologies are information and communication technologies that have cognitive awareness of the circumstances of their functioning and can respond to new circumstances. From a technical point of view, smart technologies are based on smart materials that react to external influences by the manifestation of certain properties [35]. At the stage of development of Industry 4.0, the central phenomenon was the introduction of cyber-physical systems into production. A cyber-physical or smart system is a system of sensors and related software systems that constantly receives data from the environment and uses it to further optimize management processes. On this basis, as well as according to the results of the review of works [3–14, 32, 35, 36], the following technologies are attributed to smart technologies:

– artificial intelligence (AI);
– Big Data (BD);
– cloud computing (CC);
– blockchain (BC);
– virtual/added reality and digital twins (VR/AR);
– Internet of Things (IoT);
– additive manufacturing technologies (ADL);
– cyber-physical systems and robotics (CBS);
– cellular networks (5G).

Generalized assessment indicators relating to the use of smart technologies used by international organizations [37–39] are shown in Fig. 1.

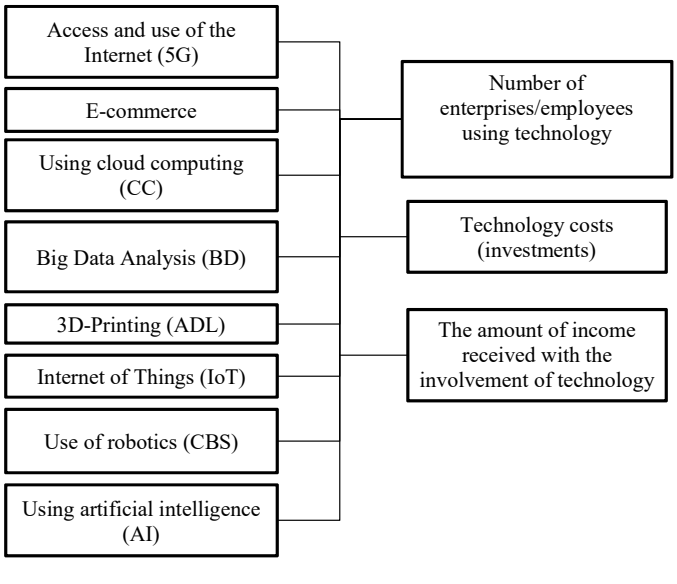

Fig. 1. Indicators for evaluating the use of smart technologies
Note: summarized by authors from [37–39]

At the country level, statistical observations are carried out in the form of a survey of enterprises. The primary data obtained in this way is summarized and published in the public domain, so the information is available throughout the country. In addition, in methodological terms, there are no official indicators of the use of blockchain and virtual reality technologies. However, it seems possible to collect primary data by analogy to the indicators of the use of other smart technologies. In addition, an indirect indicator of the use of blockchain technology can be considered indicators of e-commerce where these technologies are used to protect personal data.

The indicators shown in Fig. 1 can be applied at the enterprise level, which proves their versatility and allows their use it for analytical purposes.

5. 3. Structural model of analysis of economic behavior of companies in the context of the concept of sustainable development

The conceptual model of links between indicators of economic behavior of companies within the concept of corporate sustainable development is shown in Fig. 2.

The structural model is based on a preliminary analysis of indicators for the relevant components of corporate sustainable development. An observable manifestation of the economic behavior of companies at the same time is a strategic plan. Therefore, in fact, the formulated conceptual model expresses the results of the economic behavior of companies within the framework of the concepts of sustainable development.

Evaluation of the relationship based on the structural model shown in Fig. 2 was carried out using statistical data available in open databases of the European Union [40] and Ukraine [41]. Indicators for evaluation were selected on the basis of Table 1 and Fig. 1. The designs and indicators used in the study are given in Table 2.

Table 2

Latent variables and research indicators

Latent variables and indicators	Designation
1. Burden on the environment and society	
1. 1. Emissions of carbon dioxide, t	CO
1. 2. Energy consumption, tne	ENER
1. 3. Generation of waste, vol	WASTE
1. 4. Accidents with fatal consequences at work, number	DEATH
1 5. Accidents at work, number	ACCID
2. Smart technologies	
2. 1. The share of enterprises that used cloud computing, % of the total number	CC
2. 2. The share of enterprises that used big data, % of the total number	BD
2. 3. The share of enterprises that used the Internet of Things, % of the total number	IOT
2. 4. The share of enterprises that used 3D printing, % of the total number	3D
2. 4. The share of enterprises that used artificial intelligence, % to the total number	AI
3. Economic development	
3. 1. Sales volume, million euros	TURN
3. 2. Personnel costs, euros	WAGE
3. 3. Number of employed workers at enterprises, persons	PERS

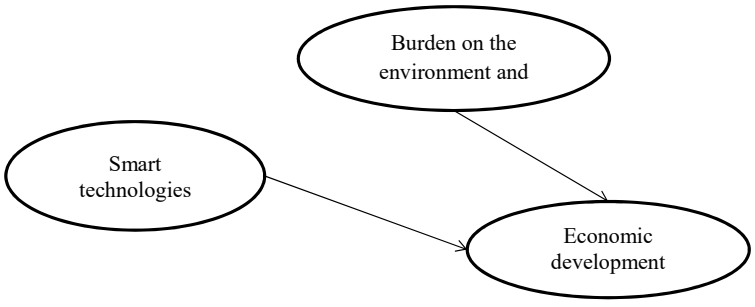

Fig. 2. Conceptual model of relations between indicators of economic behavior of companies within the concept of corporate sustainable development

Therefore, the conceptual model assumes that the spread of the use of smart technologies has a positive effect on economic development. It is also expected that the burden on the environment is significantly related to economic development. At the same time, with an extensive type of economic behavior, the connection is expected to be positive, with intensive – negative. Thus, the concept of corporate sustainable development is taken into account in the economic behavior of companies.

Indicators for 2020 were selected for the study for 26 countries of the European Union (Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, The Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, Norway) and Ukraine. The indicators concerned the industrial sector of companies. The choice of countries and indicators is due to the availability of data.

The model obtained on the basis of the PLS-SEM method, calculated in the SmartPLS program, is shown in Fig. 3.

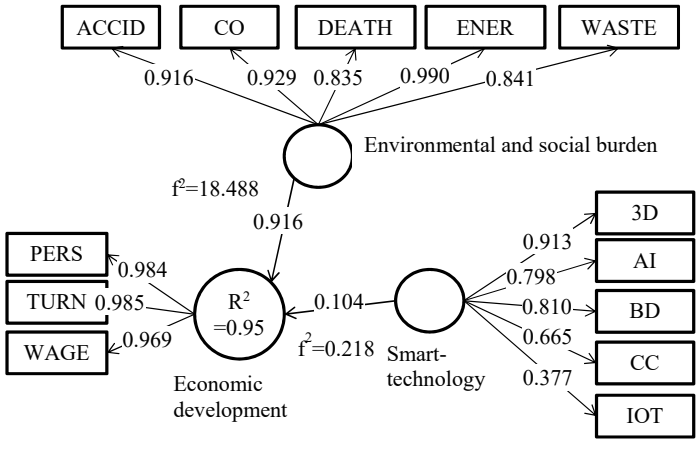

Fig. 3. Evaluation of the structural model of relations between indicators of economic behavior of companies within the concept of corporate sustainable development

In the model shown in Fig. 3, economic development is defined as a dependent variable. Independent variables – environmental and social load and smart technologies – each of which, in turn, is measured using five variables, respectively. The model, therefore, makes it possible to analyze the consideration of the concept of sustainable development, including the technological component, in the economic behavior of companies.

Reliability and validity of the studied structures as indicators of the quality of the obtained model, calculated in the SmartPLS program, the method of their calculation is given in [15, 17]. The results of the calculation are given in Table 3.

Table 3

Reliability and validity of latent variables

Construct	Alpha Kronbach	Structural reliability	Average isolated variance (AVE)
Environmental and social burden	0.943	0.957	0.818
Economical development	0.978	0.986	0.959
Smart technologies	0.816	0.847	0.542

According to Table 3, to assess the reliability of latent variables, the Kronbach alpha coefficient is used, which measures internal consistency. The reliability of latent variables with its help is determined on the basis of the relationship of the measured indicators in the composition of the latent variable. The closer its values are to 1, the better is the consistency of the indicators of the corresponding latent variable [15, 17]. The Kronbach alpha coefficient is sensitive to the number of indicators used. To level this factor, SmartPLS uses a different metric – an indicator of structural reliability. This indicator demonstrates the degree of compliance of indicators with latent variables. The greater the value of the structural reliability indicator, the more reliable the measurement model is [15, 17]. To determine the validity of the measuring model of latent variables, the average isolated variance (AVE) indicator was used. It means that the design is unique and characterizes phenomena that are not covered by other components of the model. An acceptable value of the AVE indicator is 0.5, which means that, on average, a latent variable explains 50 % or more of the variance of its elements [15, 17].

6. Discussion of results of the analysis of economic behavior under the influence of smart technologies in the context of sustainable development of companies

The level of sustainable development of companies is measured by a large number of indicators (Table 1), which, as a rule, are combined into a single integral indicator. In contrast to [23–27], where only corporate social responsibility is considered, the results of the analysis of approaches to assessing the level of sustainable development of companies (Table 1) allow us to form a comprehensive indicator that takes into account the economic, environmental, social, and managerial components.

In addition to economic, environmental, and social components, corporate sustainability includes a technological aspect since any technology in this context is called upon to reduce the use of economic resources. Thus, the importance of smart technologies for corporate sustainability is explained by their functional purpose. The use of smart technologies in the activities of companies can be estimated on the basis of the number of enterprises or employees using the relevant technologies, the cost of technology or the income derived from its use. The generalized structure of indicators for assessing the use of smart technologies (Fig. 1) makes it possible to take into account the use of various technologies.

At the same time, a specific indicator can be chosen depending on the assessment tasks, in contrast to [5–14], where either a separate technology or a general indicator of the country's digitalization is included in the analysis. This became possible due to the generalization of approaches to the assessment of international statistical bodies.

To analyze the economic behavior of the company and assess the impact of smart technologies on the sustainable development of companies, a structural model for measuring relationships has been developed (Fig. 2). The model uses three hidden variables (reflective evaluation structures) – smart technologies, economic development, and environmental and social load, and 13 indicators (Table 2). The model is used to assess the impact of indicators of the use of smart technologies and load indicators on indicators of economic development. Thus, economic behavior in the context of sustainabl development is presented as a structural model.

So, in the model in Fig. 3, reliability of indicators is estimated using factor loads. All indicators, except for indicators of the use of smart technologies such as cloud computing and the Internet of Things, have a load value greater than 0.7. This means that hidden variables explain more than 50 % of the variability of the corresponding indicators. At the same time, for the indicator of cloud computing use, the latent variable of "smart technology" explains 44 % of variability, and for the IoT usage rate – only 14 %. Thus, the reliability of these two indicators is considered low. However, they have not been removed from the model as this does not significantly affect the overall reliability, which is measured on the basis of indicators of internal consistency of structures.

The internal consistency of the structures was measured using the Kronbach alpha criterion and the structural reliability indicator, which differ in terms of indicator loads. If the Kronbach alpha coefficient implies the same reliability of all indicators, then structural reliability takes into account the factor loads of each of them. As can be seen from Table 3, both indicators for all designs are in the range from 0.8 to 0.9, which indicates high structural reliability and consistency.

The validity of structures is determined using the average isolated variance indicator. According to Table 3, for all structures, it exceeds the value of 0.5, and therefore each structure is unique and characterizes phenomena that are not covered by other components of the model.

The value of the coefficient of determination R^2 for the endogenous latent variable "economic development" is 0.95 and is greater than 0.6 (Fig. 2). This means that the structural model significantly explains this indicator [15, 17]. The coefficients of the path (the value on the arrows between the circles in Fig. 3) indicate a positive relationship between economic development and environmental and social burden and economic development and smart technologies. In this case, you should pay attention to the indicators included in the design "environmental and social burden". Therefore, an increase in pollutant emissions, accidents, and energy costs by 1 will increase economic behavior indicators by 0.916. That is, now, in fact, an increase in the burden on the environment, extensive use of resources for the studied countries activates the economic behavior of companies. At the same time, increasing the use of smart technologies by 1 will increase economic development indicators by only 0.104. This indicates a lesser power of relation between economic behavior and the use of smart technologies. This result is confirmed by the magnitude of the effect f^2 (Fig. 3), which makes it possible to analyze the relevance of some constructs to explain others [15, 17]. So, for smart technology, this indicator is in the range from 0.15 to 0.35, which corresponds to the average effect [15, 17]. For environmental and social burden, this figure is much higher than 0.35, which indicates a very strong effect [15, 17].

The results of the analysis of the structural model are explained by the following reasons. Firstly, the use of smart technologies is not yet general, and therefore does not have a significant effect on the economic behavior of companies. Secondly, the initial data for the analysis cover only industry, so the results are expected for this sector of the economy. Thirdly, for a more accurate assessment of the relationships, it is necessary to assess the increase in the corresponding indicators, but in this study, this turned out to be difficult due to the lack of comparable data in open sources. In addition, the sample size due to this fact is significantly reduced, which makes it almost impossible to further analyze.

In general, the results of the analysis of changes in the economic behavior of companies under the influence of the need to maintain sustainable development and using smart technologies indicate the following. At this stage of technology development for the countries of the European Union and Ukraine, companies in the industrial sector have not fundamentally changed their economic behavior. On the other hand, a significant positive link between economic behavior and the use of smart technologies gives reason to recommend that the management of companies in the industrial sector pay special attention to the development of the integration of smart technologies into business processes.

The practical application of the obtained results is limited by the nature of the initial data: the results were obtained for the countries of the European Union and Ukraine for companies in the industrial sector. However, the approach can be applied to analyze the situation in other countries, sectors, or companies.

The disadvantages of the study are also caused by the nature of the initial data because a limited number of indicators are used, which are associated with the analyzed designs. The inclusion of more indicators can change the strength and direction of the studied relationships.

Further research should be directed to the study of other sectors of the economy, changing the focus to data on statistical investigation of companies directly. To do this, it is advisable to form adequate questionnaires in order to obtain unified data for the entire sample of companies.

7. Conclusions

1. It has been established that existing approaches to corporate sustainable development of companies are based on approaches such as corporate social responsibility. The effectiveness of companies in terms of social responsibility is characterized by such parameters of economic behavior as reputation and competitiveness, determining the access of companies to financial resources. However, corporate social responsibility reflects the normative position on the moral and ethical code of business, which does not correspond to the concept of sustainable development. It is determined that corporate sustainable development is a combination of economic, environmental, and social components of the company's economic behavior, which provides an intensive type of economic growth. From the point of view of assessing corporate sustainable development, this means supplementing corporate social responsibility indicators with an economic component.

2. It has been established that in addition to economic, environmental, and social components, corporate sustainable development includes the technological aspect, since any technology in this context is intended to reduce the use of economic resources. Smart technologies are defined as information and communication technologies that have cognitive awareness of the circumstances of their functioning and can respond to new circumstances. From this point of view, a number of Industry 4.0 technologies can be attributed to smart technologies. In particular, these are technologies that support the implementation of production or business processes without human intervention. These include artificial intelligence, big data analysis, and cloud computing, virtual reality, Internet of Things, additive manufacturing, cyber-physical systems, robotics, and cellular networks. The importance of smart technologies for corporate sustainability is explained by their purpose in reducing energy and resource expenditure. To assess the use of smart technologies, there are official indicators within the framework of methods for assessing the digital economy. They are used at the macro level and determine the number of enterprises that use a particular technology. At the enterprise level, it is advisable for each technology to calculate the number of employees who use the technology, the cost (investments) of the technology, the amount of income received with the involvement of technology.

3. The structural model for measuring the relationships between the use of smart technologies, sustainable development and the economic behavior of companies was calculated using the PLS-SEM method. This method makes it possible to evaluate any complex model with a large number of designs and indicators. The model makes the hidden endogenous variable characterizing the economic behavior of an enterprise dependent on two hidden independent variables – sustainable development and the use of smart technologies. To assess hidden variables, 13 indicators were used, the data on which are obtained from statistical data for 2020 for 26 countries of the European Union and Ukraine. The choice of countries and indicators is due to the availability of relevant data. The results of the analysis of the structural model proved the reliability and validity of latent variables. The parameters of the model establish the existence of a close positive relationship between economic behavior and sustainable development and economic behavior and smart technologies. Taking into account the nature of the indicators included in the hidden variables, it has been proved that at this stage of technology development for the countries of the European Union and Ukraine, companies in the industrial sector have not fundamentally changed their economic behavior. Currently, in fact, an increase in the burden on the environment, extensive use of resources for the studied countries activates the economic behavior of companies. However, a significant positive link between economic behavior and the use of smart technologies gives reason to recommend that the management of companies in the industrial sector should pay special attention to the development of the integration of smart technologies into business processes.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

Funding

The study was conducted without financial support.

Data availability

All data are available in the main text of the manuscript.

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