Characteristics of Resources as a Determinant of Implementation of the Physical Internet Concept in Supply Chains

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Abstract. Contemporary companies strive for increasing efficiency of logistics processes. Efficient logistics processes allow for implementation of corporate goals with reduced use of resources. Considering the evolution of the concept of resources, authors in the article focused on the concept of Physical Internet (PI). For the study purposes, authors of the paper have limited the Physical Internet idea to sharing resources in supply chain. In the article, results of two survey studies are presented. The first was conducted among academic teachers specializing in management and logistics area. The second study was conducted among managers of production and logistic companies in Poland's territory. The first survey study aim was to identify importance of sharing resources as a way to increase efficiency of supply chains and to identify key determinants of developing PI concept at resources level. The main aim of the second study was to get the managers' opinion on whether it is possible to share resources in supply chains. Potential difficulties in sharing resources with respect to their division into material and non-material ones and possible supply chain functioning areas were identified.

Keywords: Sharing resources · Survey study · Supply chain integration

1 Introduction

The resource use efficiency is of key importance in contemporary conditions of the world economy oriented to fast meeting various customers' needs [1, 2]. In the contemporary economy, resources should be considered not as a cost generator but a developer of potential opportunities. A company (and entire supply chains as well) is given an opportunity to obtain a competitive advantage by benefiting from various (external) resources and by efficiently using its own resources.

Much attention in the reference literature is paid to supply chain integration [3–6], which is manifestation of effective sharing of resources. New integration models, integration level assessment models and supply chain maturity models are established. The above mentioned solutions are most frequently related to the process approach to supply chains management. The main aim of the paper is to identify influence of

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characteristics of resources on possibility of implementation of Physical Internet concept into supply chains. Identification was based on two steps survey studies conducted within academic environment (during ICPR 2017 conference) and among managers from production and logistic companies located in Poland.

2 Theoretical Background

2.1 Physical Internet

The Physical Internet is a new proceeding concept in the logistics area. The Physical Internet concept is based on the physical mobility of logistic resources. According to the Physical Internet concept, all supply chain partners – manufacturers, providers of transport services, retailers – will be able to function independently by using one shared logistic network. Its natural feature is the ability to make self-adaptations caused by turbulent environment [7]. Efficient use of resources (supporting transport and warehouse processes realization) is the challenge for contemporary logistic systems. The Physical Internet concept is striving to use better the resources that are currently used inefficiently, hence it has the potential to be the future option of improving the activity efficiency in supply chains.

The Physical Internet is the term that was first mentioned in 2006 by Benoit Montreuil from Université Laval in Canada. The article entitled 'The physical Internet. A survey of logistics' published in 'The Economist' includes the first presentation of the Physical Internet assumptions [8]. The Physical Internet concept is based on the World Wide Web structure. As information might be transmitted by the World Wide Web network, why should one not do the same with goods that might be sent by means of the global logistic network? This requires close cooperation of companies involved (based on process integration and resources sharing) and results in increase of efficiency of global goods flows – flexibility and performance improvement combined with the reduction of operational costs. The supply chain configuration, business models and value adding patterns are being redefined by the Physical Internet assumptions. This is because the need for searching for a new system solution is more and more noticeable. The system solution is to enable the increase in the process performance efficiency and logistics development with the simultaneous obtainment of economic, social and environmental balance [9].

The 'Physical Internet' term was first mentioned in Poland during the Polish Logistics Congress LOGISTICS 2012 as a part of the paper by Russell D. Meller from the University of Arkansas [9]. Professor Meller presented the results of simulation research. It indicated that it was possible for the supply chain to obtain considerable benefits by shortening supply cycles with a decrease in the negative impact on the environment.

Inspired by the paper, the team of authors conducted research on worldwide literature resources that has led to identification of two periods of enhanced publicising activities in the Physical Internet area [Source: Web of Science]:

- the first period related to the Physical Internet term and idea development (2006 till 2012),

- the second period of time related to the organizing international conferences on the Physical Internet topic (2013 and consecutive years).

The PI issues are divided into two approaches:

- technical-technological approach – focused on problems of unification and integration of logistic units in the supply chain and the infrastructure to facilitate the flow of these units;
- organisational approach – related to developing the concept of managing the flow of logistic units which is predominantly based on the possibilities to share resources and competences with other supply chain participants.

To sum up, the Physical Internet is a young concept that has been actively discussed in theory and from practical perspective for the last 4 years (since 2012 – worldwide, since 2014 – in Poland). However, this concept is dynamically developing. This is confirmed by the small number of conferences and scientific articles and moderately small number of implementation projects to be currently considered as pilot solutions [10].

2.2 Resources in Supply Chains

Resources according to the APICS - American Production and Inventory Control Society [11] dictionary is all that is needed to manufacture the product, and the lack of which would cause failure to implement the predefined production plan. Hence, the resources are raw materials and materials (both basic and auxiliary), the potential calculated as the time of availability of the machines and employees with appropriate competences, power supplies and money necessary to run manufacturing processes.

The issue of enterprise resources is inseparably connected with the theory of management and economics and has already appeared in the works of classical economists. The resources originally described as factors of production were discussed by: Petty [12], Smith [13], Ricardo [14], Say [15], Marks [16], Marshall [17], Clark [18], Mill [19], MacCulloch [20] who were pointing to the importance of work, qualifications, tools and capital for the economy as a whole, and for individual economic processes.

The basis of the contemporary resource approach was developed by Schumpeter and Penrose. Schumpeter [21] considered innovations introduced by entrepreneurs as crucial for achieving profit, development and economic growth. He defined innovations as new combinations of material elements and manpower, which contribute to developing new product or launching a product with new properties, using new production method, finding new market, acquiring new sources of raw materials or introducing new production organization. The ability to take innovative actions results in achieving competitive advantage. Penrose [22] in turn, stressed that the company is a unique set of production resources that can be used in a variety of ways, and this diversity translates into uniqueness and, consequently, the ability to gain a competitive advantage.

The approach based on the assumptions described above is referred to as Resource Based View of the Firm (RBV). A milestone for the development of the resource

approach was the research by Wernerfelt [23] and Rumelt [24]. The resource theory presents the enterprise as a unique bundle of material and non-material resources and skills, which are a source of competitive advantage [25–28], while strategies expressed in the resource language based on resource redundancy are indicated as the most flexible and therefore suitable in contemporary conditions. The resources most valuable for the company are those that enable achieving a sustainable competitive advantage and organizational success, namely those that meet the so-called VRIN condition, (i.e. characterized by a strategic value (V-Valuable), rarity (R-Rare), inimitability (I-Inimitable) and lack of substitutes (N-Non-substitutable)) [27]. The other characteristics referred to in the literature on the subject include rarity, low mobility, limited opportunity of imitation, substitution, possibility of appropriation, durability, mutual complementation, adjustment to strategic factors of the industry [28], as well as imperfect imitation, imperfect substitution, imperfect mobility, diversity, ex ante and ex post restrictions [29], the concepts of other authors have broadened and integrated the presented lists [30]. Such configuration of resources should be the basis for the formulation of strategies.

Apart from identifying the essential features of resources as part of the resource orientation, their classification is also made so that for the identified groups of resources with common characteristics, appropriate methods and management tools could be selected. One of the most frequently implemented ways of classifying resources is the division into material and non-material ones [31, 32]. Classification of resources into material and non-material is based mostly on the resources existence - material resources such have actual physical existence, whereas non-material resources exist in abstraction [33].

Considering the VRIN criteria, researchers suggest that non-material resources are the source of competitive advantage as they are not easily acquired and replicated in factor markets [34–36]. The nature of non-material resources includes two aspects: assets, such as intellectual property, contracts and databased, and skills [37], which makes them crucial for company's identity, culture, uniqueness and therefore competitive advantage. Nevertheless, without integration with material resources and implementing continuous improvement to make the resources structure dynamic [38, 39], single non-material resources will not built competitive advantage by themselves [35, 40]. Integration of material and non-material resources can have an influence of efficiency of processes. Efficiency of the resource usage and running processes is one of the crucial aspect of developing sustainable competitive advantage of companies [41, 42] This is the reason why material and non-material resources contribution to sustainable competitive advantage should be assessed in the same analysis.

3 Survey Studies

3.1 Framework of the Study

The Physical Internet concept is still considered as the developing idea. After analysis of publications on the subject, it can be concluded that the concept is now more dynamically developing in the scientific and technical spheres than in the practical one.

This observation served as the main guideline for developing the research framework – the study on the resources sharing and its importance as a tool for implementing the PI concept in supply chains. Due to the academic nature of the concept (implementation is subject to projects and still at development stage), in first stage of survey study was conducted among academics. The aim of the study was to identify the significance of particular characteristics of material and non-material resources for implementing the PI concept in the supply chains. The aim of the second stage of the study (addressed to managers of manufacturing companies) was to examine the difficulties and threats of sharing particular types of material and non-material resources in the supply chains as they could in become the main inhibitors of implementation of PI concept. The framework research methodology is divided into parts:

- Stage 1: Survey among academics:
  - Developing survey questionnaire
  - Survey:
    - assessment of the validity of research on the impact of PI concept on contemporary supply chains in the aspect of their integration with logistic processes
    - identification of the significance of the determinants of implementing the concept of the Physical Internet.
  - Interpretation of the results, In-depth interview (IDI)
- Stage 2: Survey within Practitioners:
  - Development of a questionnaire for managers (practitioners)
  - Survey:
    - study on urgency and influence on the supply chain functioning by its selected aspects
    - opinions on threats implied by sharing material resources and non-material resources
    - degree of difficulty in sharing non-material resources
  - Interpretation of the results
- Final conclusions, further research

In-depth study conducted after the academia survey stressed the important role of planning and coordinating the use of resources as a key factor for the possibility of efficient sharing of resources in supply chains. Thus, this factor could play a key role in the implementation of PI concept. It was decided that in the second stage of study the planning and integration of plans in the supply chains will be included. In the subsequent subsections for each of the stages, the research methodology and their results are described in detail.

3.2 Stage 1: Academic Survey Study

3.2.1 Step 1: Survey Methodology

According to the developed research methodology, the first stage of the research was addressed to academics. They were asked to complete the questionnaire on the PI concept and its implementation potential. The questionnaire was distributed in paper and electronic version among scientists from all over the world during an international

conference and for the academics not attending the conference for a moth after the event. The result of the survey were reviewed, and the opinions of 22 academics who self-assessed themselves as experts in the field were qualified as meeting the research criteria.

The main objective of the study was: Identification of the significance of determinants of the Physical Internet concept implementation in the contemporary supply chains. Moreover, two research questions were formulated:

- What will be the impact of the Physical Internet concept on logistics processes management within the next 10 years (2018–2028)?
- Which of the determinants categories material resources or non-material resources have greater impact on implementation of the PI concept in supply chain logistics management?

For the purposes of the study, as a result of brainstorming, 14 generally defined determinants of the implementation of the concept of the Physical Internet were selected. The category "others" was added in order to recognize the respondents' opinions on the completeness of the list.

3.2.2 Step 2: Survey Results

The responses of the surveyed academics to the first question: 'How do you assess impact of Physical Internet idea on contemporary supply chains in the aspect of their integration with logistic processes within the next ten years (2018–2028)?' proved that further research in the field can contribute to development of the supply chain management discipline. In total, 68% of respondents rated the examined impact of the Physical Internet concept as 'strong' or 'critical' (see Fig. 1). This means that the respondents perceive the PI concept as one of the promising and dynamically

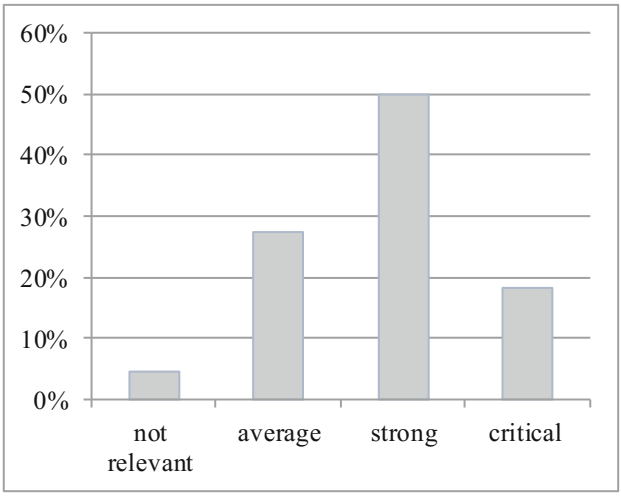

Fig. 1. Influence of Physical Internet idea on contemporary supply chains in the aspect of their integration with logistic processes within the next ten years (2018–2028).

developing ideas or one of the crucial ideas that will change operation and strategy of many companies. In the same only 5% of respondents assessed PI impact as 'not relevant' due to the early stage of the concept development, hence, lacking PI's strict definition, its importance is possible but in the distant future.

After validating the research, the next step was assessing the significance of the determinants of the Physical Internet concept implementation with respect to material and non-material resources. Respondents were asked to answer the questions acting as experts advising on implementation of the Physical Internet, and identify internal determinants of the decision on implementation assessing their importance in 5 points scale, where 1 is not relevant and 5 extremely important. The answers were analyzed with the mode of a set of data values, which is the value that appears most often in answers of respondents. Thus, according to respondents the most important material resources are (Fig. 2):

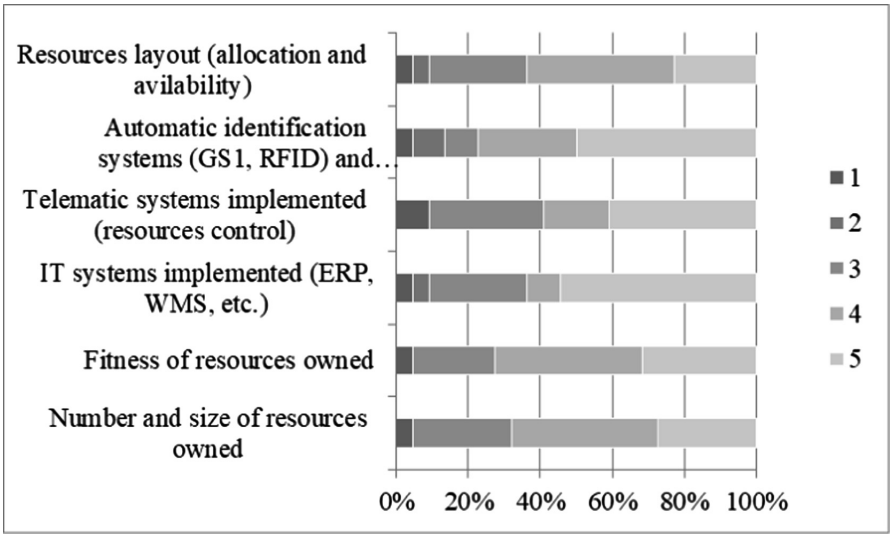

Fig. 2. Material resources - the answers distribution of respondents for importance on PI implementation (in 5 points scale, where 1 is not relevant and 5 extremely important).

The respondents have explained that that their selection was based on the assumption that companies willing to implement the PI concept need at least basic IT solutions. Implementation of automatic identification, IT systems (ERP, WMS, etc.) and Telematic systems (Fleet telematics) and their effective use is an important step towards the implementation of the PI concept.

In the non-material resources category the respondents indicated that the most important (according to the mode as a set of data values is the value that appears most often in answers of respondents) are:

- territorial scope of business activity,
- unique know how and USP (unique selling proposition),
- organizational process maturity.

Identifying Territorial scope of business activity as the most important determinant from the non-material resources category leads to the conclusion that there is probably a connection between the territorial scope of the offered logistic services and the need to cooperate and share resources with external entities. Also, having unique know how and unique selling proposition together with organizational process maturity were indicated as strong determinants. Unfortunately, at this stage of the research, it could not be unequivocally determined whether the influence of these determinants on PI implantation is positive or negative. Nevertheless, respondents noted that the organization's ability to effectively manage processes supporting implementation of strategic objectives has an impact on the analyzed research problem (Fig. 3).

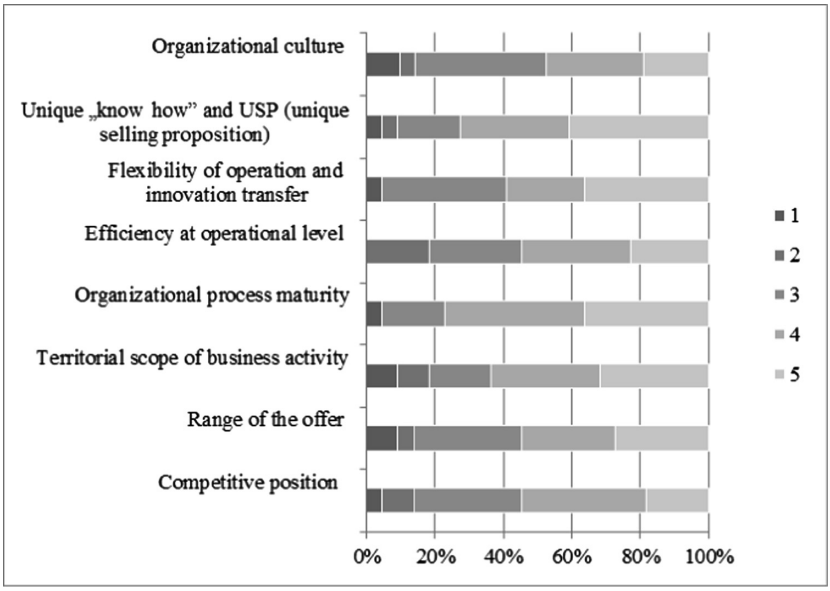

Fig. 3. Non-material resources - the answers distribution of respondents for importance on PI implementation (in 5 points scale, where 1 is not relevant and 5 extremely important).

In the 'others' category the respondents indicated:

- legislation,
- the actual delivery lead time (to the recipient from each location),
- will to cooperate; susceptibility to creating and maintaining open relationships with the business environment.

As significant. Identification of the impact of delivery lead time on the decision concerning implementation of the PI concept is related to the need to meet ever higher

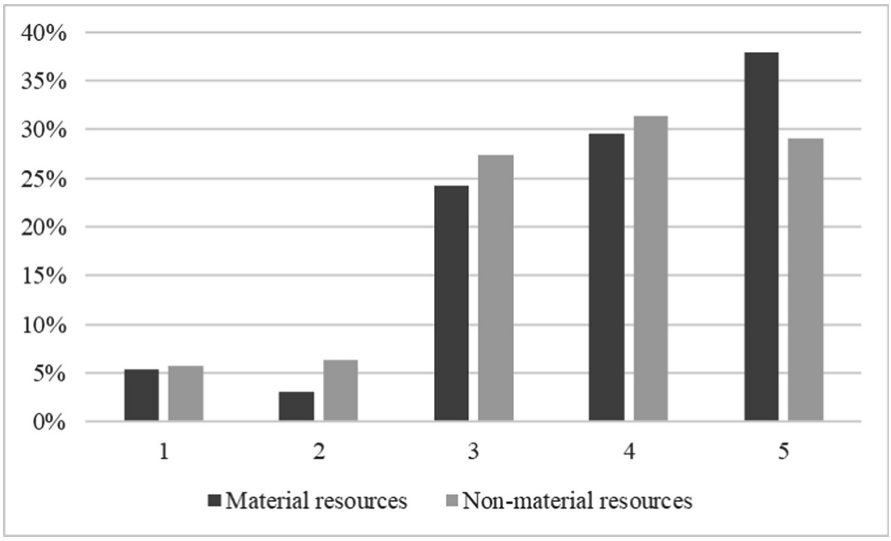

Fig. 4. The comparison of significance for material resources and non-material resources categories for importance on PI implementation (% of responses for importance in 5 points scale, where 1 is not relevant and 5 extremely important).

standards of logistics customer service. On the other hand, will to cooperate is a prerequisite for the need to share resources between market entities determines effective implementation of the PI concept. Legal regulations may also be a strong determinant, which may, for example, impose the need for cooperation between entities operating in a given region or agglomerations.

Comparison of the average assessment for both categories shows a slight advantage of material resources over non-material resources (Fig. 4).

However, the trend is not strong, which allows to conclude that we are dealing with a group of strong determinants (from both categories) affecting the analyzed problem. Differences between the categories of material resources and nonmaterial resources will probably be revealed at a lower level of analysis, i.e. specific issues for management practice (implemented partly in the second part of the research addressed to management practitioners).

3.3 Stage 2: Survey Within Practitioners

3.3.1 Step 1: Survey Methodology

The results of the first stage of study allowed to determine key characteristics and relevance of resources affecting the possibility of their sharing in the contemporary supply chains. In the second stage of the study, the authors wanted to gain knowledge about the possibility of sharing certain resources in the contemporary supply chains. In order to customize survey's questionnaire to the conditions of business practice, it was necessary to identify specific resources of contemporary supply chains (resources with the characteristics studied in the first stage of survey). And so in an in-depth study, the

academics pointed to the key material resources of supply chains of manufacturing enterprises:

- transport,
- warehousing – buildings,
- warehousing – equipment,
- production – buildings,
- production – means of labour,
- R&D.

To each of the resources listed above, characteristics that were considered in the first stage of the study were assigned. The assignment of resources to particular characteristics is presented in Table 1.

Table 1. Linking supply chain material resources (MR) with the surveyed characteristics of resources.

Characteristics of resource	Resources in supply chain of manufacturing companies
MR1: Number and size of resources owned	Transport, Warehousing – buildings, Production – buildings, R&D infrastructure
MR2: Fitness of resources owned	Warehousing – equipment, Production - means of labor
MR3: IT systems implemented (ERP, WMS, etc.)	Warehousing – equipment, Production - means of labor
MR4: Telematic systems implemented (resources control)	Warehousing – equipment, Production - means of labor
MR5: Automatic identification systems (GS1, RFID) and data interchange systems (EDI) implemented	Warehousing – equipment, Production - means of labor
MR6: Resources layout (allocation and availability)	Transport, Warehousing – buildings, Warehousing – equipment, Production – buildings, Production - means of labor, R&D

Similarly, for material resources, Academics in in-depth study indicated the most important non-material resources of contemporary supply chains:

- strategic plans,
- sales forecasts,
- data on customers and contractors,
- resource usage degree,
- R&D.

For non-material resources, specific resources were linked to given characteristics. The relations are shown in the Table 2.

During the in-depth study, the academics pointed to the planning and coordination of resource use as a key factor in the possibility of their sharing. Without planning and

Table 2. Linking supply chain non-material resources (NR) with the surveyed characteristics of resources.

Characteristics of resource	Non-material resources in supply chain of manufacturing companies
NR1: Competitive position	Strategic plans
NR2: Range of the offer	Sales forecasts
NR3: Territorial scope of business activity	Strategic plans, Data of customers and contractors
NR4: Organizational process maturity	Strategic plans, Resource usage degree
NR5: Efficiency at operational level	Resource usage degree
NR6: Flexibility of operation and innovation transfer	Resource usage degree
NR7: Unique 'know how' and USP (unique selling proposition)	Data of customers and contractors, R&D
NR8: Organizational culture	Strategic plans

coordinating using of resources, their practical sharing will not be possible. Taking into account the opinion of academics, it was decided to include the integration of planning processes in the contemporary supply chains to the second part of the study. Academics listed the scope of integration of planning processes:

- planning at the strategic level,
- planning at the tactical and operational level,
- operational processes,
- investment actions in the infrastructure area,
- investment actions in the R&D area.

Following the Tables 1 and 2, it was decided to identify connections between the scope of integration of planning processes and characteristics of material resources (MR) and non-material resources (NR). These relations are presented in Table 3.

Table 3. Linking characteristics of supply chain resources with scope of integration of planning processes.

Scope of integration of planning processes	Characteristics of material resources (MR)	Characteristics of non-material resources (NR)
Planning at the strategic level	MR1, MR6	NR1, NR3, NR4
Planning at the tactical and operational level	MR2	NR2
Operational processes	MR3, MR4, MR5	NR5, NR6
Investment actions in the infrastructure area	MR1, MR3, MR4, MR6	NR1, NR2, NR3, NR5, NR6
Investment actions in the R&D area	MR6	NR1, NR7

Assigning the characteristics of resources to particular scope of integration of planning processes allows to check the correctness of selection of integration scope in the context of ongoing research on sharing resources. Covering all ranges of integration with resource characteristics shows that these ranges relate to the issues under study. Detailed results of questionnaire surveys concerning the integration of planning processes in the contemporary supply chains and the possibility of sharing resources are presented in the next sub-chapter.

The performed study aimed at collecting opinions on the possibility to implement practical solutions based on the Physical Internet concept and its postulated resource sharing in supply chains. The opinions were given by higher-level managers employed in production and logistic companies. The managers' opinions were related to such aspects as:

- urgency of integrating particular areas of the supply chain functioning and its significance to (production and logistic) companies;
- expected integration effects within the supply chains;
- possibilities to participate in increasing costs and/or increasing supply chain profits;
- possibility to share both material and non-material resources in the supply chains;
- identification of threats imposed by sharing both material and non-material resources in the supply chains.

The study was performed with the use of a survey questionnaire in the form of both paper and electronic sheets. The tool selection solely depended on an respondent's preferences. The respondent was given the sheet in advance in order to read the questions and think of answers. The respondent was also given the opportunity to contact the research team members in order to be able to clarify all the doubts.

42 representatives of production and logistic companies participated in the study. According to the study assumptions, the respondents represented the positions of higher-level managers and executives. Among the respondents, there were i.a. chief operational officers, heads of contracts, department heads, logistics managers. The respondents represented large companies (the number of employees should be above 250 according to the adopted criterion). The large companies were not accidently selected due to their largest (organizational and capital) potential to implement modern resource coordination solutions. All the companies operated in Poland's territory but depended on foreign capital as they were (most frequently) part of an international concern.

The study was conducted in February and March 2017 in the companies that operated in Poland's territory.

The conducted study was a pilot study for the further research. The research was intended to identify whether it was possible to practically implement the Physical Internet concept. The research results were to determine whether it was justified to perform further detailed research and the scope of research was interesting to business practitioners.

3.3.2 Step 2: Survey Results

All the surveyed managers mentioned that it was necessary to perform broader integration of supply chains. This is obvious with respect to the observed economic

processes and publications discussing them. Nevertheless, it is still justified to ask a question about which areas should be integrated with each other and with what tools this integration process should be performed. The research authors indicated selected aspects of supply chain to the respondents and asked them questions about two specific integration features:

- implementation priority – defined with respect to the time category, what selected aspects of supply chain should be integrated with each other in the first place,
- influences of the aspect integration on the supply chain functioning.

The research results are presented in Figs. 5 and 6. In the figures there is also an average assessment in points (scale 1–5) where 1 means the highest priority and the

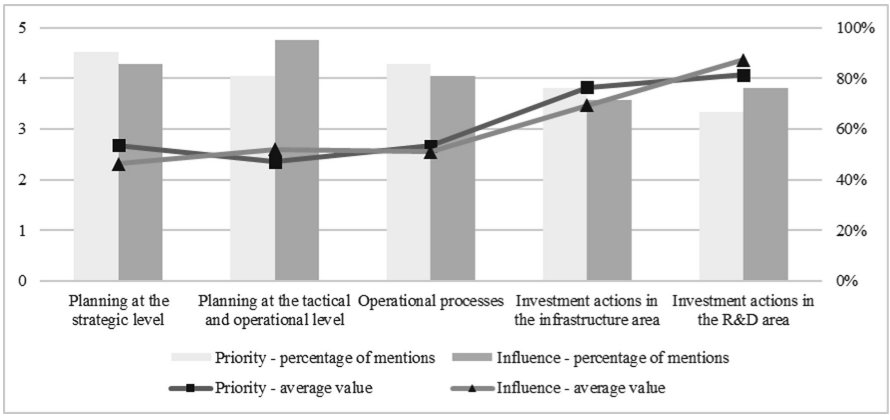

Fig. 5. Priority and influence on the supply chain functioning by its selected aspects [40].

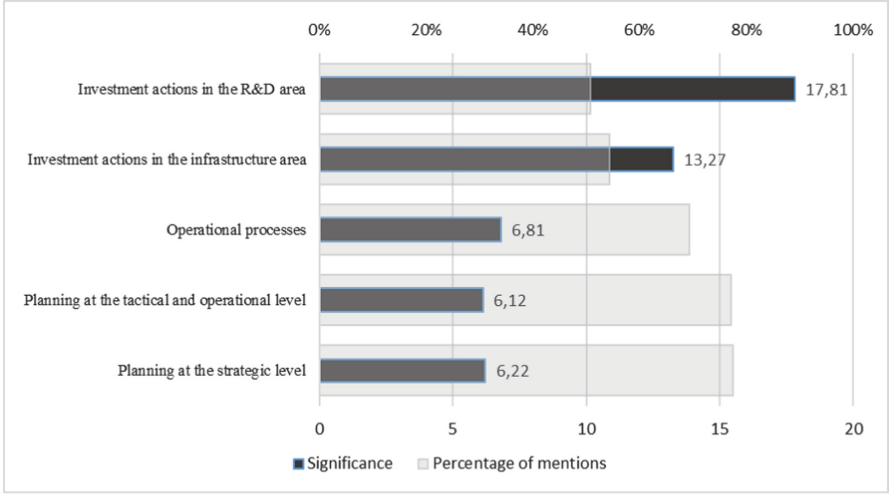

Fig. 6. Integration of selected aspects of supply chain significance [43].

largest influence and the percentage of how often a given aspect was mentioned to be significant in the supply chain integration process.

It should be stated in accordance with the results in Figs. 5 and 6 that particular selected aspects of supply chain were very similarly assessed by the survey respondents. The assessment was performed with respect to the integration priority and its influence on the supply chain functioning. Planning integration at the tactical and operational level were considered to be the aspect of the highest priority. From the respondents' perspective, strategic planning integration has the greatest influence on the supply chain.

As presented in Fig. 6, the integration significance is defined as a product of the integration priority and influence on the supply chain. The integration significance is an aggregated measure that was presented both in the category of assessment in points and the percentage of mentions. There is also a noticeable correlation between the integration significance and the percentage of mentioning a given aspect by the respondents. The aspects, which were more frequently mentioned, were assessed as more significant (lower assessment in points). According to this analysis methodology, the planning integration at the operational and tactical level, planning at the strategic level and operational process integration were considered to be the most significant to the supply chain functioning. An essential element in the operational process integration is to integrate the equipment used to perform processes, including the cargo units in use. The cooperation within the planning and operation activity performance function might be related to the necessity to transfer part of planning tasks to other supply chain entities. Do the managers consider such a situation to be possible and in what conditions? The responses to the questions are presented in Table 4.

Table 4. Opinions on transferring part of planning actions (at the operational and tactical level) to other supply chain companies [42].

Solution	Percentage of responses
Transfer to other supply chain companies with capital ties with my employing company	52.4%
Transfer to other supply chain companies regardless of capital ties	23.8%
Transfer of algorithms and electronic infrastructure (collecting and storing operational data)	42.9%
None of the above	9.5%

While analyzing the results in Table 4, two aspects should be considered. The first one is rather obvious and shows that it is possible to transfer part of planning functions to companies that are capital-related entities. The second one is much more interesting with respect to the possibility to practically implement the Physical Internet assumptions and concept. What is indicated by the second aspect, it is relatively highly acceptable to transfer the planning functions to algorithms and electronic infrastructure. From respondents' perspective, this option is more than 2 times probable than the transfer of planning functions to other companies with no capital ties.

In the follow-up to the topic of sharing resources, the managers of logistic and production companies seem to notice much more difficulties in sharing non-material resources. The detailed results within this topic are presented in Table 5.

Table 5. Opinions of the difficulties in resource sharing [43].

Threats to material resources	Percentage of mentions
Yes, as no full freedom in using resources	38.1%
Yes, as a risk of getting resources destroyed	28.6%
Yes, as a necessity to coordinate the usage of resources	52.4%
There is no risk related to sharing material resources	9.5%

To conclude the presently described results, it should be stated that there seem to be numerous difficulties in the most expected cooperation within the operational and tactical planning. The latter one is treated as an information process. It seems to be much easier to cooperate within operational process and sharing material resources within the processes. In the surveyed managers' opinion, it is expected by the above action to reduce operational costs (42.9% of mentions and order processing time reduction – 38.1% of mentions). In the opinion of 57.1% of the respondents, the obtained results as reduced operational costs in supply chains should be distributed in the supply chain among the companies that share their resources.

Nevertheless, the resource sharing is not only potential opportunities but also threats. It seems to be justified to identify the dangers with respect to each of the resource types (material, non-material) separately. This is motivated by the identified differences within the possibility to share the resources according to their types. Table 6 includes the results of the research on potential threats implied by sharing material resources.

Table 6. Opinions about threats implied by sharing material resources [43].

Threats to material resources	Percentage of mentions
Yes, as no full freedom in using resources	38.1%
Yes, as a risk of getting resources destroyed	28.6%
Yes, as a necessity to coordinate the usage of resources	52.4%
There is no risk related to sharing material resources	9.5%

The observation implied by Table 6 is the coordination in using the resources by various supply chain entities. This is the largest difficulty in sharing the resources in the authors' opinion. Importantly, this difficulty is more frequently mentioned than no full freedom in using the resources and the possibility to get them destroyed.

When moving on to analyzing the difficulty in sharing non-material resources in detail, the managers of production and logistic companies were asked questions about the degree of difficulty in sharing them according to the resource types. The responses

to such questions were analyzed as presented in Fig. 7. The respondents were asked to state whether it was possible to share a certain type of resources and if so, what degree of difficulty in such actions was based on the scale 1–5 (1 means the highest difficulty degree, 5 the lowest difficulty degree).

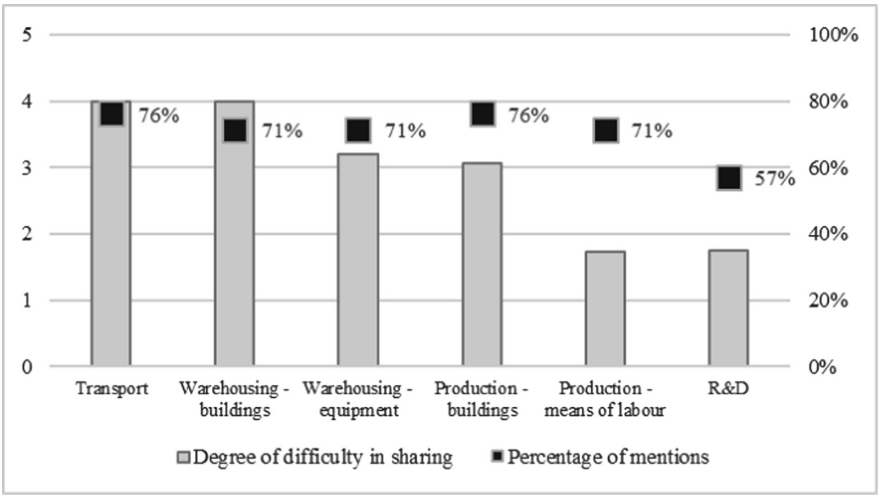

Fig. 7. Degree of difficulty in sharing material resources [43].

In the surveyed managers' view, it is most difficult to share R&D infrastructure material resources. Furthermore, it is possible to share means of labor. This is, however, a difficult task due to their low mobility. The respondents notice large chances in sharing transport and warehousing resources and they do not identify large difficulties in the share. Table 7 includes the opinions on the threats in sharing non-material resources.

Table 7. Opinions on threats from sharing non-material resources [43].

Threats to non-material resources	Percentage of mentions
Yes, information is a competitive advantage element of the company	76.2%
Yes, as a risk of losing full control over the information access	28.6%
Yes, as a risk	9.5%
There is no risk related sharing non-material resources	4.8%

What indisputably hampers the share of non-material resources, is that they are a competitive advantage element of a company. In the authors' opinion, the risk of losing full information control is of secondary significance compared to the mere information

value for companies. As part of the thorough assessment of sharing non-material resources, the managers were asked to mention the possibilities to share them and the degree of difficulty in their share by analogy to the material resources. In this research an analogical scale (1–5) was used. The research results are presented in Fig. 8.

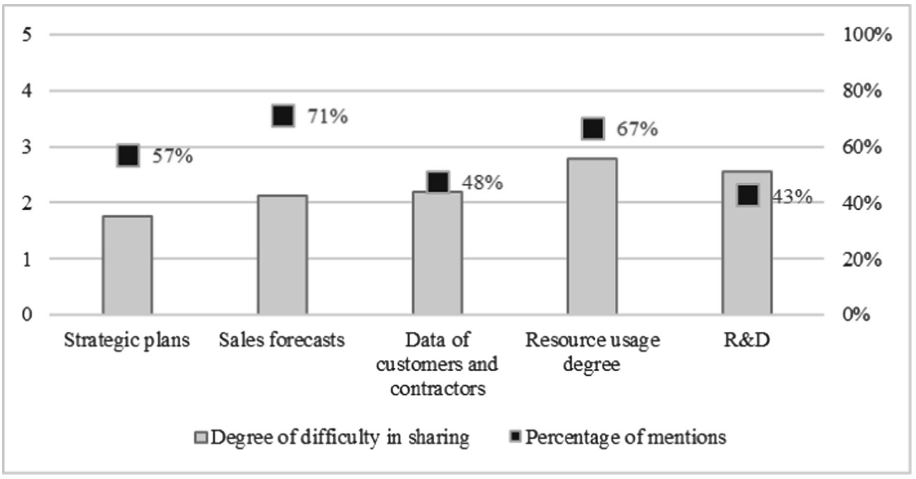

Fig. 8. Degree of difficulty in sharing non-material resources [43].

The managers of production and logistic companies mention that there is the largest possibility to share data about the resource usage forecasts and degree. Such actions are being executed in supply chains within such solutions as CPFR, VMI, CMI or contract logistics. The largest difficulties are noticed in sharing strategic plans. It is necessary to emphasize that the indicated degrees of difficulty are very close to each other.

4 Conclusions

All the surveyed managers were unanimous to state that it is necessary to integrate companies within supply chains. Independently of the survey questionnaire, they motivated their opinions by the necessity to fulfil customers' requirements and meet the increasing market competition. The managers identify the integration as a tool to make the supply chain obtain a competitive advantage. These observations are in line with numerous publications about the integration. Thereby, it is not a scientific novelty. It is current and essential to specify what areas should be integrated with each other in the supply chain and how it should be performed. The Physical Internet concept provided a theoretical solution that was oriented to the share of (mostly material) resources. It is obvious that it is not possible to integrate material resources without any share of non-material resources. The performed research results showed that the largest potential of the Physical Internet concept fulfillment occurred in sharing material (transport and warehousing) resources used in the supply chain operational processes.

It is feasible to state based on the pilot study results that one should consider two (technical-technological and organizational) approaches in further practical development of the Physical Internet concept. The technical-technological approach development is observed by numerous researchers and described in numerous publications. This approach is additionally supported by the fast development of data exchange and access technologies by wireless networks and M2M communication (and broader IoT concept). The authors notice larger challenges in the Physical Internet concept development in the organizational approach. As shown by the research results, it is necessary to define new company management models and adapt the currently existing models for need of implementation the Physical Internet concept and to convince the managers of coexisting or cooperating companies in supply chains to the models.

The team of authors is planning to perform the next step of the study with respect to the size of a sample that will enable statistical result verification. The scope of the study is going to be spread by in-depth study of PI implementation determinants and its systematization. Due to the international supply chain specifics, it will be necessary to expend the scope of the research to other countries outside Poland.

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