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# Assessment of the Competitiveness and Effectiveness of an Open Business Model in the Industry 4.0 Environment

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**Abstract:** With the changing conditions of business conduct, Industry 4.0 means a rapid development of new technologies, increased intensity of competition and evolving globalization, thus presenting enterprises with new challenges. There is a need to transform business models into open models that make extensive use of open innovations. A company's aspiration to achieve success on the market requires monitoring the degree of strategy implementation. The aim of this article is to present a tool for assessing the competitiveness and effectiveness of the business model of an enterprise in the Industry 4.0 era. The tool for assessing the business model is based on the balanced scorecard. It was constructed on the basis of literature and expert research. The article presents its practical application in an enterprise.

**Keywords:** open business model; open innovations; Industry 4.0; balanced scorecard; competitiveness; efficiency



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## 1. Introduction

The era of Industry 4.0 has been going on for a few years now, influencing not only business or industry, but also other areas of life, providing opportunities previously unattainable for companies and customers [1]. A dynamically changing environment, evolving globalization, increased intensity of competition and threats of crisis phenomena require development, improvement and implementation of innovative management systems [2]. In order to gain and maintain competitive advantage, enterprises need to focus their management system on increasing efficiency, innovation and competitiveness [3,4]. The intensifying crisis in the world economy caused by the COVID-19 pandemic will particularly affect the behavior of enterprises, significantly influencing both their strategic reorientation and operational activity [5,6]. This is reflected in the creation of new (open) business models, ones that allow for open innovation, rapid reorganization of processes and very flexible adjustment of company operations to new conditions and a dynamically changing competitive and common environment [6]. New or modified strategies will be even more oriented toward competitiveness and effectiveness of enterprises' operations [7–9].

Every company, which wants to be successful in the market, has to build a competitive open business model that will distinguish it from its competitors [10]. The condition for achieving a competitive advantage is the efficiency of operation [11,12]. Management concepts focused on increasing efficiency and innovation are expected to lead to an increase in company value [13,14]. In the context of value management, a balanced scorecard is an important concept and management instrument. The shaping of the company's value depends, to a large extent, on the architecture of its open business model and the elements of its business processes (which absorb open innovations) [15]. Business processes by their very nature generate value for the customer. The value obtained is expressed in profitable sales, customer satisfaction and customer loyalty [16].

The literature review indicates a research gap in the assessment of competitiveness and effectiveness of open business models in the era of Industry 4.0. Hence, it seems reasonable to undertake research in this area. The following research questions are formulated: How to assess the competitiveness and effectiveness of an open business model of the Industry 4.0 era? What key elements should such an assessment contain? Which tool/template known in management science can be used for such assessment? The aim of the article is to present a tool for assessing the competitiveness and effectiveness of the business model of an enterprise in the era of Industry 4.0.

The article consists of six parts. The first part is the Introduction, providing a brief introduction to the topic, signaling the need for research in the presented area and the purpose of the article. The second part is the Literature Review outlining the theoretical framework of open business models of the Industry 4.0 era and the balanced scorecard, which is the foundation of the research work. The third part describes the methodological framework. The fourth part presents the results of the research, i.e., a tool for assessing the competitiveness and effectiveness of the business model of Industry 4.0 environment, and verifies its usefulness in an enterprise from the food industry (case study). The fifth part contains a discussion relating the presented tool to the research conducted by other researchers. Lastly, the paper is concluded.

## 2. Literature Review

### 2.1. *The Open Business Model of the Industry 4.0 Era*

Industry 4.0 is undoubtedly a technological change, but social and industrial changes are also caused by the digital transformation of industry. These changes are shaping a new environment in which companies function and, to a different extent, influence the emergence of contemporary challenges for companies and society [17–19]. Industry 4.0 means changes caused by the digital transformation of industry, but it is not limited only to the aspect of technological changes, which should be implemented in manufacturing companies [20]. Observing the economy and society, the trends and effects of this revolution are visible in all macro- and micro-areas of the market.

Today, we are seeing rapid advances in technology, from Industry 4.0 to the fourth industrial revolution. However, an exponential growth in economic productivity relative to the rate of technological development is expected in vain. The world is facing declining entrepreneurship, declining productivity, and a slowdown in the power of human ingenuity. Open business models creatively connect modern technology and the marketplace, which is why they are so important in the development of the world's economies [21].

The open business model of the Industry 4.0 era can be understood as a configuration of business processes that connect and develop resources formed in the form of social and technical architecture of the enterprise. The technical architecture of this model is built on flexible, digital processes. The processes support the creation of a cyber–physical network of cooperation, so that the business model of the Industry 4.0 era becomes an open model using open innovation. The open business model of the Industry 4.0 era enables the delivery of personalized products to customers [22].

The technical architecture of the open business model of the Industry 4.0 era will include the pillars (key technologies) of Industry 4.0, such as big data, cloud computing, 3D printing, ICT systems integration, prototyping, industrial Internet of Things (IoT), augmented reality, autonomous systems, cyber–physical systems. These technologies will enable an open model concept for a smart factory (enterprise) based on networking with other enterprises [23]. Smart factories will create cyber–physical systems (CPS) to build and enhance their competitive advantage [24]. The technical architecture of the model will enable CPSs to collect data, process it and interact with physical processes across the manufacturing network through unlimited interconnected networks of smart communication, mechatronic assets (machines, equipment, robots, transportation assets, etc.) [25].

The foundation of this architecture will be communication, allowing machines and sensors to not only transfer data between each other but also directly with ethernet or the cloud.

Closed systems will become open systems. In the future, using decentralized computing power, data will be transformed into information directly in the sensor. Decisions will be made on a decentralized level [26]. Process, production and enterprise information will be transmitted directly to ethernet and the cloud. Maximizing the digitization of the technical architecture is to increase machine availability, increase manufacturing speed, increase product quality, increase manufacturing flexibility, increase worker safety and increase the ability to leverage open innovation. The technical architecture will rapidly absorb the latest technology solutions and open innovation, supporting the ability to personalize production while keeping mass-produced products competitively priced [27].

The social architecture of the open business model of the Industry 4.0 era is: human resources, organizational structure, decision-making authority and company performance management systems. Due to the fact that the fourth industrial revolution creates new work environment and conditions on the labor market, competency management and talent management in a company will be an important element of this architecture. Automation and digitalization of business, as well as the need for constant adaptation to the changing conditions of the company's environment, require completely new competencies of employees, and, therefore, a change or reorganization of the company's HR structure [28]. Therefore, for the fourth-generation industry, it is crucial not only to attract talent from the labor market, but above all, to develop skills among the employed workforce, which should be the strategic goal of every smart enterprise. Such actions make it possible to notice staff shortages or gaps in employees' competencies in time and enable the implementation of corrective measures [29]. Such actions include not only classical training but also employee rotation between teams, enabling engineers to plan their own career paths or including them in the process of shaping the company's development vision. In smart companies, it is necessary to remember about soft competencies of the employees, which have not been required from engineers so far. Skills of cooperation, communication, empathy, creativity or responsibility for own actions will determine the success of a smart enterprise [30–32].

Another foundation of the open business model of the Industry 4.0 era will be business processes that are, as it were, a way of realizing value in the form of customer relationships, in particular, providing them with products and/or services that satisfy specific needs [33]. Business processes are a combination of social architecture and technical architecture, at the same time deriving from them the resources necessary to produce appropriate products that create value for the customer, often personalized [34]. Ongoing research on business models and Industry 4.0 has identified key principles in business process design. Business processes will be characterized by [35]:

- Interoperability—the creation of communication standards between businesses, cyber-physical systems and human teams;
- Virtualization—creating virtual work/collaboration/cooperation models and simulation models;
- Decentralization—devolving manufacturing decisions to intelligent products, with full electronic traceability throughout the value chain;
- Real-time decision-making capability—access to all key process information automatically, based on data collected from machines and equipment;
- Service orientation—opening the use of assets (factory, technology, human teams) for service use in other factories, as well as for servitization;
- Orientation to personalization of production—providing the customer with the product maximally adapted to their needs;
- Orientation to servitization—increasing the proportion of services in the enterprise's portfolio;
- Orientation on sustainable production—production connected with the concept of limiting the use of resources and the environmental impact of the product, from its design to the end of its life.

Of particular note in the open business model of the Industry 4.0 era are: the role of the customer as a partner in the design process; partners working together in a cyber-physical network, forming agile teams to implement a specific project; automated production in line

with personalized customer expectations; production as a service; elimination of unused production capacity by making spare capacity available to cyber–physical network partners; offering personalized products, maximally tailored to customer preferences, at the price of a mass-produced product; partnership with the customer throughout the product’s life cycle, with a positive impact on sustainable consumption; servitization [36–39].

Open innovation is a key foundation for building open business models. Based on the business model design compass, it can be said that a modern business model must be distinguished by four aspects:

1. Pushing the boundaries of existing business models;
2. Extending the bottom-up framework of the modern business model;
3. Cultivating the front neighborhood of the modern business model;
4. Cultivating the back neighborhood of the new business model. Existing companies can implement open innovation into the modern business model by cultivating the neighborhood and value of change. The important actors in this concept are engineers, technology, customers and social entrepreneurs [21].

## 2.2. *Balanced Scorecard (BSC)*

A study conducted by R. Kaplan and D. Norton [40–43] indicates that the balanced scorecard is treated as a strategic management system, which is related to its use in the following key management processes:

- refining the vision and strategy;
- clarification of strategic objectives and metrics and their integration into management systems;
- planning, setting objectives and undertaking strategic initiatives;
- improving the organization’s monitoring, strategy execution and learning systems.

The development of a balanced scorecard mobilizes the management of the company to formulate precisely the strategy and vision by detailing the strategic objectives and identifying the key factors affecting their implementation [44]. The formulated strategic objectives are future oriented and must be taken into account in the developed plans. BSC integrates and enables coordination of implemented plans of the company, giving the possibility to define coherent initiatives leading to continuous improvement, reconstruction of processes or establishment of restructuring programs [45]. The last management process in which the balanced scorecard plays an important role is the process of organizational learning at the highest levels of management, which is especially important in the era of Industry 4.0 [46]. BSC serves both the purpose of monitoring the implementation of the strategy and taking appropriate corrective actions, and if necessary, it also enables designing changes in the strategy itself. A balanced scorecard allows for translating vision into operational activities and individual goals, understandable for employees at all levels of the organization [4,47]. Moreover, it facilitates giving common direction to the activities of all organizational units, makes all employees do what is optimal for the company [48].

The last of the management processes in which the balanced scorecard plays an important role is the process of organizational learning at the highest levels of management. The card serves both as a means of monitoring the implementation of the strategy in order to take appropriate corrective action, and if necessary, it also enables the design of changes in the strategy itself [49]. The implementation of these activities is possible thanks to the feedback on the implementation of the adopted strategy and assumptions formulated in the charter, which the management receives and uses. The information flow generated by the charter influences the process of organizational learning, as it provides managers with information not only on the implementation of the strategy in accordance with the plan (single-loop learning), but above all, information on whether the adopted strategy will ensure survival and success (double-loop learning). As a result of the double-loop learning process, the strategy may be adjusted or completely changed to suit the new market conditions and internal capabilities of the company [50]. The creators of the card emphasize that the basis for effective implementation of the strategy becomes: a process

of collecting information, a process of testing hypotheses, a process of analysis, a process of strategic learning and a process of adaptation. Thus, the balanced scorecard makes it possible to analyze an organization from a financial, customer, internal process and development perspective [51]. The scorecard reflects the balance between short- and long-term goals, financial and non-financial measures, past indicators, internal and external performance measures.

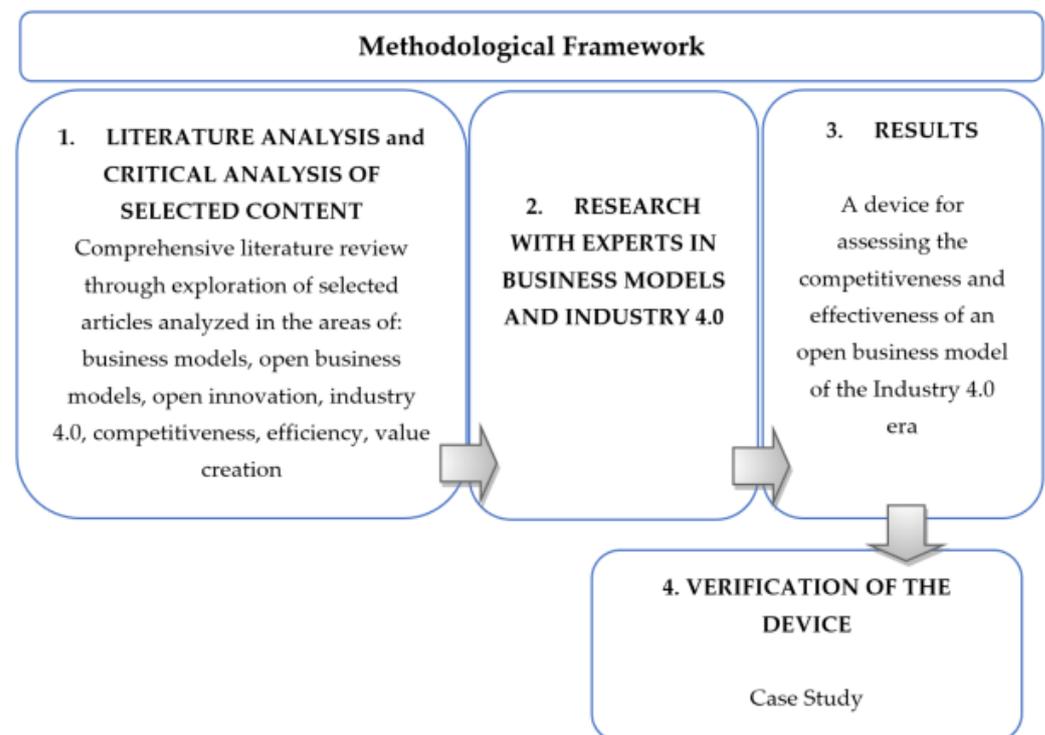
Most often, the strategic scorecard is developed in four perspectives, within which the following questions must be answered [52]:

- Financial perspective—How should we be perceived by shareholders to be considered financially successful?
- Development perspective—How to maintain the ability to change and improve efficiency in order to achieve our vision?
- Internal processes perspective—What internal processes do we need to improve to keep the owners and customers of the company happy?
- Customer perspective—How should customers perceive us so that we achieve our vision?

The above-described perspectives constitute the foundation of the balanced scorecard and allow for creating financial success of the company, market position, customer loyalty, capital development and, most importantly, they enable the control of business processes. This division is most often proposed, but it can be modified depending on the needs and type of organization. The most important point is to define precisely the strategic objectives and then the metrics that relate to them. The BSC makes it possible to measure value for current and future customers. Without diminishing the importance of financial indicators, the card shows the factors that shape the competitive advantage [53].

### 3. Materials and Methods

The research methodology consisted of four consecutive stages (Figure 1). The first stage of the study was a literature analysis and a critical content analysis of the selected publications. This part of the study sought answers to the questions described in the Introduction section. In the second part of the research, based on the selected knowledge from the selected publications, research was conducted with the participation of experts. The research was based on a selected panel of 10 experts. This results from the assumption accepted in the social sciences that for some problems, it is more appropriate to use in-depth analysis with a small number of experts, rather than conducting superficial research with a large number of experts. Research with the participation of experts is a particularly useful research approach in situations where the high complexity of the research problem makes it difficult to create a standardized research tool. It is also useful when the data necessary for the analysis of individual research units come from many sources [54–56]. The experts were 10 specialists in the field of open business models and Industry 4.0. Eight experts were from Europe (Poland, Czech Republic, Slovakia, Germany, Greece), two from the USA, as efforts were made to account for cultural differences. The experts participating in the study were selected purposively, based on a qualitative criterion. Each of the experts is a university employee, cooperates with business, actively conducts research and has scientific achievements in the areas under study. Interviews with experts were conducted.



**Figure 1.** Methodological framework. Source: own study.

The interviews conducted with experts were structured, based on a survey questionnaire. The questions of the questionnaire were based mainly on the theoretical background from the earlier part of the research. The survey questionnaire contained 35 questions. It was based on closed, semi-open and open questions. In terms of content, the survey questionnaire was divided into three parts. The questionnaire opened with questions focused on the issues of open business models and Industry 4.0. In this part, particular attention was paid to the issue of key perspectives, which should form the basis for assessing the competitiveness and effectiveness of open business models operating in the environment of Industry 4.0. Next, there were questions oscillating around the effectiveness and competitiveness of open business models. This part of the questionnaire focused on identifying the strategic objectives that should be measured in order to strive for 100% implementation of the company's strategy. The questionnaire closed with questions identifying measures for each objective.

The results obtained in the form of necessary indicators and areas that should be included in the assessment of competitiveness and model efficiency allowed us to proceed to the third stage of research. In this stage, based on the balanced scorecard, a tool was created to assess the competitiveness and effectiveness of an open business model in the era of Industry 4.0, and then, its usefulness was verified in a selected company (stage 4).

## 4. Results and Case Study

### 4.1. Results

The construction of the balanced scorecard template for the open business model of the Industry 4.0 era began with the definition of its perspectives. Four perspectives were defined:

1. organizational perspective,
2. business process perspective,
3. technical architecture process perspective,
4. knowledge and learning perspective.

Goals were assigned to each of the perspectives, for which metrics were defined. The developed tool was used for aggregate assessment of the open business model of an enterprise operating in the Industry 4.0 environment, with a focus on efficiency and competitiveness (Table 1).

**Table 1.** Assessment/balanced scorecard tool for the effectiveness and competitiveness of the open business model of the Industry 4.0 era.

Goal	Measure	Size of the Measure during the Measurement Period
Organizational perspective		
Cooperation and projects	Projects carried out	Number
Strategy	Assessment of strategy implementation	Scale 1–5
Employees	Qualitative assessment of employees	Scale 1–5
Leadership	Qualitative assessment of leadership	Scale 1–5
Networking	Execution of projects within cyber–physical networks	Number of completed projects
Business process perspective		
Internal process integration	Degree of integration of processes within the enterprise	%
Process integration with the environment	Degree of process integration with the environment	%
Degree of process integration in the product life cycle	Degree of integration of processes in the product life cycle area	%
Service life cycle process integration	Degree of process integration in the service life cycle area	%
Standardization of technology purchasing	Degree of standardization of technology purchasing	%
Standardization and optimization of energy efficiency	Degree of standardization and optimization of energy efficiency	%
Customer cooperation	Degree of customer cooperation	%
Product personalization	Range of product personalization	%
	Personalized products, their number in the company’s offer	Number
Personalization of service	Scope of service personalization	%
	Personalized services, their number in the company’s offer	Number
A technical architecture process perspective		
Automation	Degree of process automation	%
Connectivity	Quantity of data exchange between devices, machines and computer systems	Quantity of data
Smart technologies	Number of smart technologies	Number
Smart product	Number of smart products	Number
Smart service	Number of smart services	Number
A knowledge and learning perspective		
Employee satisfaction	Percentage of satisfied employees according to surveys	%
Staff qualifications	Percentage of employees who have a degree, license or credential	%
Talents	Number of employees covered by talent management program	Number
Employee competence management	Training costs per employee	EUR
Innovation of employees	Number of reported innovative solutions	Number

#### 4.2. Case Study

The usefulness of the tool for assessing the competitiveness and effectiveness of an open business model of the Industry 4.0 era was verified in the example of a case study. The examined company is a manufacturer of packaging for the meat industry, which for years has been one of the world’s leading manufacturers of sausage nets. It has been operating in Poland since 1989. The company supplies its products to over 1300 meat processing plants and wholesalers in Poland. All over the world, the company’s products are available through a network of over a thousand distributors in 45 countries in Europe, Asia, North and South America, and Australia. The company employs nearly 300 people at its production plant and subsidiaries. The company’s open business model is based on short lead times, high product quality, a wide range of products, expert advice and cooperation with external business partners. The description of the business model of the studied enterprise is presented in tabular form in Table 2.

**Table 2.** The description of the business model of the studied enterprise.

Elements of the Model	Description
Customer value	High-quality products, guarantee of realization of orders in a short time (within Poland—within two working days), wide range of assortment, professional consulting.
Social Architecture	
Human resources	71% of employees have a university degree, including 45% in engineering, 26% in economics (mainly trade and finance).
Organizational structure	Dominated by a line structure, characterized by process management with elements of a virtual organization (which enables cooperation with a network of over a thousand distributors in 45 countries around the world).
Decision-making authority	The decision-making authority is held by those responsible for the implementation of specific processes in the company and those who manage the various departments of the company. In the enterprise, all data are stored in the cloud and processed/analyzed by an externally designed system.
Enterprise performance management systems	Significantly increased scope of formalized information and knowledge (training, postgraduate studies, extensive information systems). Information and knowledge acquired individually by employees (broader scope). Less importance of using tacit knowledge.
Processes and Activities	
Business processes	Production of sausage industry packaging, customer training, purchasing, sales, sausage market marketing, consulting with business partners and customers, HR process, risk management.
Type and structure of the value chain	Developed value chain adapted to customer needs—a source of value creation based on professional consulting.
Information and knowledge resources	Strong support of business processes by information systems. Intensive development of the use of information resources to build explicit knowledge resources.
Achieved competitive advantage and its sources	Advantage in the quality of offered products obtained thanks to implemented pillars of Industry 4.0 and well-trained employees. Advantage due to flexibility of production and reduction in unit costs. Advantage due to localization and e-business.
Technical Architecture	
ICT resources	Controlling information system, CRM system, production planning and control systems, digitalization of business processes (industrial scanners), automatic identification of customer order fulfillment.
Industry 4.0 pillars supporting the use of open innovation	Manufacturing automation (at 45%), systems integration (at 60%), industrial Internet of Things (15%), technologies supporting cyber security, big data, cloud computing.

An assessment of the effectiveness and competitiveness of the business model was conducted for the company using the tool presented in the Results section. The results are summarized in Table 3 in the form of a balanced scorecard.

**Table 3.** Balanced scorecard for the enterprise.

Goal	Measure	Size of the Measure during the Measurement Period	Year I	Year II	Year III
Organizational perspective					
Strategy	Assessment of strategy implementation	Scale 1–5	3	3	3
Employees	Qualitative assessment of employees	Scale 1–5	3	3	4
Leadership	Qualitative assessment of leadership	Scale 1–5	3	3	4
Networking	Execution of projects within cyber–physical networks	Number of completed projects	0	5	12
Business process perspective					
Internal process integration	Degree of integration of processes within the enterprise	%	45%	60%	65%
Process integration with the environment	Degree of process integration with the environment	%	5%	15%	15%

**Table 3.** *Cont.*

Goal	Measure	Size of the Measure during the Measurement Period	Year I	Year II	Year III
Degree of process integration in the product life cycle	Degree of integration of processes in the product life cycle area	%	42%	43%	44%
Standardization and optimization of energy efficiency	Degree of standardization and optimization of energy efficiency	%	42%	43%	44%
Customer cooperation	Degree of customer cooperation	%	46%	50%	52%
A technical architecture process perspective					
Automation	Degree of process automation	%	25%	45%	45%
Connectivity	Quantity of data exchange between devices, machines and computer systems	Quantity of data	10 T	12 T	13 T
Smart technologies	Number of smart technologies	Number	6	7	7
A knowledge and learning perspective					
Staff qualifications	Percentage of employees who have a degree, license or credential	%	69%	69%	71%
Talents	Number of employees covered by talent management program	Number	6	7	5
Employee competence management	Training costs per employee	EUR	120	120	150
Innovation of employees	Number of reported innovative solutions	Number	21	19	20

Analyzing the data contained in the customer perspective, it can be seen that the company’s rating of the degree of strategy implementation has held steady at 3 over the three years studied. There was an increase in the qualitative assessment of employees and leadership over the three years studied. In Year II, the first projects within the cyber-physical collaboration network were implemented, and in the following year, the number of projects was increased from 5 to 12.

Within the business process perspective, increases in evaluation parameters were noted in all processes. The integration of processes into the environment and the integration of processes into the process life cycle reached the same value in the study period II and III.

In the perspective of technical architecture processes, the degree of automation was increased from 25% to 45%. The amount of data transferred between devices continuously increased, and the number of intelligent technologies increased to 7.

In the perspective of knowledge acquisition and learning, staff qualifications were increased, and a total of eighteen employees were included in the talent management program. The budget allocated for staff training was increased. Staff innovation as expressed by the number of innovative solutions submitted was maintained at an average level of 20 submissions per year.

**5. Discussion**

The dynamic technological development that has been ongoing since 2011, significantly influencing the strategic reorientation of enterprises, forces a redefinition of their business models. In addition, the intensifying crisis in the global economy caused by the COVID-19 pandemic will particularly affect the behavior of enterprises, significantly influencing both their strategic reorientation and operational activity [57,58]. New or modified strategies will be oriented to an even greater extent on the competitiveness and effectiveness of enterprises’ operations. This will be accompanied by the development, improvement and implementation of management systems that effectively implement such strategies, using, in particular, innovative management instruments. The balanced scorecard is one such instrument [59].

The use of the balanced scorecard methodology for corporate competitiveness strategy enables the transformation of measurement into a management process. This integrated measurement system allows for a holistic view of the problem of assessing the competitiveness and effectiveness of an open business model in all areas of its operation. BSC

should evolve from a set of measures to a complex system, monitoring all services and solutions used at all levels of management and in all organizational units. Currently, strong competition and globalization of markets force innovation, manifested, among other things, in short design and production times, excellent quality and additional services as part of after-sales customer service [17–21].

Balanced scorecard is understood as a form of modern business management. In fact, it is a tool for programming the company's activities aimed at achieving its mission, vision and strategy. In traditional methods of measuring efficiency and competitiveness of business models (such as econometric models), there are serious gaps, which are connected with their failure to adapt to the environment. The fundamental inadequacy of traditional measurement methods stems from a focus on historical data that do not necessarily relate to a company's current strategic objectives. This results in overlooking the performance of the company's intangible assets [60].

The balanced scorecard addresses the fundamental shortcomings of measuring the performance and competitiveness of a business model. The card first identifies the factors on which the company's future performance depends, thus allowing a focus on key resources. The second positive aspect of the balanced scorecard is the possibility of translating the results of intangible resources into measurable indicators that reflect the level of implementation of the strategy (to which the business model is linked) [61].

The balanced scorecard makes it possible to measure the effectiveness and competitiveness of a business model from the point of view of four perspectives, thanks to which it is possible to translate the company's vision and strategy into measurable goals [62]. In the presented balanced scorecard tool/template, objectives were defined for each perspective based on empirical research and the company's digital maturity assessment tool developed by experts from the Future Industry Platform. The perspectives developed are extremely important in assessing the current and future success of the company. In terms of the organizational perspective, the following objectives were defined [63]:

1. Collaboration and projects—collaboration between people, teams and partners inside and outside the company. It is defined by how projects are managed, how interdisciplinary teams are formed and how partners work together to achieve common goals. Teams build a shared knowledge base that allows lessons to be learned for all teams in the future for continuous improvement. Teams can be formed in a flexible and agile way to solve problems as they arise. Risk, responsibility and rewards are shared [64,65].
2. Strategy—involves identifying priorities, developing a system of rules, practices and processes to transform vision into business value. A long-term strategy and an appropriately aligned business model should be implemented in all areas of the company and remain constantly evolving, taking into account changes in the latest trends in technology, management and consumer preferences.
3. Employees—training, employee competence development, talent management is a system of processes and programs that aims to develop the skills, knowledge and competencies of employees to achieve organizational excellence in line with the concept of Industry 4.0 [28,29].
4. Leadership—leadership competencies refer to the readiness of the management to use the potential of the latest management trends and technological solutions in order to maintain the competitiveness and effectiveness of the company's business model [39]. Management should have an established knowledge of the latest solutions, be able to implement them on their own in key business areas, and in complementary areas, use an integrated network with external partners [66]. Such cooperation is enabled by an open business model that absorbs open innovations [29].
5. Networking—the company is capable of building cyber–physical networks, sharing knowledge, competencies, spare capacity but also risks with network partners during joint production and/or service projects [64].

In terms of the business process perspective, the following objectives were defined:

1. Internal integration—vertical integration of processes within the company. All data should be comprehensively integrated with related digital tools and systems. Their real-time analysis will allow autonomous decision making by systems (which are the pillars of Industry 4.0) [23]. The processes inside the company and the IT systems connected to them will be comprehensively integrated and automated. All systems will be able to actively analyze data in real time and make autonomous decisions based on them, which will enable the optimization of processes integrated with them [26].
2. Integration with the environment—horizontal integration of processes across the company and across the value chain. Data will be comprehensively integrated with related digital tools and systems, and real-time analytics will allow systems to make autonomous decisions. Supply chain processes and related IT systems will be comprehensively integrated and automated. The systems will be able to proactively analyze data in real time and make autonomous decisions based on those data to optimize their integrated processes [65,66].
3. Product life cycle integration—an integrated product life cycle will involve the integration of people, processes and systems across the entire product life cycle, spanning the design and development, engineering, manufacturing, customer service, service and sales stages. Data will be comprehensively integrated with related digital tools and systems, and real-time analytics will allow systems to make autonomous decisions. Product life cycle management processes and related information systems will be comprehensively integrated and automated [67]. The systems will be able to actively analyze data in real time and make autonomous decisions based on them, allowing for optimization of the integrated processes [68].
4. Standardization of technology purchasing—total cost of ownership (TCO) over the life cycle of the investment will be a key bidding criterion for companies. Machines and technologies will be selected in tenders where total cost of ownership (TCO) over the planned technology life cycle will be a key consideration. The purchase specification will include requirements for open communication interfaces of the machines, allowing for real-time data reading [1]. The machine will immediately become part of the industrial Internet of Things infrastructure when installed in the plant [2].
5. Energy efficiency standardization and optimization—the company will use machine-learning algorithms to support energy cost optimization and recommend changes [52].
6. Cooperation with the customer—in the open business model of the Industry 4.0 era, cooperation with the customer takes on the dimension of a partnership and requires deep communication, interaction and personalization of communication [69]. As part of the cooperation with the company, the customer has the opportunity to personalize the product and to co-create it from the very beginning of its creation. Co-creation and communication will be possible through the use of digital tools and channels. Communication with customers will take place through online and offline channels and will be personalized and automated [70].
7. Product personalization—will be achieved through online configurators. The customer will be involved in co-creating the product by providing information and guidance for product development and new product design [71]. Digital technological solutions and the adopted competitive strategy will enable customer involvement in product co-creation through dialog, active provision of guidance for its development and design of new products and testing of prototypes [72,73].

In terms of the technology perspective, the following objectives were defined:

1. Process automation—in the scope of production, together with internal logistics, it will be characterized by implementation of technologies for monitoring, controlling and automation of production processes. The processes will be fully automated, flexible, not requiring the intervention of employees. This will enable collaboration and dynamic interactions within highly autonomous networks (between departments and between partners). Automation within the administration and management of the

company will be characterized by the implementation of technology for monitoring and control, and automation of administrative processes of the company, e.g., product sales, demand planning, marketing, order processing, human resources planning and management. Automation within the building infrastructure will be characterized by the implementation of technology to monitor, control and automate processes inside buildings and rooms where production takes place, e.g., management of heat, ventilation and air conditioning (HVAC), chillers, refrigeration, security and lighting systems [63].

2. Connectivity in the area of production execution and internal logistics will be characterized by connectivity, ability to communicate and freely exchange data between devices, machines and computer systems [3]. Systems and equipment will be secured, able to interact in real time and to be quickly and easily reconfigured. Information exchange and interactions within the network will be conducted in real time, while maintaining data security. There will be the ability to quickly and easily reconfigure the network to accommodate any modifications, enabling scalability [7].
3. Smart technologies—will be used to process and analyze data to optimize existing manufacturing processes and create new smart systems. Applied IT systems will be able to predict and diagnose potential deviations and make autonomous and intelligent decisions to optimize productivity and resource efficiency. Systems will make autonomous decisions to optimize productivity and resource efficiency [24].
4. A smart product—the vision of a smart product in the open business model of the Industry 4.0 era is characterized by the ability to make autonomous, intelligent decisions based on real-time data from sensors embedded in the product. It will also have its digital counterpart, the so-called digital twin, enabling simulation of processes using the product [25].

In terms of the knowledge and learning perspective, the following objectives were defined:

1. Employee satisfaction—job satisfaction is a priority of the social architecture area of the open business model of the Industry 4.0 era, which seeks to provide employees with a work–life balance. It is an indispensable element to achieving high performance by an enterprise [28].
2. Staff qualifications—a number of employees with specialist education, including engineering/technical education. The level of staff qualifications reflects the level of knowledge of the company, affecting its competitiveness and attractiveness from the point of view of the customer and business partners [74,75].
3. Talent—talent management will be a set of activities aimed at finding, recruiting, developing, valuing and empowering individuals with above-average intellectual skills, as well as being aimed at the effective use of these abilities by the company for the implementation of its strategy [28].
4. Employee competence management—a system of training aimed at improving the skills of employees. The company will acquire well-trained professional staff and will thus increase the effectiveness and efficiency of their work and their profits. Training will make the staff increase their ingenuity, innovation, gain a new perspective on the tasks performed routinely [29].
5. Innovativeness of employees—indicates the creativity of employees. It will allow the company to achieve success on the market and strive for progress by stimulating and supporting creative and active employees. Innovativeness increases company's competitive advantages and abilities, thanks to the need for constant observation of competitors' actions and customers' reactions, as well as the necessity for permanent implementation of novelties [28,32].

Each of the balanced scorecard perspectives measures different aspects of the open business model, each providing different information that together form a picture of the strategy execution process; therefore, these perspectives cannot be treated separately [76–79].

## 6. Conclusions

Each enterprise wishing to achieve success in the market must build a competitive business model that will distinguish it from competitors. The basis of this model will be a defined competitive advantage, which determines the uniqueness of the company in the eyes of customers and business partners. Creating a profitable, open business model of the Industry 4.0 era will not be possible without translating its strategic assumptions into measurable goals. A tool was developed to evaluate the effectiveness and competitiveness of such a model. The appropriate template turned out to be a strategic scorecard that allows monitoring the implementation of the strategy, translating the vision into operational activities and individual goals, understandable to employees at all levels of the company. The presented balanced scorecard template is a proposed tool for the evaluation of an open business model of the Industry 4.0 era. This template combines, in a balanced way: long- and short-term objectives, financial and non-financial metrics, operational performance indicators and internal efficiency. It is a management tool that supports the communication of strategy and its effective implementation. The main difference between the presented balanced scorecard and traditional performance and competitiveness measurement systems is the inclusion of innovation processes and open innovations in the aggregated open business model measurement system (which is an important added value of the tool). In order to use it for the evaluation of an enterprise or processes, it should be modified for this particular enterprise, e.g., by not using all the elements of the template.

The study's focus on analyzing the business model in terms of efficiency and competitiveness, without considering the cultural differences that may exist in companies in different parts of the world, can be identified as a limitation of the study.

An interesting direction for further research may be the development of an assessment tool for use in dynamically changing market conditions, customer expectations, etc. It is also worth taking into account the framework of the Industry 5.0 concept focusing on human centricity, sustainability and resilience.

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## References

1. Hermann, M.; Pentek, T.; Otto, B. *Design Principles for Industrie 4.0 Scenarios, A Literature Review*; Working Paper; Technische Universität: Dortmund, Germany, 2015.
2. Lu, Y. Industry 4.0: A survey on technologies, applications and open research issues. *J. Ind. Inf. Integr.* **2017**, *6*, 1–10. [[CrossRef](#)]
3. Beier, G.; Ullrich, A.; Niehoff, S.; Reißig, M.; Habich, M. Industry 4.0: How it is defined from a sociotechnical perspective and how much sustainability it includes—A literature review. *J. Clean. Prod.* **2020**, *259*, 120856. [[CrossRef](#)]
4. Birkel, H.; Veile, J.W.; Müller, J.M.; Hartmann, E.; Voigt, K.-I. Development of a Risk Framework for Industry 4.0 in the Context of Sustainability for Established Manufacturers. *Sustainability* **2019**, *11*, 384. [[CrossRef](#)]
5. Kagermann, H. Industrie 4.0: Mit dem Internet der Dinge auf dem Weg zur 4. Industriellen Revolution. In Proceedings of the VDI-Nachrichten, Berlin, Germany, 1 April 2011.
6. Kagermann, H.; Helbig, J.; Hellinger, A.; Wahlster, W. Recommendations for Implementing the Strategic Initiative Industry 4.0: Securing the Future of German Manufacturing Industry. Final Report of the Industry 4.0 Working Group. Forschungsunion 2013.

- Available online: [http://www.acatech.de/fileadmin/user\\_upload/Baumstruktur\\_nach\\_Website/Acatech/root/de/Material\\_fuer\\_Sonderseiten/Industrie\\_4.0/Final\\_reportIndustrie\\_4.0\\_accessible.pdf](http://www.acatech.de/fileadmin/user_upload/Baumstruktur_nach_Website/Acatech/root/de/Material_fuer_Sonderseiten/Industrie_4.0/Final_reportIndustrie_4.0_accessible.pdf) (accessed on 6 February 2021).
7. Azmi, A.N.; Kamin, Y.; Noordin, M.K.; Nasir, A.N.M. Towards industrial revolution 4.0: ‘employers’ expectations on fresh engineering graduates. *Int. J. Eng. Technol.* **2018**, *7*, 267–272.
  8. Bauernhansl, T.; Hompel, M.; Vogel-Henser, B. *Industrie 4.0 in Produkten. Automatisierung und Logistik*; Springer: Fachmedien/Wiesbaden, Germany, 2014.
  9. Berger, R. The Industrie 4.0 Transition Quantified. In *How the Fourth Industrial Revolution Is Reshuffling the Economic, Social and Industrial Model*; Roland Berger: Munich, Germany, 2016.
  10. Grabowska, S. Business model metallurgical company built on the competitive advantage. In Proceedings of the 25th International Conference on Metallurgy and Materials, METAL 2016, Brno, Czech Republic, 25–27 May 2016; pp. 1800–1807.
  11. Schneider, S.; Spieth, P. Business model innovation: Towards an integrated future research agenda. *Int. J. Innov. Manag.* **2013**, *17*, 1340001. [[CrossRef](#)]
  12. Teece, D.J. Business models, business strategy and innovation. *Long Range Plan.* **2010**, *43*, 172–194. [[CrossRef](#)]
  13. Wirtz, B.W.; Pistoia, A.; Ullrich, S.; Gittel, V. Business model innovation: Development, concept and future research directions. *J. Bus. Models* **2016**, *4*, 1–28.
  14. Zott, C.; Amit, R. The business model: A theoretically anchored robust construct for strategic analysis. *Strateg. Organ.* **2013**, *11*, 403–411. [[CrossRef](#)]
  15. Stewart, A.C.; Carpenter-Hubin, J. The balanced scorecard. *Plan. High. Educ.* **2001**, *29*, 37–42.
  16. Kaplan, R.S.; Norton, D.P. Balanced scorecard. In *Das Summa Summarum des Management*; Springer Gabler: Wiesbaden, Germany, 2007; pp. 137–148.
  17. Lasi, H.; Fettke, P.; Kemper, H.G.; Feld, T.; Hoffmann, M. Industry 4.0. *Bus. Inf. Syst. Eng.* **2014**, *6*, 239–242. [[CrossRef](#)]
  18. Olsen, T.L.; Tomlin, B. Industry 4.0: Opportunities and challenges for operations management. *Manuf. Serv. Oper. Manag.* **2020**, *22*, 113–122. [[CrossRef](#)]
  19. Xu, L.D.; Xu, E.L.; Li, L. Industry 4.0: State of the art and future trends. *Int. J. Prod. Res.* **2018**, *56*, 2941–2962. [[CrossRef](#)]
  20. Lele, A. Industry 4.0. In *Disruptive Technologies for the Militaries and Security*; Springer: Singapore, 2019; pp. 205–215.
  21. Yun, J.J.; Zhao, X. Business Model Innovation through a Rectangular Compass: From the Perspective of Open Innovation with Mechanism Design. *J. Open Innov. Technol. Mark. Complex.* **2020**, *6*, 131. [[CrossRef](#)]
  22. Arnold, C.; Kiel, D.; Voigt, K.I. How industry 4.0 changes business models in different manufacturing industries. In Proceedings of the International Society for Professional Innovation Management (ISPIM), Boston, MA, USA, 13–16 March 2016; p. 1.
  23. Pilloni, V. How Data Will Transform Industrial Processes: Crowdsensing, Crowdsourcing and Big Data as Pillars of Industry 4.0. *Future Internet* **2018**, *10*, 24. [[CrossRef](#)]
  24. Strozzi, F.; Colicchia, C.; Creazza, A.; Noè, C. Literature review on the ‘Smart Factory’ concept using bibliometric tools. *Int. J. Prod. Res.* **2017**, *55*, 6572–6591. [[CrossRef](#)]
  25. Wang, S.; Wan, J.; Li, D.; Zhang, C. Implementing Smart Factory of Industrie 4.0: An Outlook. *Int. J. Distrib. Sens. Netw.* **2016**, *12*, 3159805. [[CrossRef](#)]
  26. Müller, J.M.; Kiel, D.; Voigt, K.-I. What Drives the Implementation of Industry 4.0? The Role of Opportunities and Challenges in the Context of Sustainability. *Sustainability* **2018**, *10*, 247. [[CrossRef](#)]
  27. Müller, J.M.; Buliga, O.; Voigt, K.I. Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technol. Forecast. Soc. Chang.* **2018**, *132*, 2–17. [[CrossRef](#)]
  28. Dobrowolska, M.; Knop, L. Fit to Work in the Business Models of the Industry 4.0 Age. *Sustainability* **2020**, *12*, 4854. [[CrossRef](#)]
  29. Bawany, S. The Future of Leadership in the Fourth Industrial Revolution. 2017. Available online: <https://strategicleaders.com/future-leadership-fourth-industrial-revolution/> (accessed on 12 February 2022).
  30. Weking, J.; Stocker, M.; Kowalkiewicz, M.; Bohm, M.; Krcmar, H. Archetypes for industry 4.0 business model innovations. In Proceedings of the 24th Americas Conference on Information Systems (AMCIS), New Orleans, LA, USA, 16 August 2018; Bush, A., Grover, V., Schiller, S., Eds.; Association for Information Systems (AIS): Atlanta, GA, USA, 2018; pp. 1–10.
  31. Śledziwska, K.; Włoch, R. Jakich kompetencji wymaga rewolucja przemysłowa 4.0? *Pomor. Prz. Gospod.* **2020**, *2*, 1–4.
  32. Hu, B.; Zhang, T.; Yan, S. How Corporate Social Responsibility Influences Business Model Innovation: The Mediating Role of Organizational Legitimacy. *Sustainability* **2020**, *12*, 2667. [[CrossRef](#)]
  33. Brzóška, J. *Model biznesowy–współczesna forma organizacyjnego zarządzania przedsiębiorstwem*; Kwartalnik Naukowy Organizacja i Zarządzanie: Gliwice, Poland, 2009; Volume 2, pp. 5–23.
  34. DaSilva, C.M.; Trkman, P. Business model: What it is and what it is not. *Long Range Plan.* **2004**, *47*, 379–389. [[CrossRef](#)]
  35. Magretta, J. Why Business Models Matter? 2002. Available online: <https://hbr.org/2002/05/why-business-models-matter> (accessed on 3 February 2022).
  36. Prahalad, C.K.; Krishnan, M.S. *New Age of Innovation*; Mc Graw Hill: New York, NY, USA, 2010.
  37. Frank, A.G.; Mendes, G.H.; Ayala, N.F.; Ghezzi, A. Servitization and Industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective. *Technol. Forecast. Soc. Chang.* **2019**, *141*, 341–351. [[CrossRef](#)]
  38. Afuah, A. *Business Models: A Strategic Management Approach*; McGraw-Hill Irwin: New York, NY, USA, 2004.
  39. Moradi, E.; Jafari, S.M.; Doorbash, Z.M.; Mirzaei, A. Impact of organizational inertia on business model innovation, open innovation and corporate performance. *Asia Pac. Manag. Rev.* **2021**, *26*, 171–179. [[CrossRef](#)]

40. Kaplan, R.S.; Norton, P.D. The Balanced Scorecard—Measures That Drive Performance. 1992. Available online: <https://hbr.org/1992/01/the-balanced-scorecard-measures-that-drive-performance-2> (accessed on 12 February 2022).
41. Kaplan, R.S.; Norton, P.D. Putting the Balanced Scorecard to Work. Available online: [https://hbr.org/1993/09/putting-the-balanced-scorecard-to-work?cm\\_sp=Article\\_-\\_Links\\_-\\_Comment](https://hbr.org/1993/09/putting-the-balanced-scorecard-to-work?cm_sp=Article_-_Links_-_Comment) (accessed on 12 February 2022).
42. Kaplan, R.S.; Norton, P.D. *Balanced Scorecard: Translating Strategy into Action*; Harvard Business School Press: Boston, MA, USA, 1996.
43. Kaplan, R.S.; Norton, P.D. *Norton: Strategy Maps: Converting Intangible Assets into Tangible Outcomes*; Harvard Business School Press: Boston, MA, USA, 2004.
44. Hansen, E.G.; Schaltegger, S. The Sustainability Balanced Scorecard: A Systematic Review of Architectures. *J. Bus. Ethics* **2016**, *133*, 193–221. [[CrossRef](#)]
45. Cabrita, M.R.; Machado, V.C.; Grilo, A. Leveraging knowledge management with the balanced scorecard. In Proceedings of the IIEEM2010—IEEE International Conference on Industrial Engineering and Engineering Management, Macao, China, 7–10 December 2010; IEEE: Piscataway, NJ, USA, 2010; pp. 1066–1071.
46. Zhou, S.S.; Zhou, A.J.; Feng, J.; Jiang, S. Dynamic capabilities and organizational performance: The mediating role of innovation. *J. Manag. Organ.* **2019**, *25*, 731–747. [[CrossRef](#)]
47. Silva, R.; Oliveira, C. The Influence of Innovation in Tangible and Intangible Resource Allocation: A Qualitative Multi Case Study. *Sustainability* **2020**, *12*, 4989. [[CrossRef](#)]
48. García-Valderrama, T.; Mulero-Mendigorry, E.; Revuelta-Bordoy, D. A Balanced Scorecard framework for R&D. *Eur. J. Innov. Manag.* **2008**, *11*, 241–281.
49. Poll, R. Performance, Processes and Costs: Managing Service Quality with the Balanced Scorecard. *Libr. Trends* **2001**, *49*, 709–717.
50. Lesáková, L.; Dubcová, K. Knowledge and Use of the Balanced Scorecard Method in the Businesses in the Slovak Republic. *Procedia Soc. Behav. Sci.* **2016**, *230*, 39–48. [[CrossRef](#)]
51. Mooraj, S.; Oyon, D.; Hostettler, D. The balanced scorecard: A necessary good or an unnecessary evil? *Eur. Manag. J.* **1999**, *17*, 481–491. [[CrossRef](#)]
52. Cooper, D.J.; Ezzamel, M.; Qu, S. *Creating and Poularizing a Management Accounting Idea: The Case of the Balanced Scorecard*; Alberta School of Business: Edmonton, AB, Canada, 2011; Unpublished Paper.
53. Frigo, M.L.; Krumwiede, K.R. The balanced scorecard: A winning performance measurement system. *Strateg. Financ.* **2000**, *81*, 50–54.
54. Męczyńska, A. *Grupowa Ocena Ekspertów w Procesach Decyzyjnych Zarządzania*; Zeszyty Naukowe Politechniki Śląskiej, seria Organizacja i Zarządzanie z. 40; Wydawnictwo Politechniki Śląskiej: Gliwice, Poland, 2007.
55. Helmer, O. Korzystanie z ocen ekspertów. In *Analiza Systemowa-Podstawy i Metodologia*; Findeisen, W., Ed.; PWN: Warszawa, Poland, 1985; pp. 235–289.
56. Męczyńska, A. Metoda heurystyczna-grupowa ocena ekspertów w zastosowaniu do analizy procesów, produktów. In *Komputerowo Zintegrowane Zarządzanie*; Knosala, R., Ed.; WNT: Warszawa, Poland, 1999; pp. 275–286.
57. Alling, S.; Knoesen, A. Introduction of Students to Engineering Design Practices of Remote and Distributed Collaboration: Lessons Learnt from COVID-19. *Adv. Eng. Educ.* **2020**, *8*, n4.
58. Orzeł, B.; Wolniak, R. Digitization in the Design and Construction Industry—Remote Work in the Context of Sustainability: A Study from Poland. *Sustainability* **2022**, *14*, 1332. [[CrossRef](#)]
59. Riyanti, B.P.D.; Suryani, A.O.; Sandroto, C.W.; Soeharso, S.Y. The construct and predictive validity testing of Indonesian entrepreneurial competence inventory-situational judgment test model. *J. Innov. Entrep.* **2020**, *11*. [[CrossRef](#)]
60. Giannopoulos, G.; Holt, A.; Khansalar, E.; Cleanthous, S. The use of the balanced scorecard in small companies. *Int. J. Bus. Manag.* **2013**, *8*, 1–22. [[CrossRef](#)]
61. Gumbus, A.; Lussier, R. Entrepreneurs use a balanced scorecard to translate strategy into performance measures. *J. Small Bus. Manag.* **2006**, *44*, 407–425. [[CrossRef](#)]
62. Stalmachova, K.; Chinoracky, R.; Strenitzerova, M. Changes in Business Models Caused by Digital Transformation and the COVID-19 Pandemic and Possibilities of Their Measurement—Case Study. *Sustainability* **2022**, *14*, 127. [[CrossRef](#)]
63. Narzędzie Oceny Dojrzałości Cyfrowej. 2009. Available online: <https://przemyslprzyszlosci.gov.pl/narzedzie-oceny-dojrzalosci-cyfrowej-firm/> (accessed on 3 February 2022).
64. Saniuk, S.; Saniuk, A.; Cagánová, D. Cyber Industry Networks as an Environment of the Industry 4.0 Implementation. *Wirel. Netw.* **2021**, *27*, 1649–1655. [[CrossRef](#)]
65. Chesbrough, H. Managing open innovation. *Res.-Technol. Manag.* **2004**, *47*, 23–26. [[CrossRef](#)]
66. Wang, J.-J.; Chen, H.; Rogers, D.S.; Ellram, L.M.; Grawe, S.J. A bibliometric analysis of reverse logistics research (1992–2015) and opportunities for future research. *Int. J. Phys. Distrib. Logist. Manag.* **2017**, *47*, 666–687. [[CrossRef](#)]
67. Kaur, R.; Awasthi, A. City logistics: A review and bibliometric analysis. *Int. J. Bibliometr. Bus. Manag.* **2018**, *1*, 160–188. [[CrossRef](#)]
68. Grzybowska, K.; Awasthi, A. Literature review on sustainable logistics and sustainable production for Industry 4.0. In *Sustainable Logistics and Production in Industry 4.0 New Opportunities and Challenges*; Grzybowska, K., Awasthi, A., Sawhney, R., Eds.; Springer: New York, NY, USA, 2020; pp. 1–19.
69. Saniuk, S.; Grabowska, S. The Concept of Cyber-Physical Networks of Small and Medium Enterprises under Personalized Manufacturing. *Energies* **2021**, *14*, 5273. [[CrossRef](#)]

70. Saniuk, S.; Grabowska, S.; Gajdzik, B. Personalization of Products in the Industry 4.0 Concept and Its Impact on Achieving a Higher Level of Sustainable Consumption. *Energies* **2020**, *13*, 5895. [[CrossRef](#)]
71. Wang, Y.; Ma, H.-S.; Yang, J.-H.; Wang, K.-S. Industry 4.0: A way from mass customization to mass personalization production. *Adv. Manuf.* **2017**, *5*, 311–320. [[CrossRef](#)]
72. Senanayake, M.M.; Little, T.J. Mass customization: Points and extent of apparel customization. *J. Fash. Mark. Manag.* **2010**, *14*, 282–299. [[CrossRef](#)]
73. Hu, S.J. Evolving paradigms of manufacturing: From mass production to mass customization and personalization. *Procedia CIRP* **2013**, *7*, 3–8. [[CrossRef](#)]
74. Blom, J.; Monk, A. Theory of personalisation of appearance: Why people personalise their mobile phones and PCs. *Hum. Comput. Interact.* **2003**, *18*, 193–228. [[CrossRef](#)]
75. Saniuk, S.; Caganova, D.; Saniuk, A. Knowledge and Skills of Industrial Employees and Managerial Staff for the Industry 4.0 Implementation. *Mob. Netw. Appl.* **2021**. [[CrossRef](#)]
76. Salgado, C.; Maciel, R. Exploring a Three-Dimensional, Requirements-Based, Balanced Scorecard Business Model. In Proceedings of the IEEE 17th Conference on Business Informatics, Lisbon, Portugal, 13–16 July 2015.
77. Soderberg, M.; Kalagnanam, S.; Sheehan, N.T.; Vaidyanathan, G. When is a balanced scorecard a balanced scorecard? *Int. J. Product. Perform. Manag.* **2011**, *60*, 688–708. [[CrossRef](#)]
78. Chytas, P.; Glykas, M.; Valiris, G. A proactive balanced scorecard. *Int. J. Inf. Manag.* **2011**, *31*, 460–468. [[CrossRef](#)]
79. Chavan, M. The balanced scorecard: A new challenge. *J. Manag. Dev.* **2009**, *28*, 393–406. [[CrossRef](#)]