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Social Factors as a Basic Driver of the Digitalization of the Business Models of Railway Companies

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Abstract: The aim of the paper is to present the results of research into the assessment of social factors resulting from the digitalization of railway companies' business models and building, by means of the AHP method, a ranking of the significance of these criteria in the process of their digital transformation. The results focused on identifying the components of the business models of railway companies that are most affected by social factors and the creation of such factors. Railway companies do not operate within the business environment alone. In the context of processes, they form one common technical and service ecosystem. Digitalization should increase opportunities to create positive social effects which influence the quality of services provided and the safety of rail traffic as well as the increased efficiency of business models.

Keywords: digitalization; business model; social aspects; railway companies

1. Introduction

The aim of the paper is to present the results of research into the assessment of social factors resulting from the digitalization of railway companies' business models and building, by means of the AHP method, a ranking of the significance of these criteria in the process of their digital transformation. The results focused on identifying the components of the business models of railway companies that are most affected by social factors and create such factors. Railway companies do not operate within the business environment alone. In the context of processes, they form one common technical and service ecosystem. Digitalization should increase opportunities for creating positive social effects which influence the quality of services provided and the safety of rail traffic as well as the increased efficiency of business models. Digitalization has been recognized as one of the main trends which are changing society and business. Digitalization brings about changes for companies due to the adoption of digital technologies in an organization or in an operational environment [1]. The dynamics of global market development are based on the development of the digital economy. Traditional value chains are subject to digitalization. Business models based on classical solutions (traditional construct of the value chain) are also subject to digitalization, in part or in whole, and thus achieve new opportunities to increase their efficiency and effectiveness. The Internet economy is essentially characterized by its considerable dynamics and the speed of change. The rapid digitalization of numerous areas of life has resulted in a shift towards today's Information Society [2]. An innovative business model may be subject to changes in the individual components of business models, the extension of the existing business model, or the introduction of parallel business models bringing about the disorganization of the business model, which may potentially involve replacing the existing model with a completely different one [3]. Therefore, the concept of the business model refers to a more transformational

approach, which uses the concept as a tool to make changes and innovations in the organization or change the model itself [4]. A positive effect of the dynamic development of the digital economy is the creation of social effects. Building a community focused on achieving common goals based on innovative technological solutions allows for the development of modern and conscious human behaviour and positive patterns. Traditional sectors of the economy also follow new trends and opportunities resulting from the development of the digital economy. The wider use of digital social innovations in transformation processes is used to fully exploit the potential of business models, designed not only in economic terms but also for the benefit of society [5]. The social nature of business activity is also apparent in the rail transport sector. This is influenced, in particular, by criteria related to railway traffic safety and the complex value-added chain based on cooperation between many entities. In Poland, as throughout Europe, the rail market is highly liberalized. The rules governing the operation of the railway market are based on directives regarding unrestricted access to the rail market, interoperability and safety. This legal arrangement ensures the transport of goods and services by rail across Europe while maintaining a standardized level of quality, safety and technical compatibility. There are several infrastructure managers in Poland and about 100 railway undertakings. In addition, in terms of market characteristics, it is possible to identify about 100 entities in charge of maintenance, as well as inspection bodies, notified bodies, and the market regulator and the National Safety Authority, which is important for the maintenance of railway vehicles. This arrangement of relationships builds an important ecosystem of the rail business where exogenous factors are the key to its effectiveness. The organizational and legal system means that railway companies' business models are strongly limited by legal regulations. The configuration of the value chain and the proposal to supply value to the customer depend on the solution adopted by entrepreneurs that meets stringent legal requirements in terms of interoperability, regulated accounting and security. At the same time, it should be noted that the railway undertaking market is very competitive while most of the transport processes are carried out on the railway network of the national infrastructure manager. The digitalization of railway companies in such a system is, on the one hand, building the potential to compete, and on the other hand, facilitating the development of social factors that can be achieved through digitalization. As already mentioned, rail transport operators, i.e., infrastructure managers and railway undertakings, are obliged to provide high quality services and the highest level of railway traffic safety. The digital economy creates new opportunities for achieving social effects, building communities, and improving the efficiency of railway companies. The aim of the paper is to present the results of research into the assessment of social factors resulting from the digitalization of railway companies' business models and building, by means of the AHP method, a ranking of the significance of these criteria in the process of their digital transformation. The research results focused, in particular, on identifying such components of the business models of railway companies that are most affected by social factors and create such factors. Railway companies do not operate within the business environment alone. In the context of processes, they form one common technical and service ecosystem. Digitalization should increase opportunities for creating positive social effects which influence the quality of services provided and the safety of rail traffic as well as the increased efficiency of business models. The social aspect in digital business models has two dimensions. The first one is built into the idea of building a community created by using, in whole or in part, the scope of activity of multifaceted technological platforms that are distinctive compared to other business models, while the other refers to the social impact of the value delivered by the business model. Both shape a pro-social approach, which is expressed in delivering social value to business model stakeholders. Both of these approaches are complementary and create the image of socially acceptable business models, where this social aspect is a condition for adapting such business models to the expectations of the contemporary global market. The issue of rail transport is strategic in terms of the place and role of this sector in the economy as well as the effectiveness of railway companies. The digitalization of the economy significantly determines changes in the configuration of business models, which also affects changes in the social ecosystem shaped by these enterprises. Research does not refer to political solutions from the sphere of regional

development in the context of rail transport. It is focused on the study of the economic and social determinants of the digital transformation of the rail business. The research described in this paper is devoted to this issue. This paper is structured as follows: Section 2 presents the theoretical background of Digital Transformation—key approaches and definitions. Section 3 presents the main idea of digital business models and the genesis and direction of the evolution of business model concept. Section 4 presents the problems of digitalization through Service Management and Industry 4.0 concepts in the context of the specificity of the rail transport sector. Section 5 analyzed the theoretical aspects of social factors of the digital transformation of business models. In Section 6, research methodology based on the AHP method was presented. Section 7 described the results of research into the social results of digital transformation on the business models of railway companies. The subsequent sections present a discussion and conclusion—in addition, Section 9 presents limitations and includes suggestions for future research. At the end the references used were indicated.

2. Digital Transformation—Key Approaches and Definitions

Digitalization is now a dynamic process covering all sectors of the economy. Traditional solutions in the sphere of the value chain are subject to the process of digital transformation [6].

Contemporary business models are the subject of digital transformation. W. Smith, A. Binns, and M. Tushman define the business model as a "configuration" by which the company chooses the options of strategies that can create value, and then uses the organizational architecture to create and retain value [7]. The business model is "the architecture for products, service and information flow, with a description of the various business actors and their roles; a description of the potential benefits for various business actors and a description of the sources of revenue" [8]. The individual components of business models in the company's life cycle change so that enterprises are able to survive and develop in many situations. Digitalization is a factor which stimulates changes in business models. Digitalization forms a part of Industry 4.0 and constitutes both a threat and opportunity to transform business as we know it; and can make entire business models redundant [9]. The definitions of digital transformation include different approaches to this issue. Digital Transformation is defined as the use of technology to radically improve the performance or reach of enterprises [10]. Digital Transformation is the changes that digital technology causes or influences in all aspects of human life [11]. In turn, the level of digital maturity of companies is assessed in terms of numerous criteria such as strategy, leadership, products, operations, culture, people, governance, and technology [12,13]. The different definitions for Digital Transformation (DT) may be categorized in three distinct elements: (1) Technological—DT is based on the use of new digital technologies such as social media, mobile, analytics or embedded devices; (2) Organizational—DT requires a change of organizational processes or the creation of new business models; (3) Social—DT is a phenomenon that influences all aspects of human life by, e.g., enhancing customers' experience [14]. Digitalization has an influence on many areas of activities of an organization such as new and emerging customer segments, cultural diversity in a global marketplace, market volatility, heightened customer expectations in terms of the quality of products and services, and the impact of the internet on an organization's core business [15]. Digital transformation is the subject of research in many contexts: in the field of entrepreneurship [16], in the field of Digital Learning [17], in terms of the dynamic capabilities concept [18] as well as in the context of the sectoral approach [19,20], and also in the context of small and medium-sized enterprises [21]. Digital transformation processes are also studied in terms of changes in the labor market [22,23]. Digitalization plays a key role in the context of changes in business models, the configuration of which is shaped using innovative technologies. The problems resolved are related, among others, to the structured approach to the digital transformation of business models, the activities and results of digitalization of business models, and the role of enablers and best practice in the digitalization of business models [24]. Optimization solutions in the field of the effectiveness of digital business models are proposed, taking into account areas such as content, experience and platform [25]. In the context of business models, as research results reveal, the digital transformation involves the transformation

of subsequent areas of business model configuration. The process of the digital transformation of the business model includes the preparation phases, value proposition, value creation, and value capture [26].

A broad approach to this issue results from the common digitalization of many aspects, not only of company activity, but in particular of modern life.

3. Digital Business Models—Key Aspects

The concept of digital business models is developing dynamically in the context of conditions for the development of new technologies. The very concept of traditional business models is widely recognized in the relevant literature. In general, the concept of business models is based on the development of three key research trends: the development of generic concepts and the search for optimal definitions, shaping effective business model structures, and the management of the business model [27].

The development of the concept of business models can be divided into several stages. The definition of a business model emerged in the 1950s. From 1975 to 2000 a technological approach was observed, leading to the initial phase of the development of online models. From 2000 to 2010 a strategic approach developed. Finally, from 2010 until today, solutions based on an integrated approach have been developed [28]. In the context of technology development resulting from the digital economy, the business model is a coherent link between products, services, information flow and the description of various roles of business actors [8]. The use of technology allows the business model to transform resources into economic results through the activation of customers and the use of markets [29]. This approach, based on the evolution of the approach to shaping business models, migrates the processes of business model design towards fully exploiting the potential of the digital economy. The digital economy creates many opportunities through the creation of many innovative approaches to transform traditional business models into partially or completely digital models. There is a distinction between innovative digital and non-digital undertakings. Combining practical management tools with the principles of network theory as well as the theory of organizational learning creates new possibilities for creating business models [30]. The specialist skills that change the existing balance of power in global markets are important for the development of digital business models [31], whereas digital ecosystems should provide companies based on innovative business models with attractive value sources that create new ways to grow [32]. Consequently, digitalization should affect the economic success of enterprises based on the potential of the digital economy [33]. This new approach to the dynamic search for attractive business models is in line with new trends based on the assumptions of consistent and interdependent development of management aspects and innovative technological solutions that support them.

4. Digitalization by Service Management and Industry 4.0 Concepts and the Specificity of the Rail Transport Sector

Industry 4.0 as a concept is a great challenge for many sectors of the world's economies. Despite many publications on the subject, there is no single model of its implementation in theory and practice. However, in the relevant literature there are descriptions of the positive effects of implementing the digital transformation of business models. In the context of the Industry 4.0 concept, the authors of the research indicate four areas of digitalization: changes in value creation and value offered, organizational aspects, and technical aspects [34]. In particular, it is based on intelligent solutions which combine aspects such as vertical integration, virtualization, automation, traceability, flexibility, and energy management [35]. The role of an employee as the operator of complex technical systems changes in the sense that the proportion of working time spent on decision-making processes declines [36]. Industry 4.0 and Internet-operated technologies are very useful for the creation of added value for organizations and society [37]. This is in line with the specificity of the rail transport sector, which belongs to the services sector as part of the transport of goods and people and infrastructure management. In this

model of action, smart networks connect machines, processes, systems, products, customers and suppliers. The digitalization of the business models of railway companies is of key importance in this approach to improve the efficiency of their operation. In this context, an important role is played primarily by the service approach to the challenges in question, which is the Service Management 4.0 concept. Value can be offered as a physical product, a real or virtual service, or as a combination of products and services [38]. The business objective of Service Management 4.0 is dedicated to outlining a system of the future that drives the service organization and its information closer to the customer as a means of developing a deeper customer relationship [39]. The implementation of dynamic quality models and tailor-designed software solutions for transport companies was clearly beneficial on the basis of the findings. The benefits of implementation are a shortened response time during extraordinary circumstances; the transparency of transactions and responsibilities; the company's approach to customers in terms of taking into account their wishes and maintaining or increasing the number of passengers as a result; creating a positive image of the company; but ultimately also reducing the costs incurred in removing weaknesses and errors [40]. The required data capture and intelligence is an integrated part of the offering, which reflects a technology-driven business development strategy [38]. The use of Industry 4.0 and Service Management 4.0 concepts may include the following areas specific to the rail transport sector:

- Modern and innovative methods for ensuring the efficiency of companies by collecting and processing information in real time.
- Creating a Smart Factory in the rail transport industry.
- Machine support for modern companies.
- Using the Internet of Things (IoT) and Cyber-Physical Systems (CPS).
- The Connected Enterprise—a new cooperation model and a new value creation chain, expanded to include business partners and customers.
- Application of Lean Management.
- Supporting the automatization of technologies through innovative methods of optimization, configuration, self-control and intelligent employee support.

Therefore, the digitalization of the business models of railway companies is part of the conceptual assumptions which constitute a significant challenge for building theoretical and practical solutions due to the specific conditions for the functioning of this sector within the liberal rail transport market in Europe. The specificity of the rail transport sector is based on different models. The classic solution in the sphere of rail transport processes is the legal separation of the activity of railway undertakings from the activity of infrastructure managers. Both of these entities operate within one complex technical and organizational railway system, but based on two different business models. Digitalization plays a key role as part of their process integration. It provides a platform for improving customer service processes and the use of full automatization of processes, which improves transport safety and passenger satisfaction. Achieving social effects through the use of digitalization in the rail transport sector is becoming a priority challenge obtained through the implementation of innovative and complex technical and organizational solutions that are a key strategic goal for the dynamically developing rail transport sector. The dynamics of changes in the railway sector in the legal dimension determines the development of new organizational, operational and technical solutions, which must be systemic and multidimensional [41]. The key milestone of this assessment is to verify the accuracy of the description of the rail system undergoing change with regard to its scope, functions and associated interfaces [42]. Hence, the basic criterion for assessing the efficiency of railway companies is accessibility and safety. Both of these factors depend on the digitalization of the business model and the digital integration of operational processes. They are supported by formalized systems of safety management, which are used to integrate many processes, including the processes of mutual communication between railway system operators between which interfaces occur while creating technical and social relations [43]. In this way, the social factors of the digitalization of railway companies are created.

5. Social Factors of the Digital Transformation of Business Models

In terms of shaping business models, digitalization is also social in nature. Through innovative technological solutions, it is possible to develop social attitudes and behaviours and achieve social effects. The development of innovative ways of doing business that are oriented towards balancing the goal of making profit and achieving the assumptions of sustainable development is a key challenge for corporate managers and business strategists in the twenty-first century [44]. Research in this area is not extensive. This topic is just beginning to be the subject of scientific analysis.

A classical approach to sustainable development based on the new triple bottom line concept [45] can also be used to create sustainable solutions in the context of digital economics. It should be considered in the context of the life cycle of business models [46]. The Industrial Internet of Things (IIoT) is also influential in terms of economic, ecological, and social aspects referring to the Triple Bottom Line (TBL) of sustainable value creation. In recent years, digitalization and related social aspects have been the subject of research. A number of key articles have been published in this research area. Sustainable Industrial Value Creation in the context of Industry 4.0 was the subject of research by a team of scientists from Germany, as well as the influence of the Industrial Internet of Things (IIoT), and also in terms of economic, ecological, and social aspects referring to the Triple Bottom Line (TBL) of sustainable value creation. In [47] the authors included a triple bottom line concept in the logic of IIoT. From a broad perspective, the impact limit of IIoT is based on three pillars, namely Technical Integration, Data & Information, and the Public Context. The social aspect includes Resource Efficiency and mainly refers to human resources, while the economic factor includes issues such as competitiveness, finance, overall equipment effectiveness (OEE), novel business models, time and individualization. A research challenge in terms of Industry 4.0 is to identify the place and role of the concept of sustainability. The opportunities include elements such as strategy, operations and environment and people, while challenges include competitiveness and future viability, organizational and production fit and employee qualification and acceptance [48]. The aspect of sustainability in terms of the concept of the Internet of Things can be considered in the micro context in terms of the shape of the ecosystem of contemporary global economies and in the micro context in terms of changes in the construction of value chains [49]. Research into the social innovation perspective for the application of the fourth industrial revolution (Industry 4.0) has already been undertaken. Readiness for such revolutionary conversion requires coupling the forces of technological innovation and social innovation under the sustainability umbrella [50]. The target for the economic sustainability of digital information services is to ensure cheaper, easier and better access to information. The target for the social sustainability of digital information services is to ensure equitable access in order to build a better (well informed) and healthy society, whereas the target for the environmental sustainability of digital information services is to ensure reductions in the environmental impact of digital information [51]. In terms of digital business models, the sustainability aspects have an impact on the migration of value, as confirmed by research [52]. They are important in the context of fledgling enterprises [53]. The development of a new approach to stakeholder theory in the context of the digital age is also required. In this respect, the new approach to this theory includes stakeholder theory, sustainability as a transformative concept and Big Data and digitalization [54]. It also refers to hybrid organizations [55]. The acceleration of interest and the search for a scientific gap in the issue of creating social drivers through digital business models results from the dynamic development of the Circular Economy concept, the conceptualization and operationalization of which is more efficient thanks to the use of modern technologies. In this respect, the factor that dynamizes processes is the circulation of values [25]. In addition, in the context of the development of the digital economy, as highlighted by researchers, attention should be paid to the fact that social media is one of the major drivers in the change of public perceptions, as it has facilitated the spread of information and misinformation about sustainability issues [16]. Previous research also covers the principles underlying social trade [56]. The issues of creating social aspects in digital business models cover many research areas. The main assumptions are based on two issues. The first includes the aspect based on the traditional triple

bottom line concept and the increased potential of this idea through innovative digital solutions, as in the case of Circular Economy assumptions, while the second one results from the specificity of technological solutions particular to the digital economy—building community and focused on socially acceptable ideas in its activities, trying to achieve positive social effects. Both of these approaches are built into the modern solutions of digital business models. The space for researching the digital transformation of business models may include many organizational and technological aspects that shape the effective configurations of business models. In this respect, social factors are the basic driver of business model value.

6. Research Methodology

The research procedure involved collecting the relevant literature on the digital transformation of business models, social aspects of the digital economy and the railway transport sector, and analyzing the evolution of the concept of a digital business model and its key trends. The authors defined the key attributes of digital business models and their development trends, taking strategic reflection into account. Factors that affect the digital transformation of the business models of railway companies were identified. The AHP method was applied to build a ranking of social criteria related to the digital transformation process of the business models of railway companies.

The AHP method was chosen as a research method because it is a general hierarchical approach to making multi-criteria decisions. It involves deconstructing the problem into simpler components and processing the ratings obtained on the basis of pairwise comparisons. The AHP method has numerous applications in terms of supporting economic, technical or social decisions. This allows for the arrangement of the elements of the decision-making problem, described in the form of the hierarchy of factors. This way, the best factor was selected. In this article, the following steps were taken using the AHP method to obtain a hierarchy of individual factors analyzed:

- The deconstruction and presentation of the problem in hierarchical form—defining the general objective to be achieved as regards the problem under consideration, attributes detailing the general objective and decision options considered,
- the specification of decision options and the final graphical representation of the hierarchy,
- the creation of a pairwise comparison matrix to compare all the elements of the lower level with the successive elements of the higher level,
- the calculation of local priorities—calculation of the largest eigenvalue and the eigenvector corresponding to this eigenvalue,
- the calculation of global priorities.

The results obtained by means of the AHP method give an image of how experts from the railway industry perceive the issues raised by the authors of the article related to the subject of the article. As a result, a ranking of individual criteria and sub-criteria was received, taking into account experience, strategies in the railway industry, and—most importantly—the value systems that individual enterprises follow. This means that making a decision involves identifying and defining the problem and objective, options and criteria. Subsequently, the decision-making problem is analyzed by evaluating the options/solutions and then the option/solution is chosen. Thus, the questionnaire was composed and sent to the companies surveyed. For the purpose of considering all possible sources of errors which the study could have been exposed to, a pilot study was conducted, which was a miniature of the main study. It aimed to provide data that was omitted by the researchers while planning the study. As a consequence, it could also have an impact on the final results. The pilot study, as part of testing research questionnaires, was conducted on a much smaller sample, i.e., 3%. After collecting the responses from the surveys, conclusions were inferred based on the research results.

As part of the research process, railway undertakings and infrastructure managers were taken into account. In Poland, 16 managers provide infrastructure to railway undertakings and 110 railway undertakings operate. The responses obtained through surveys were examined using the AHP

method. Nineteen responses were received from the companies surveyed. This accounts for 15% of the companies to which questionnaires were sent—the entire population of all railway companies operating on the Polish market. All of the completed surveys were filled in correctly.

The aim of the analysis was to examine the problem of the digital transformation of railway companies in the context of building a ranking of factors which create social effects. The respondents were asked to give answers to key issues arising from the review of the relevant literature on company digitalization, including the following social factors:

- The digital transformation of the business models of railway companies.
- Opportunities for the development of social factors through digital transformation.
- The mutual process integration of railway companies through digital transformation.
- The servitization of railway companies.
- The socialization of the business models of railway companies.

The responses to the survey allowed for the presentation of the results in this article. Experts were consulted for their opinions on their activity, meaning the railway industry. This was the basis for the assessment of the criteria and provided the opportunity to build an initial matrix of preferences.

7. The Results of Research into Social Factors for the Digital Transformation of Business Models of Railway Companies

In the context of studying the issue of the digital transformation of railway companies, a ranking of factors which create social effects was developed. To this end, the AHP (Analytic Hierarchy Process) method proposed by Thomas L. Saaty [57] was used. This method is used in solving decision-making problems that contain more than one criterion. The algorithm of the AHP method consists of four phases: creating a hierarchical structure of the decision-making process, defining the decision-maker's preferences and calculating significance ratings for all elements of the hierarchy, examining the consistency of the preference matrix, and creating the final ranking. The following scheme of the hierarchical model was used in the study (Figure 1):

Decision options, which are at the lowest level of the hierarchy of the model, were subject to comparative analysis by means of the AHP method. These options are railway undertakings and railway infrastructure managers. The five areas adopted in which survey questions (in the form of statements) were defined are as follows:

1. The digital transformation of the business models of the railway companies.
    - Statement 1.1. The business model of our company is strongly supported by digital economy solutions.
    - Statement 1.2. Our operational processes are essentially based on the use of digital communication.
    - Statement 1.3. The strategy of our company assumes the digitalization of the key areas of our activity in the next three years
    - Statement 1.4. Guaranteeing cybersecurity is a priority in our company's activity.
    - Statement 1.5. The digital solutions used in our company improve railway traffic safety.
2. Opportunities for the development of social factors through digital transformation:
    - Statement 2.1. The implementation of digital solutions increases the chances of improving relationships with our stakeholders.
    - Statement 2.2. The digital solutions used in our company improve the quality of human-human, human-machine and machine-machine interfaces.
    - Statement 2.3. The digital solutions in our company generate positive relationships with suppliers/partners.

- Statement 2.4. We build social capital with rail market actors through digital solutions.
- Statement 2.5. The digital solutions used in our company foster the implementation of social effects—ecology, ethics, and economics.

3. The mutual process integration of railway companies through digital transformation:

- Statement 3.1. The digital solutions in our company improve process efficiency.
- Statement 3.2. The digitalization of our technological processes helps us improve integration with other railway traffic participants.
- Statement 3.3. The digital solutions in our company help improve the ability to cooperate within the organizational and technical solutions of the railway ecosystem.
- Statement 3.4. We build cooperation platforms with other railway companies using digital technologies.
- Statement 3.5. The digital solutions used are fully compatible with the solutions of other enterprises within the railway ecosystem.

4. The servitization of railway companies:

- Statement 4.1. We apply solutions based on the transition from a product/service- oriented model to a service-oriented business model and its logic.
- Statement 4.2. We notice the potential of the effective management of the business model of our company.
- Statement 4.3. We constantly monitor and adjust our business model in every case, in a bottom-up, emergent and iterative way.
- Statement 4.4. We try to design a business model to co-create value with customers.
- Statement 4.5. We pay attention to the creation of a value network with all rail market actors.

5. The socialization of the business models of railway companies:

- Statement 5.1. In our business model, the aspect of positive social impact plays an important role.
- Statement 5.2. Employees in our company are treated with respect and are an important voice in the decision-making process.
- Statement 5.3. We pay attention to positive relationships with communities gathered around the railway ecosystem.
- Statement 5.4. Our business model is based on an effective dialogue with stakeholders.
- Statement 5.5. Building trust with business partners is an important component of our business model.

The individual criteria (areas) were compared and the degree of their fulfillment was examined. Survey questions form sub-criteria in this study. The above criteria and sub-criteria were prepared in order to check to what extent social factors influence the process of the digitalization of business models of railway undertakings. They were constructed by the authors based on their knowledge of the railway market and railway company management. The above five criteria were compared in pairs using the following scale (Table 1):

Table 1. Saaty scale used to compare the pairs of criteria.

Significance Scale	Explanation
1	No criterion has an advantage over the other in achieving the goal.
3	Criterion A has a moderate advantage over option B.
5	Criterion A has a strong advantage over option B.

Source: Own study based on [59].

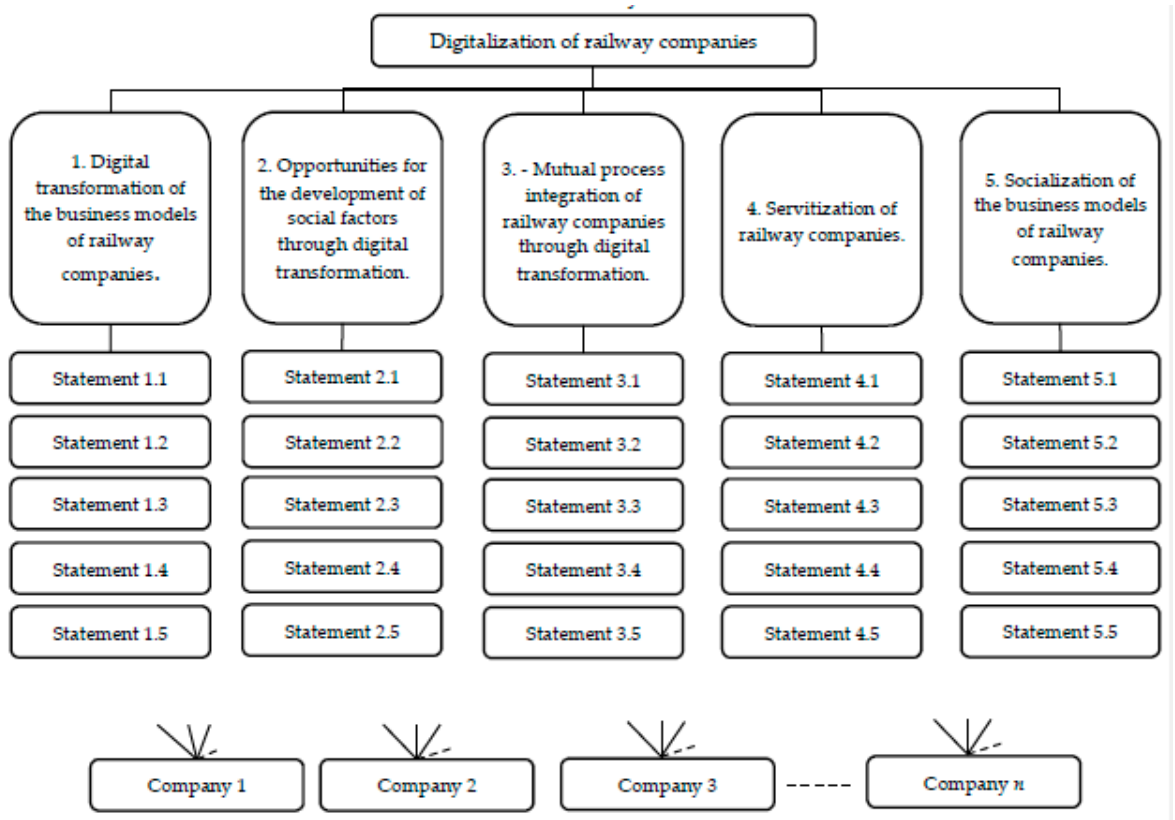

Figure 1. Scheme of the hierarchical model adopted for the study. Source: Own study based on [58].

7.1. Calculation of Global Weights for Adopted Criteria

Using the Saaty scale, a matrix was obtained that shows the advantage of a given criterion over another, in order to finally have them ranked by means of global weights.

In addition to the pairwise comparison of criteria, sub-criteria were also compared. This resulted in obtaining the weight values for all sub-criteria in order to assess the degree of the digitalization of railway companies.

After comparing the pairs of criteria, the matrix n x n was made, where n is the number of criteria. In this case n = 5, because five criteria were adopted. In the AHP method, there are inverse ratings, which means that the matrix is consistent in pairs, i.e.,

$$w_{ij} \cdot \frac{1}{w_{ji}} = 1$$

The data which was necessary to obtain a matrix of comparisons, i.e., the assessments of the significance of criteria and the superiority of one over the other, was obtained thanks to the participation of experts in the railway industry. Their necessary participation results from obtaining opinions on a different perception of reality and the processes occurring therein. Their approaches are built on experience, different priorities, value systems and other factors. Using the comparison scale, the AHP

method directs the person expressing opinions to two types of questions. They refer to the strength of the advantage of the elements compared over a given criterion by selecting:

- Which of the two criteria has a greater advantage over the other,
- which of the two sub-criteria has a greater impact on the third main criterion.

As a result, the matrix showing the pairwise comparison of criteria is as follows (Table 2):

Table 2. Matrix showing pairwise comparisons for particular groups of criteria.

Criteria	1. Digital Transformation of the Business Models of Railway Companies	2. Opportunities for the Development of Social Factors through Digital Transformation	3. Mutual Process Integration of Railway Companies through Digital Transformation	4. Servitization of Railway Companies	5. Socialization of the Business Models of Railway Companies
1. Digital transformation of the business models of railway companies	1.00	1.00	1.00	0.33	0.20
2. Opportunities for the development of social factors through digital transformation	1.00	1.00	1.00	3.00	0.33
3. Mutual process integration of railway companies through digital transformation	1.00	1.00	1.00	1.00	0.20
4. Servitization of railway companies	3.00	0.33	1.00	1.00	1.00
5. Socialization of the business models of railway companies	5.00	3.00	5.00	1.00	1.00
Total	11.00	6.33	9.00	6.33	2.73

Source: Own study.

Subsequently the matrix of normalized W ratings was obtained by dividing the individual ratings in the criteria columns by the sum of the ratings of a given column and saving the results in a given matrix cell:

$$W = \begin{bmatrix} 0.09 & 0.16 & 0.11 & 0.05 & 0.07 \\ 0.09 & 0.16 & 0.11 & 0.47 & 0.12 \\ 0.09 & 0.16 & 0.11 & 0.16 & 0.07 \\ 0.27 & 0.05 & 0.11 & 0.16 & 0.37 \\ 0.45 & 0.47 & 0.56 & 0.16 & 0.37 \end{bmatrix}$$

The following criteria description is used in the tables so that the notation in the table is clear:

- Criterion 1—The digital transformation of the business models of railway companies,
- Criterion 2—Opportunities for the development of social factors through digital transformation,
- Criterion 3—The mutual process integration of railway companies through digital transformation,
- Criterion 4—The servitization of railway companies,
- Criterion 5—The socialization of the business models of railway companies.

To obtain weights for each criterion, values from individual rows/lines were added up and then divided by the number of the criteria (i.e., number 5). Table 3 presents normalized matrix calculated for criteria and global weights obtained.

Table 3. Normalized matrix calculated for criteria and global weights obtained.

Criteria	Criterion1	Criterion2	Criterion3	Criterion4	Criterion5	Global Weight
Criterion1	0.0909	0.1579	0.1111	0.0526	0.0732	0.0971
Criterion2	0.0909	0.1579	0.1111	0.4737	0.1220	0.1911
Criterion3	0.0909	0.1579	0.1111	0.1579	0.0732	0.1182
Criterion4	0.2727	0.0526	0.1111	0.1579	0.3659	0.1920
Criterion5	0.4545	0.4737	0.5556	0.1579	0.3659	0.4015
						∑weight = 1

Source: Own study.

The above weights are ranked from highest to lowest. As a result, the following ranking of criteria was obtained (Table 4):

Table 4. Ranking of adopted criteria together with global weights.

Ranking	Criterion	Criterion name	Global Weight
1	Criterion5	The socialization of the business models of railway companies.	0.4015
2	Criterion4	The servitization of railway companies	0.1920
3	Criterion2	Opportunities for the development of social factors through digital transformation	0.1911
4	Criterion3	The mutual process integration of railway companies through digital transformation	0.1182
5	Criterion1	The digital transformation of the business models of railway companies	0.0971

Source: Own study.

The above ranking shows that "the socialization of the business models of railway companies" is most important, achieving a global weight of 40.15%, followed by "the servitization of railway companies" with a global weight of 19.20% and the equally significant" opportunities for the development of social factors through digital transformation"—at 19.11%, "the mutual process integration of railway companies through digital transformation", and "the digital transformation of the railway companies", which gained 9.71% significance.

Subsequently, the correctness of the results was checked by calculating the inconsistency index λmax (i.e., the average of the matrix's own value). The value of λmax is a measure of the consistency of comparisons reflecting the proportionality of preferences. Pairwise comparisons are all the more consistent the closer λmax is to n (the number of elements in the matrix = the number of rows = the number of columns). In the case of total consistency, λmax = n (Table 5).

Table 5. Inconsistency index λmax for criteria.

Criteria	Total rating of Individual Criteria (Columns)	Obtained Weights	Values in Relation to the Inconsistency Index
Criterion1	11.00	0.10	1.07
Criterion2	6.33	0.19	1.21
Criterion3	9.00	0.12	1.06
Criterion4	6.33	0.19	1.22
Criterion5	2.73	0.40	1.10
		5.66	

Study: Own study

The value of λmax is equal to 5.66, which means that it is close to 5, i.e., the number of criteria studied (Table 5).

The next step was to calculate the Consistency Index (CI) of the comparison matrix, which talks about the deviation from consistency. It was calculated using the following formula:

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

However, the interpretation of CI is difficult. Thus, the CR (Consistency Ratio) was determined. The CR determines the degree of inconsistency of the comparison of the significance of the descriptions, which can be expressed as a number or percentage. It is determined by the following formula:

$$CR = \frac{CI}{RI} \times 100\%$$

To calculate the Consistency Ratio, you need the RI value—a Random Consistency Index which is unchanged, and which was presented in the book "Fundamentals of decision making and the priority theory with the Analytic Hierarchy Process" by T.L. Saaty. The value of the RI for the 5×5 matrix is RI = 1.12. The random consistency index was calculated from a randomly generated matrix with the dimensions $n \times n$ and the values of R.I. were generated from several thousand such matrices and presented by T.L. Saaty in his publication.

For such a matrix dimension, the CR value should not exceed 10% ($CR \leq 0.10$), because then the CR is accepted and the comparisons are consistent. In this case, the CR value is 15%, which means that it slightly exceeds the recommended threshold. There is a risk that the comparisons are inconsistent. If the comparisons were fully consistent, the values of coefficients would be: $\lambda max = n$, CI = 0 and CR = 0.

7.2. Calculation of Local Weights for Sub-Criteria

In accordance with the previously presented steps to obtain weights for individual criteria, the same was done for sub-criteria to obtain local weights. Thus, five separate calculation sheets were developed. The matrices with the results obtained by testing pairs of sub-criteria are presented below (Tables 6–10).

Table 6. Pairwise comparison matrix for Criterion 1—digital transformation of business models of railway companies.

Digital Transformation of the Business Models of Railway Companies	Statement 1.1. The Business Model of our Company is strongly Supported by Digital Economy Solutions	Statement 1.2. Our Operational Processes are essentially based on the Use of Digital Communication	Statement 1.3. The Strategy of our Company Assumes the Digitalization of the Key Areas of our Activity in the next Three years	Statement 1.4. Guaranteeing Cybersecurity is a Priority in our Company's Activity	Statement 1.5. The Digital Solutions used in our Company Improve Railway Traffic Safety
Statement 1.1. The business model of our company is strongly supported by digital economy solutions	1.00	1.00	3.00	3.00	3.00
Statement 1.2. Our operational processes are essentially based on the use of digital communication.	1.00	1.00	5.00	3.00	3.00
Statement 1.3. The strategy of our company assumes the digitalization of the key areas of our activity in the next three years.	0.33	0.20	1.00	0.33	3.00
Statement 1.4. Guaranteeing cybersecurity is a priority in our company's activity	0.33	0.33	3.00	1.00	3.00
Statement 1.5. The digital solutions used in our company improve railway traffic safety	0.33	0.33	0.33	0.33	1.00

Source: own study.

Table 7. Pairwise comparison matrix for Criterion 2—opportunities for the development of social factors through digital transformation.

Opportunities for the Development of Social Factors through Digital Transformation	Statement 2.1. The Implementation of Digital Solutions Increases the Chances of Improving Relationships with our Stakeholders.	Statement 2.2. The Digital Solutions used in our Company Improve the Quality of Human-Human, Human-Machine and Machine-Machine Interfaces.	Statement 2.3. The Digital Solutions in our Company Generate Positive Relationships with Suppliers/Partners.	Statement 2.4. We Build Social Capital with Rail Market Actors through Digital Solutions.	Statement 2.5. The Digital Solutions used in our Company Foster the Implementation of Social Effects—Ecology, Ethics, and Economics
Statement 2.1. The implementation of digital solutions increases the chances of improving relationships with our stakeholders.	1.00	0.20	0.33	0.33	0.33
Statement 2.2. The digital solutions used in our company improve the quality of human-human, human-machine and machine-machine interfaces.	5.00	1.00	3.00	1.00	0.33
Statement 2.3. The digital solutions in our company generate positive relationships with suppliers/partners.	3.00	0.33	1.00	0.33	0.33
Statement 2.4. We build social capital with rail market actors through digital solutions.	3.00	1.00	3.00	1.00	0.33
Statement 2.5. The digital solutions used in our company foster the implementation of social effects—ecology, ethics, and economics	3.00	3.00	3.00	3.00	1.00

Source: Own study.

Table 8. Pairwise comparison matrix for Criterion 3—the mutual process integration of railway companies through digital transformation.

The Mutual Process Integration of Railway Companies through Digital Transformation.	**Statement 3.1. The Digital Solutions in our Company Improve Process Efficiency**	**Statement 3.2. The Digitalization of our Technological Processes Helps us Improve Integration with other Railway Traffic Participants.**	**Statement 3.3. The Digital Solutions in our Company help Improve the Ability to Cooperate within the Organizational and Technical Solutions of the Railway Ecosystem.**	**Statement 3.4. We Build Cooperation Platforms with other Railway Companies using Digital Technologies.**	**Statement 3.5. The Digital Solutions used are fully Compatible with the Solutions of other Enterprises within the Railway Ecosystem.**
Statement 3.1. The digital solutions in our company improve process efficiency	1.00	0.33	0.33	0.33	0.20
Statement 3.2. The digitalization of our technological processes helps us improve integration with other railway traffic participants.	3.00	1.00	3.00	3.00	0.20
Statement 3.3. The digital solutions in our company help improve the ability to cooperate within the organizational and technical solutions of the railway ecosystem.	3.00	0.33	1.00	0.33	0.33
Statement 3.4. We build cooperation platforms with other railway companies using digital technologies.	3.00	0.33	3.00	1.00	0.33
Statement 3.5. The digital solutions used are fully compatible with the solutions of other enterprises within the railway ecosystem.	5.00	5.00	3.00	3.00	1.00

Source: Own study.

Table 9. Pairwise comparison matrix for Criterion 4—the servitization of railway companies.

The Servitization of Railway Companies.	**Statement 4.1. We Apply Solutions based on the Transition from a Product/Service-Oriented Model to a Service-Oriented Business Model and its Logic.**	**Statement 4.2. We Notice the Potential of the Effective Management of the Business Model of our Company.**	**Statement 4.3. We constantly Monitor and Adjust our Business Model in every Case, in a Bottom-Up, Emergent and Iterative way.**	**Statement 4.4. We try to Design a Business Model to Co-Create Value with Customers.**	**Statement 4.5. We pay Attention to the Creation of a Value Network with all Rail Market Actors.**
Statement 4.1. We apply solutions based on the transition from a product/service- oriented model to a service-oriented business model and its logic.	1.00	3.00	0.33	3.00	0.33
Statement 4.2. We notice the potential of the effective management of the business model of our company.	0.33	1.00	0.33	0.33	0.20
Statement 4.3. We constantly monitor and adjust our business model in every case, in a bottom-up, emergent and iterative way.	3.00	3.00	1.00	3.00	0.33
Statement 4.4. We try to design a business model to co-create value with customers.	0.33	3.00	0.33	1.00	0.33
Statement 4.5. We pay attention to the creation of a value network with all rail market actors.	3.00	5.00	3.00	3.00	1.00

Source: Own study.

Table 10. Pairwise comparison matrix for Criterion 5—the socialization of the business models of railway companies.

The Socialization of the Business Models of Railway Companies.	Statement 5.1. In our Business Model, the Aspect of Positive Social Impact Plays an Important Role.	Statement 5.2. Employees in our Company are Treated with Respect and are an Important Voice in the Decision-Making Process.	Statement 5.3. We Pay Attention to Positive Relationships with Communities Gathered around the Railway Ecosystem.	Statement 5.4. Our Business Model is based on an Effective Dialogue with Stakeholders.	Statement 5.5. Building Trust with Business Partners is an Important Component of our Business Model.
Statement 5.1. In our business model, the aspect of positive social impact plays an important role.	1.00	0.33	0.33	0.33	0.33
Statement 5.2. Employees in our company are treated with respect and are an important voice in the decision-making process.	3.00	1.00	3.00	3.00	3.00
Statement 5.3. We pay attention to positive relationships with communities gathered around the railway ecosystem.	3.00	0.33	1.00	3.00	1.00
Statement 5.4. Our business model is based on an effective dialogue with stakeholders.	3.00	0.33	0.33	1.00	1.00
Statement 5.5. Building trust with business partners is an important component of our business model.	3.00	0.33	1.00	1.00	1.00

Source: Own study.

Subsequently the above data in the tables was normalized, thus obtaining matrices as below. They allowed us to obtain the values of weights, and subsequently the ranking inside the criterion studied (Table 11):

Table 11. Normalized sub-criterion matrix for Criterion 1.

Normalized W-Matrix	Statement 1.1	Statement 1.2	Statement 1.3	Statement 1.4	Statement 1.5	Weights = Local Priorities	RANKING
Statement 1.1	0.33	0.35	0.24	0.39	0.23	0.31	2
Statement 1.2	0.33	0.35	0.41	0.39	0.23	0.34	1
Statement 1.3	0.11	0.07	0.08	0.04	0.23	0.11	4
Statement 1.4	0.11	0.12	0.24	0.13	0.23	0.17	3
Statement 1.5	0.11	0.12	0.03	0.04	0.08	0.07	5

Source: Own study.

Among the five defined sub-criteria for Criterion 1 (Table 11), i.e., the digital transformation of the business models of railway companies, Statement 1.2—"Our operational processes are fundamentally based on the use of digital communication" was the most important, receiving a weight of 0.34. Statement 1.1 that "The business model of our company is strongly supported by digital economy solutions" was slightly less important—a local weight at the level of 0.31. The other three statements obtained local weights below 0.20. Statement 1.5 "The digital solutions used in our company improve railway traffic safety" was the least important, gaining a weight equal to 0.07.

Taking into account Criterion 2 (Opportunities for the development of social factors through digital transformation), the highest rated was Statement 2.5 "The digital solutions used in our company support the implementation of social effects—ecology, ethics, economics". It obtained a local weight of 0.40. It was followed by Statement 2.2 "The digital solutions used in our company improve the quality of human-human, human-machine and machine-machine interfaces", with a local weight of 0.22. Statement 2.1 "The implementation of digital solutions increases the chances of improving relations with our stakeholders" was at the bottom of the ranking with a weight of 0.07 (Table 12).

Table 12. Normalized sub-criterion matrix for Criterion 2.

Normalized W-Matrix	Statement 2.1	Statement 2.2	Statement 2.3	Statement 2.4	Statement 2.5	Weights = Local Priorities	RANKING
Statement 2.1	0.07	0.04	0.03	0.06	0.14	0.07	5
Statement 2.2	0.33	0.18	0.29	0.18	0.14	0.22	2
Statement 2.3	0.20	0.06	0.10	0.06	0.14	0.11	4
Statement 2.4	0.20	0.18	0.29	0.18	0.14	0.20	3
Statement 2.5	0.20	0.54	0.29	0.53	0.43	0.40	1

Source: Own study

In the case of Criterion 3 "The mutual process integration of railway enterprises through digital transformation" (Table 13), the overarching sub-criterion turned out to be Statement 3.5 "The digital solutions used are fully compatible with the solutions of other enterprises within the railway ecosystem", obtaining a local weight of as much as 0.44. Statement 3.2 "The digitalization of our technological processes helps us improve integration with other railway traffic participants" was ranked second, with the local weight being lower by half at 0.22. Statement 3.1 "Digital solutions in our company improve process efficiency", with a local weight of 0.06, was at the bottom of the ranking.

Table 13. Normalized sub-criterion matrix for Criterion 3.

Normalized W-Matrix	Statement 3.1	Statement 3.2	Statement 3.3	Statement 3.4	Statement 3.5	Weights = Local Priorities	RANKING
Statement 3.1	0.07	0.05	0.03	0.04	0.10	0.06	5
Statement 3.2	0.20	0.14	0.29	0.39	0.10	0.22	2
Statement 3.3	0.20	0.05	0.10	0.04	0.16	0.11	4
Statement 3.4	0.20	0.05	0.29	0.13	0.16	0.17	3
Statement 3.5	0.33	0.71	0.29	0.39	0.48	0.44	1

Source: Own study

When analyzing Criterion 4 "The servitization of railway companies" (Table 14), the highest local weight of 0.41 was for Statement 4.5 "We pay attention to the creation of a value network with all rail market actors". Statement 4.3 "We constantly monitor and adjust our business model in every case, in a bottom-up, emergent and iterative way" was ranked second with a local weight of 0.25. The fifth and last place was occupied by Statement 4.2 "We notice the potential of the effective management of the business model of our company", which obtained a local weight equal to only 0.06.

Table 14. Normalized sub-criterion matrix for Criterion 4.

Normalized W-Matrix	Statement 4.1	Statement 4.2	Statement 4.3	Statement 4.4	Statement 4.5	Weights = Local Priorities	RANKING
Statement 4.1	0.13	0.20	0.07	0.29	0.15	0.17	3
Statement 4.2	0.04	0.07	0.07	0.03	0.09	0.06	5
Statement 4.3	0.39	0.20	0.20	0.29	0.15	0.25	2
Statement 4.4	0.04	0.20	0.07	0.10	0.15	0.11	4
Statement 4.5	0.39	0.33	0.60	0.29	0.45	0.41	1

Source: Own study

When examining Criterion 5 (Table 15), Statement 5.2 "Employees in our company are treated with respect and are an important voice in the decision-making process" was the most important with a local weight of 0.40. It was followed by Statement 5.3 "We pay attention to positive relationships with communities gathered around the railway ecosystem" with a local weight of 0.21. Statement 5.1 "In our business model, the aspect of positive social impact plays an important role", which gained a local weight of 0.07, ranked last.

Table 15. Normalized sub-criterion matrix for Criterion 5.

Normalized W-Matrix	Statement 5.1	Statement 5.2	Statement 5.3	Statement 5.4	Statement 5.5	Weights = Local Priorities	RANKING
Statement 5.1	0.08	0.14	0.06	0.04	0.05	0.07	5
Statement 5.2	0.23	0.43	0.53	0.36	0.47	0.40	1
Statement 5.3	0.23	0.14	0.18	0.36	0.16	0.21	2
Statement 5.4	0.23	0.14	0.06	0.12	0.16	0.14	4
Statement 5.5	0.23	0.14	0.18	0.12	0.16	0.17	3

Source: Own study.

For each criterion matrix, the values of the inconsistency index λmax, the consistency ratio CR and the values of the random consistency index RI were calculated (Table 16).

Table 16. Values of the inconsistency index λmax, the consistency ratio (CR) and the values of the random consistency index (RI) for each criterion.

Criterion	Criterion1	Criterion2	Criterion3	Criterion4	Criterion5
λ_{max}	5.48	5.46	5.28	5.48	5.35
n	5	5	5	5	5
RI	1.12	1.12	1.12	1.12	1.12
CR	0.11	0.10	0.06	0.11	0.08

Source: Own study.

The previously obtained weight values for each criterion and the local weights for sub-criteria are as follows (Table 17):

The above-mentioned local weights of the sub-criteria multiplied by the global weights of the criteria gave the global weights of sub-criteria. It was assumed that the above percentage values represent the ideal state, where the digitalization of railway companies is at a very high level. Among all 25 sub-criteria, the most important statements in the global sense included:

- Statement 2.5—"The digital solutions used in our company foster the implementation of social effects—ecology, ethics, and economics." with a global weight of 0.09.
- Statement 5.2—"Employees in our company are treated with respect and are an important voice in the decision-making process", with a global weight of 0,09.
- Statement 3.5— "The digital solutions used are fully compatible with solutions of other enterprises within the railway ecosystem", with a global weight of 0.08.
- Statement 4.5—"We pay attention to the creation of a value network with all rail market actors", with a global weight of 0.08.

Table 17. Matrix of local and global weights for criteria and sub-criteria for the issue of the digitalization of railway companies.

1. The Digital Transformation of the Business Models of Railway Companies			**2. Opportunities for the Development of Social Factors through Digital Transformation**			**3. The Mutual Process Integration of Railway Companies through Digital Transformation**			**4. The Servitization of Railway Companies**			**5. The Socialization of the Business Models of Railway Companies**		
0.18	Share in the group	Share in total	0.22	Share in the group	Share in total	0.17	Share in the group	Share in total	0.20	Share in the group	Share in total	0.22	Share in the group	Share in total
Statement 1.1	0.31	0.06	Statement 2.1	0.07	0.01	Statement 3.1	0.06	0.01	Statement 4.1	0.17	0.03	Statement 5.1	0.07	0.02
Statement 1.2	0.34	0.06	Statement 2.2	0.22	0.05	Statement 3.2	0.22	0.04	Statement 4.2	0.06	0.01	Statement 5.2	0.40	0.09
Statement 1.3	0.11	0.02	Statement 2.3	0.11	0.02	Statement 3.3	0.11	0.02	Statement 4.3	0.25	0.05	Statement 5.3	0.21	0.05
Statement 1.4	0.17	0.03	Statement 2.4	0.20	0.04	Statement 3.4	0.17	0.03	Statement 4.4	0.11	0.02	Statement 5.4	0.14	0.03
Statement 1.5	0.07	0.01	Statement 2.5	0.40	0.09	Statement 3.5	0.44	0.08	Statement 4.5	0.41	0.08	Statement 5.5	0.17	0.04

Source: Own study.

7.3. Analysis of Responses from Surveys Sent to Railway Companies

After creating the surveys which take into account the above criteria and sub-criteria in the form of statements, they were sent to railway undertakings and infrastructure managers. They were asked to evaluate the criteria set in relation to the functioning of their company and meeting the issues set using the following scale (Table 18):

Table 18. The scale used to assess the company in terms of sub-criteria.

Scale	Statement
1	I strongly disagree
2	I somewhat disagree
3	I have no opinion
4	I somewhat agree
5	I definitely agree

Source: Own study.

After collecting a certain sample from the data set, namely railway undertakings and infrastructure managers, calculations were made taking into account the accumulated ratings from questionnaires and percentage result calculated for the ideal company. The total score for each criterion for a given company was calculated. The maximum result in a given cell for a criterion are values of global weights calculated for six groups of criteria. At the end, the results obtained were ranked and the ranking of railway companies was obtained in terms of their digitalization. Below is a table with individual results in each area examined, together with the total result obtained and the final ranking from the above study. The total result obtained for each company studied by means of the AHP analysis, which took into account all five criteria, indicated the level of the railway company's digitalization in relation to the given statements. Obtaining the value of 1.0 characterizes an ideal company in terms of digitalization. The highest total value of ratings was obtained for Company 16—0.92, followed by Company 10 with a result of 0.89, and third place was occupied by Company 11—0.85. Company 7 was ranked last, with only a 0.62 rating.

The maximum ratings were achieved in Criterion 5. In this way, Company 6, Company 9, Company 10, Company 15 and Company 16 were evaluated. Company 3 dominated only in the case of Criterion 1. In other cases, it did not appear at all. An interesting case is Company 12, which ranked first in the rating in terms of Criterion 2 and Criterion 3, and it ranked third for Criterion 1. However, in the overall ranking, it occupied sixth place. This results from its low position for Criterion 4 (16th place out of 19) and Criterion 5 (17th place). Company 3, despite being in first place in Criterion 1, was ranked below 10th for the remaining criteria, so in the final analysis it ranked 17th. To sum up, the highest rated companies were Company 16, Company 10 and Company 11.

The values obtained within each criterion indicated that the highest mean is obtained in the results of Criterion5, amounting to 4.3. This mainly results from the assessment of individual statements such as "I have no opinion", "I somewhat agree" and "I definitely agree". The lowest ranked statements are from the Criterion 1 range—the average rating was 3.6. Other average values are also shown in the table below. The responses to particular groups of criteria indicated a 'somewhat agree' level.

Highly rated statements are:

- "Statement 3.1. The digital solutions in our company improve process efficiency",
- "Statement 5.4. Our business model is based on an effective dialogue with stakeholders".
- This means that such areas predominate in the functioning of railway companies. The lowest average was obtained for the following statements:
- "Statement 1.4. Guaranteeing cybersecurity is a priority in our company's activity",
- "Statement 1.5. The digital solutions used in our company improve railway traffic safety",

- "Statement 3.4. We build cooperation platforms with other railway companies using digital technologies",
- "Statement 4.1. We apply solutions based on the transition from a product/ service-oriented model to a service-oriented business model and its logic".

All four of the above statements received an average of 3.5. This means that this issue should be corrected by improving the business models of railway companies.

On the basis of the above, it can be concluded that the purpose of the article was achieved, because the study conducted showed that social factors are the fundamental factor in the digitalization of the business models of railway companies. In addition, the answer to the question of which of the given factors are the most important aspects in the activity of the railway companies studied was obtained. Due to the lack of significant deviations in the results obtained, it can be safely stated that the research is a reliable sample which gives an image of the hierarchy of basic social factors in building the digitalization of business models.

The homogeneity of the scale was verified by means of Cronbach's alpha. This coefficient takes values between [0; 1]. When $\alpha > 0.7$, the high reliability of the scale is demonstrated. This coefficient indicates to what extent a set of variables is consistent. If all positions were perfectly reliable and measured the same thing, the coefficient $\alpha = 1$. Cronbach's alpha was estimated using the following formula:

$$\alpha = \frac{K}{K-1}\left(1 - \frac{\sum_{i=1}^{K} \sigma^2_{\text{Statement i}}}{\sigma^2_{\text{Group}}}\right)$$

where:

K—number of statements,
Statement—answers obtained for individual questions given by all companies
$\sigma^2_{\text{Statement i}}$—variance for the answers obtained to a given question, and
σ^2_{Group}—variance from the sum of answers to all questions for individual companies.

Hence the value of Cronbach's alpha was 0.90. The higher the value of the coefficient, the greater the reliability of the scale, therefore the reliability in this study is very high. This means that there was a large similarity between the individual responses, and the way of answering individual questions was similar. Therefore, the questions are similar to each other and examine similar phenomena.

8. Conclusions

As part of the research model adopted in the scope of the digitalization of railway companies, five key criteria were adopted: the digital transformation of the business models of railway companies, opportunities for the development of social factors through digital transformation, the mutual process integration of railway companies through digital transformation, the servitization of railway companies, the socialization of the business models of railway companies, and the process integration of railway companies. The research results showed that the ranking of the significance of the adopted criteria is as follows: the most important criterion is "The socialization of the business models of railway companies", which obtained a global weight of 40.15%. "The servitization of railway companies" ranks second with a global weight of 19.20% and "Opportunities for the development of social factors through digital transformation" is equally significant at 19.11%. The next place in the ranking was occupied by "The mutual process integration of railway companies through digital transformation", followed by "The digital transformation of the business models of railway companies", with a global weight of 9.71%. For each criterion, the results confirm that the defined criteria show the key factors responsible for the effectiveness of implementing the digital transformation of business models of railway companies. The above-mentioned local weights of the sub-criteria multiplied by the global weights of the criteria gave the global weights of the sub-criteria, assuming that percentages represent

the ideal state, where the digitalization of railway companies is at a very high level. Among all 25 sub-criteria, four research areas which describe factors influencing the digitalization of the business models of railway companies were the most significant in the global sense. First of all, digital solutions foster the implementation of social effects—ecology, ethics, and economics. The companies surveyed pay attention to the role of employees in creating social attitudes. Moreover, employees should be treated with respect and be an important voice in the decision-making process, and digital solutions should be fully compatible with the solutions of other enterprises within the railway ecosystem. Finally, the creation of a value network with all rail market players is important within the socialization of the business models of railway enterprises. The research results are adequate for the specificity of the railway companies' operations and their business models.

The social factors of the business models of railway companies cannot be examined in terms of their digitalization without taking into account the complex value chain based on cooperation between infrastructure managers and railway undertakings that have an organizational and technical nature. The digitalization of one group of railway companies (infrastructure managers) should be compatible with the second group (railway undertakings). The implementation of digital solutions at the technical level facilitates the better integration of operational processes and building better mutual relations, which should affect the quality of services provided and the level of railway traffic safety.

The process of the digitalization of the business models of railway companies is important for the development of social factors. The search for social aspects in the field of digitalization is important for improving the efficiency of these business models as well as finding new spaces that have an impact on building relationships between enterprises as part of shaping a complex organizational and technical business ecosystem.

Constructing the configuration of social factors influencing the process of the digitalization of the business models of railway companies was used to identify several important conclusions.

1. The business models of railway companies are increasingly supported by digital economy solutions.
2. The operational processes are essentially based on the use of digital communication.
3. The strategies of railway companies assume the digitalization of key areas of activity in the next three years.
4. The issue of cyber security is a priority in the context of railway companies' operations.
5. Digital solutions built in the business models of railway companies significantly improve railway traffic safety.
6. The implementation of digital solutions increases the chances of improving relationships with stakeholders.
7. Digital solutions improve the quality of human-human, human-machine and machine-machine interfaces.
8. Digital solutions generate positive relationships with suppliers/partners.
9. Social capital is built with rail market actors through social solutions.
10. Digital solutions foster the implementation of social effects—ecology, ethics, and economics.

Railway companies are subject to the process of digital transformation much like other companies in traditional sectors. The digitalization of business models is dynamic and results from technological progress as well as the need to improve the efficiency of these companies. Due to the strategic role of the rail transport sector in the economy, the social aspect plays a key role and the process of digitalization studied is conducive to it. The research results confirm that there are still many issues to be clarified in this respect. Research into the digitalization processes of the business models of railway companies requires further research and analysis, which results from the complexity of this sector and the dynamics of changes in the area of designing digital economy solutions. The socialization of business through digitalization is also the subject of further research projects by the authors. The social perspective demonstrates that technical innovations are likely to positively affect the diffusion of social innovation, and vice versa. The technological revolution that accompanies Industry 4.0 achieves its

true potential in combination with social innovation. It should be noted that, referring to other research into social aspects of digital business models, the results achieved are in line with other results in this area. The social perspective demonstrates that technical innovations are likely to positively affect the diffusion of social innovation, and vice versa.

Hence, businesses that succeed in Industry 4.0 will be those that offer both social progress and economic benefits. It should be noted that, referring to other scientific studies in the field of social aspects in digital business models, the results achieved are in line with other results in this area. The social perspective demonstrates that the development of social innovation and digital solutions influence digital process of business model transformation. Research by R. Morrar, H. Arman, and S. Mousa confirms the course of thinking and defines the scope of research and scientific argument adopted in this article [50]. Obviously, the specificity of the railway sector is quite different, but it is part of current research into the digitalization of the business models of technology companies. This subject seems to be very interesting in terms of the impact of research on the level of the perception of the digital transformation of companies which hitherto had poorly implemented the latest technological innovations while changing their business models evolutionally or sometimes revolutionarily.

9. Limitations and Suggestions for Future Research

The key limitations of the research process should include sector conditions typical of the complexity of the rail transport sector. Due to legal conditions, the description of rail transport business models is set in specific market realities. On the one hand, it has the character of a natural monopoly—some infrastructure managers, on the other hand, companies such as railway undertakings operate in a very competitive market. This means that research into this sector and the attempt to expand this research for other sectors is not always effective. Another limitation of the research conducted is the selection of criteria for evaluation. In the relevant literature, research into the digital transformation of business models is in its infancy. As regards research in this area, there are many issues which require clarification. The paper is a step towards a better understanding of the processes of the digitalization of business models which have operated in the traditional way so far.

The specificity of railway companies can also be a limitation. As those whose business models largely depend on legal requirements must create digital solutions on their own, believing that in a liberalized and very competitive market the readiness to create an ecosystem of the digital economy may help the company gain a competitive advantage over its competitors in future. Certainly, the national infrastructure manager may have a different opinion, with a safe and monopolistic position in this respect, but looking at the experience of Polish and other European companies, these entities can set standards in the use of digital solutions.

As regards the need to explore the subject presented in the context of future research, it is reasonable to study the processes of the digital transformation of business models in other sectors of the economy and services. It is worth examining the differences between digital transformation processes in sectors considered to be traditional, such as rail transport, heavy industry and the digital transformation of services. Differences between these areas in the context of universal digitalization can give results that allow for a better understanding of changes that are taking place in the dynamically developing digital economy and their impact on the business models of companies. These issues are important not only in terms of theory, but also in the utilitarian sense. Understanding digital transformation processes in terms of the development of social aspects is of key importance because, due to the development of social aspects, business models have a wider scope and can not only increase economic efficiency but also affect the added value of digitalization, namely social profit. The social aspect is also related to the issue of trust, which is the leading criterion for the development of digitalization. In addition, the influence and role of the mutual process integration of railway companies through digital transformation should be indicated as a research gap and thus the subject of future research. These issues are the subject of further research by the authors.

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