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IMPACT OF SUPPLIER-SPECIFIC INVESTMENTS IN INTER-ORGANISATIONAL INFORMATION SYSTEMS ON STRATEGIC ELECTRONIC COORDINATION: THE MODERATION EFFECT OF BUYER DEPENDENCE

SERGEI TERYOKHIN, GØRIL HANNÅS

ABSTRACT

This paper examines the factors which influence sharing of the strategic information (in other words, electronic coordination) in a buyer–supplier dyad. The antecedents of this coordination are examined rather well in the transaction cost economics (TCE) theory and resource-dependency theory (RDT), while the supply chain management perspective is contemplated. The mentioned frameworks are used in the analysis. However, the research focus is narrowed down to the exploration of the antecedents of information exchange conducted via inter-organisational information systems (IOS). The empirical analysis is based on 198 observations of Norwegian companies operating in different types of industries. A regression model is used to test the hypotheses about the antecedents of strategic electronic coordination. The research results indicate that the direct effect of the supplier-specific investments in the IOS on the exchange of strategic information in the buyer–supplier dyad is not statistically significant. The supplier-specific investment in the IOS becomes positively associated with the strategic information exchange in the buyer–supplier dyad only when the buyer is dependent on the supplier. The buyer dependency creates a high motivation for the company to exchange the strategic information with the supplier who is more powerful in the dyad. This research concludes that the companies making substantial investments in the IOS for electronic coordination purposes may not reach their goals if relation-specific factors, such as buyer dependency, are not comprehensively considered.

KEY WORDS

buyer dependency, inter-organisational information system (IOS), resource dependency theory, strategic electronic coordination, specific IOS investment, transaction cost economics (TCE)

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INTRODUCTION

Coordination is one of the most used terms in the supply chain management (SCM) literature. Moreover, some of the researchers like Mentzer et al. (2001) define the supply chain management as the strategic and tactical coordination of business functions within a company and across the supply chain (SC) actors intended to improve the perfor-

mance of individual companies and the entire SC. That ensures that the coordination of the core activity of companies performs well in modern supply chains.

Another notable characteristic of today's coordination mechanisms in the SC is that inter-organisational information systems (IOS) play a pivotal role in the information exchange between the companies. Today, the types of the information that companies

exchange via IOSs go far beyond the simple data exchange regarding the processed invoices, orders, and payments. Some companies, such as Wal-Mart, Chrysler, and Ford, force their suppliers to deploy an IOS for the better coordination and collaboration (Subramani, 2004). This paper uses the terms “coordination” and “information sharing” interchangeably.

Despite the fact that business entities recognise the coordination as an important value-increasing tool, the practice shows that the companies are often reluctant to share their information or afraid to disclose certain strategic information because of the threat of opportunistic behaviour.

The problem mentioned above is the impetus to the search for the drivers and barriers for the coordination. Over time, the stream of literature which examines the information sharing and coordination is widening (Kembro et al., 2014). At the same time, the SCM literature is lacking a single framework which could comprehensively answer such questions as “What are the drivers of coordination?”, “Why are collaboration relationships successful in some business relationships but do not bring desirable results to others?”, “What kind of the collaboration level (tactical, strategic) fits the current goals and strategies of companies the best?” The researchers are using different theoretical “lenses” to investigate the coordination. Therefore, it leaves room for further explorations in the field.

The relevance of this study can be substantiated by addressing the issue of mixed results in the IOS literature with respect to the modelling results (i.e. the sign in the statistical models) reflecting the correlation between the investments in the IOSs and the expected outcomes of the IOS use, such as cost reduction, finding new distribution channels, speed and flexibility, electronic coordination, and value creation (Yao et al., 2010). Even though modern IOSs provide SC members with the possibility to exchange a broad spectrum of business information, the companies are often unwilling to exchange this information. Furthermore, some researchers claim that the IOSs can be considered a threat to organisations when, for instance, “they fear the risk of becoming more dependent on IOS partners, to be disintermediated or to be forced to move to more competitive markets...” (Boonstra & Vries, 2005, p. 486). Disintermediation effect of the IOSs which leads to the arm-length business relationships rather than the collaboration has been widely studied in the literature (Malone et al., 1987; Clemons & Row, 1992; Clark, 1992; Short & Venkatraman, 1992). This

research pool demonstrates that companies who invest heavily in the IOSs also reduce the coordination costs since the market information becomes easily accessible to the IOS-users. As a result, companies tend to prefer the market forms of the relationships to the collaborative forms (i.e. hybrids and hierarchies). At the same time, such an aspect of buyer–seller relationships as the influence of dependency on electronic coordination has been given less attention in IOS literature so far. This aspect, if considered, can assist in choosing of the proper governance mechanism.

This paper aims to provide an insight into the information exchange mechanism in buyer–supplier dyads, namely, the exchange of strategic information conducted via information systems.

The paper contributes to the research area by exploring the antecedents of successful information exchange in buyer–supplier dyads. Given that companies may share various types of information and use different means of information exchange, the scope of the research was narrowed down to the exploration of antecedents of the strategic electronic coordination. The latter implies coordination of production plans, product design, and modifications, as well as development and testing of the new products in a buyer–supplier dyad via IOS. The study examines the buyer dependency as one of the important factors which may enforce the strategic electronic collaboration.

The research model used in this paper is based on 198 observations representing the data collected from Norwegian enterprises operating in different industries. A buyer–supplier dyad is taken as a unit of analysis. The empirical data are collected from the buyer perspective.

The following sections briefly describe the conceptual background for the strategic electronic coordination, develop the hypothesis and the model. The concluding sections discuss the results and limitations and make suggestions for future research.

1. THEORY AND HYPOTHESES

There is no single definition of the coordination between the SC actors in the literature (Arshinder et al., 2008; Gao & Tian, 2014). The SC coordination is viewed by researchers from different perspectives: long-term contracts, risk and benefits sharing, information exchange and IOS usage, joint planning and

product development (Larsen, 2000); coordination as a tool to manage dependencies between the firms in the SC (Malone & Crowston, 1994; Xu & Beamon, 2006); coordination as general decision making and interaction between the SC actors in order to plan, control and adjust inventories, funds and information, and support the key SC business processes (Romano, 2003). The provided viewpoints suggest that the coordination mechanisms are different, and they include the following dimensions: information exchange and the use of IOS, contracting, joint decision making, and risk and revenue sharing. This paper focuses on an aspect of the coordination, namely, information exchange in the buyer–supplier dyad conducted via an IOS.

According to the literature review article by Kembro et al. (2014), the most applied theories which explain information exchange in dyadic relationships are transaction cost economics (TCE), relational governance theories, contingency theory, and resource dependency theory (RDT). Concerning the information sharing these theories discuss the following issues: whether to share the information or not and why, what to share and with whom, how to share, what kind of barriers, drivers, and prerequisites of information exchange questions may exist (Kembro et al., 2014).

The following subsections briefly present the theories most relevant to the study emphasising how they explain the drivers for the information exchange in the dyadic relationships. In the light of the research, information exchange drivers are also considered as the drivers for the coordination.

1.1. TCE PERSPECTIVE

The primary focus of TCE is the minimisation of the transaction costs which can be reached if the considered companies choose appropriate governance structures (Williamson, 1985). The latter should be selected by firms based on the main transaction characteristics, such as asset specificity, environmental uncertainty, and the frequency of information exchange. Opportunism is one of the central TCE assumptions (Williamson, 1985). Firms which invest in highly specific assets are exposed to opportunistic behaviour. To protect the specific assets from opportunism, the firms need to develop safeguards, such as formal contracts (Porterfield et al., 2010) or bind the interacting companies together by prompting the collaborating party to invest in the specific assets, or by other specific

procedures (Bensaou & Andersen, 1999). According to TCE, formal contracts are the main driver for the information sharing (Grover & Saeed, 2007; Porterfield et al., 2010).

Another mechanism of firm bonding that motivates to maintain the relationship is switching costs (Geiger et al., 2012). There is no consensus on the conceptualisation of switching costs (Barroso & Picon, 2012). They can be defined as costs of concluding the ongoing relationship while establishing the relationship with a new business partner (Kim et al., 2010; Blut et al., 2016). The magnitude of switching costs is closely related to the level of specificity of the assets deployed in the relationship. Specific investments made both unilaterally and bilaterally increase switching costs. On the one hand, the firms investing in the asset increasing the switching costs become more dependent on each other (Berry & Parasuraman, 1991). On the other hand, high switching costs indicate that the companies believe that the relationship will strengthen in the future. Blut et al. (2016) highlight that the interdependency which is induced by high switching cost is the impetus for communication and knowledge transfer between the trading partners.

Though the TCE provides a framework to explain the drivers for information sharing through interdependency mechanism, the explanatory power of this mechanism is limited due to the interdependency being viewed merely because of some specific asset investments. Several researchers (e.g. Dietrich, 1989; Bournakis & Bournakis, 2005) note that TCE fails to explain the interdependent nature of business-to-business (B2B) relationships. The dependency concept is more broadly examined in RDT.

1.2. RDT PERSPECTIVE

The main tenet of RDT is the existence of some companies that are self-sufficient in terms of resources (Reid et al., 2001). Companies with inefficient resources become dependent on the companies who possess them. RDT suggests that to secure scarce resources and reduce uncertainty, companies tend to build bilateral relationships through, for example, mergers and acquisitions, joint ventures and other inter-organisational relationships (Pfeffer & Salancik, 1978; Stern & Reve, 1980). Any asset, such as information, knowledge, material or capital, may be regarded as a resource in this context (Tillquist et al., 2002).

According to RDT, “A depends upon B if he aspires to goals or gratifications whose achievement is facilitated by appropriate actions on B's part” (Emerson, 1962, p. 32). The power concept is closely related to dependency, meaning that if A depends on B, then B has power over A (Emerson, 1962). The magnitude of dependency is determined by the following factors: (1) the importance of the resource (structural dependence), (2) the availability of alternatives (market power), (3) the deployment of the resource (who controls the resource) (Medcof, 2001; Petersen et al., 2008). It may be observed that the nature of the dependency as a concept is much broader in RDT than in TCE.

The RDT literature examines the dependency as a tool which can be implemented by powerful actors in a supply chain to obtain favourable conditions in relationships with their dependent partners (Tillquist et al., 2002, pp. 93-94; Dastmalchian, 1986; Frooman, 1999; Pfeffer, 1992; Provan et al., 1980; Willer et al., 1997) and as a mechanism that promotes cooperation in the supply chain (Bensaou, 1997). Similar problems are also examined in the concept of power sources (French & Raven, 1959) where power asymmetry serves the interests of the more powerful party. This research stream also addresses the tactics which lead to more balanced power positions between the parties (Cowan et al., 2015; Pérez & Cambra-Fierro, 2015; Siemieniako & Mitreġa, 2017).

When examining the impact of the dependency on the integration and coordination processes between the firms, the researchers highlight that only mutual dependency can lead to a successful collaboration and commitment (Kumar et al., 1995; Vijayarathy, 2010; Kim et al., 2010; Kembro et al., 2014). Conversely, asymmetrical (unilateral) dependency is potentially considered a destructive factor in the organisational relationships (Vijayarathy, 2010).

1.3. CONNECTING TCE AND RDT THEORIES WITH IOS LITERATURE

The study defines an IOS as an information system which is used in the buyer-supplier dyad for the purpose of coordination, i.e. sharing the information and knowledge. There are many technological solutions today which fall under the IOS category. The most commonly used IOSs are electronic data interchange (EDI) systems, integrated enterprise resource planning (ERP) systems, vendor managed inventory (VMI) systems, as well as highly customised software solutions offered by various IT develop-

ers. The expected benefits of employing an IOS are well-described in the literature. They may include the following: reduced transaction costs, reduced lead times, improved SC visibility, quick reaction to market changes, optimisation of internal processes, improved customer satisfaction (Chang et al., 2010; Johnson & Vitale, 1988; Malone et al., 1987).

In the literature, IOSs are often considered as a highly specific investment. These systems may reconfigure the existing business processes. It refers to the procedural asset specificity (Grover & Malhorta, 2003), and it often requires significant investments in the personnel training (Nelson & Winter, 1982).

When making the connection between the IOS, TCE and RDT theories with respect to the impact that IOSs have on the strategic electronic coordination, it is worth mentioning that the power-related issues may both (1) affect the IOS implementations and (2) be affected by the IOSs.

A powerful party can force a less powerful partner to deploy an IOS. A less powerful party, in its turn, has little possibilities to persuade the other party to use an IOS if the latter has little interest in using it (Wilson & Vlosky, 1998; Boonstra & Vries, 2005). For instance, the empirical research conducted by Yigitbasioglu (2010) demonstrates that the buyer dependency on the supplier and key supplier dependency on the buyer are positively related to the intensity of information sharing in the considered dyadic relationships. Yigitbasioglu (2010) asserts that the dependent buyers (for instance, due to the specific investments in the IOS) are more willing to share their information with the suppliers. Such buyers may also invest in the supplier information systems to get more information from the supplier side. The same arguments hold for the supplier dependency on the buyer.

On the other hand, the investments in the IOSs may have an impact on power-dependency structure which in the dyadic relationships has been established prior to the implementation of an IOS (Webster, 1995). For example, the buyer's power will increase if more suppliers will integrate their information systems with the buyer's IS. In that case, the buyer can take advantage of the leverage effect through the mechanism of electronic tendering.

It is worth to mention one specific feature of the IOS investments. On the one hand, TCE asserts that heavy investments in IOSs should increase the need for the investing party to safeguard the assets at risk. On the other hand, the companies make heavy invest-

ments in IOSs to reduce the cost of communication and increase monitoring power to protect the investments at risk (Clemons et al., 1993). While there is a consensus in the literature regarding the need to safeguard the highly specific assets, the impact that investments in an IOS have on the increased monitoring power and the strategic electronic coordination is not obvious. For example, the supplier's investments into an IOS made to obtain more information from the buyer about the demand, production planning, and inventory levels may not fulfil the purpose because of the buyer's unwillingness to share this strategic information. Thus, it can be concluded that the supplier's specific IOS investment is the necessary condition for the strategic electronic coordination improvement, but this condition alone does not suffice the coordination improvement.

A similar problem is addressed by Buvik and Reve (2002). They note that the main distinction between the TCA-based dependency established by the investments in specific assets and the RDT-based dependency may be described as "an important distinction between the incentive and the ability to safeguard assets at risk" (Buvik & Reve, 2002, p. 266). The authors claim that the RDT-based dependency (structural power) has an impact on a company's ability to protect specific assets and its bargaining power. A firm's need to safeguard the specific assets becomes lower when the firm can exercise the structural power over its partner.

1.4. CONCLUSIONS BASED ON THE LITERATURE EXAMINATION

When a company invests in an IOS with the purpose of strategic information exchange, it puts investments at risk due to the excessive levels of procedural and human specificity of the IOS investments. According to TCE, high asset specificity increases switching cost and therefore the dependency on its trading partner. There is a need for the investing firm to safeguard these risky investments. TCE suggests using formal contracts as a safeguard tool and the main driver for information sharing. The other party's unwillingness to share the strategic information may create obstacles to formal contracting. It results in a search for other possible bonding mechanisms in the buyer-supplier dyad which can motivate the contractual parties to exchange the strategic information. The RDT asserts that structural dependency favours better terms of trade for more powerful actors. When the dependency is mutual, it influences the collabora-

tion and commitment in a positive way.

Based on this reasoning, it is proposed that mutual dependency in a buyer-supplier dyad may occur when both conditions are satisfied: the supplier makes the investments in an IOS (TCE-based dependence), and the buyer is dependent on the supplier (structural RDT-based dependence). This type of mutual dependency can enforce the exchange of strategic business information via the IOS in the buyer-supplier dyad. Consequently, the following hypothesis is proposed:

Hypothesis 1: *When the buyer dependency is high, there is more positively shaped association between the supplier specific IOS investments and the strategic electronic coordination than under the conditions of low buyer dependency.*

1.5. IOS LEVELS AND STRATEGIC ELECTRONIC COORDINATION

IOSs provide different functionalities that serve different purposes in the buyer-seller relationships. According to Premkumar (2000), there are three levels of IOS development: (1) communication (substitution of paper/phone/fax modes of communication with computer-based communication), (2) coordination (information exchange on production planning, delivery schedules), and (3) cooperation (collaboration over product design and performance evaluation). A similar approach to classification of the stages of the IOS development is provided by Saeed, Malhorta, and Grover (2005). The first two stages imply only the integration of the buyer's purchasing system with the vendor's information system (placing the orders, order status check, etc.). Stages 3 and 4 imply the involvement of the buyer's production planning and control system into the information exchange with the vendor.

The section above examines the IOSs which allow firms to exchange their strategic information about production planning, product design, modifications, as well as new product development. These IOS characteristics correspond to the highest levels of the IOS development. On the other hand, the fact that the supplier uses the IOS for strategic coordination purposes does not conflict the use of the same IOS for both strategic and operational purposes such as processing of orders and invoices. Moreover, companies normally start the electronic collaboration with the exchange of simplest forms of information. It is reasonable to assume that the success of electronic information exchange on high levels of the IOS

sophistication depends (to some extent) on the way successful companies conduct their routine operations (such as invoicing and ordering via the IOS). For example, to cooperate on product design and its modifications, as well as development and testing of some new products, the companies also need to carry out the routine purchasing operations. The development and testing of new products require purchasing components, raw materials, and other items. Therefore, the strategic electronic collaboration process may be enhanced if the routine purchasing operations are supported by the IOSs instead of the older communication modes, such as phones and faxes. The following hypothesis is thereby proposed:

Hypothesis 2: *The electronic information exchange for tactical purposes is positively associated with the strategic electronic coordination.*

1.6. OTHER ANTECEDENTS TO STRATEGIC ELECTRONIC COORDINATION

To validate the suggested regression model which may be referred to as “Buyer dependency – strategic electronic coordination”, three control variables are introduced: Buyer’s industry type (BUYIND), Purchasing relative turnover (RELPUR), and Length of IT cooperation (LNITCOOP).

Buyer’s industry type (BUYIND) is included to control possible differences between the type of manufacturing industry and other industries. The manufacturing sector is addressed more frequently in the TCE literature compared to other industry types (Zhao et al., 2004). It can be explained, for example, by the nature of business processes in the manufacturing industry which is more complex compared to those of the service industry. Broad use of physical assets, such as equipment, tools, vehicles, and the flow inventories, generate wider volumes of information compared to other industries. Therefore, it can be expected that manufacturing companies would be more willing to use an IOS for the purpose of strategic coordination. The variable is coded as a dummy variable: 1 – manufacturing, 0 – other industries (service, retail, public administration).

Purchasing relative turnover (*purchasing importance* RELPUR) demonstrates the buyer’s purchasing volume from a particular supplier relative to the supplier’s annual sales. This variable indicates the importance of the buyer for the supplier. In other words, it describes the magnitude of the supplier dependency. Pfeffer and Salancik (1978) note that the relative importance of sale or purchase interdependency

positively correlates with the likelihood of mergers. Given that mergers correspond to a vertically integrated type of relationships, it can be assumed that high purchasing importance motivates firms to share their strategic information. As for the study, an assumption is made that high purchasing importance of a particular buyer can enforce the supplier’s willingness to cooperate over such strategic issues as the product design and development, testing of new products, and the production planning.

Length of IT cooperation with the supplier (LNITCOOP) is measured as the natural logarithm of the number of years the companies have been cooperating via an IOS (Heide & John, 1990).

A positive association between the LNITCOOP and strategic electronic coordination is expected because of the increasing level of trust between the partners which normally evolves over time and with less IOS malfunctions.

2. RESEARCH METHOD

A structural equation model (regression model) has been developed for the hypotheses testing. To collect the empirical data for the model, survey-based research has been conducted. The subsections below describe the data collection process and present the confirmatory factor analysis for the constructs used in the model “Buyer dependency – strategic electronic coordination.”

2.1. DATA COLLECTION

The unit of analysis is a buyer–supplier dyad which uses an IOS to exchange the business information. The data has been collected from Norwegian firms operating in different industries. First, a pilot test has been conducted among 20 firms to achieve the reliability of the items and to avoid possible misunderstandings in questions, scaling methods and inappropriate vocabulary (Hunt et al., 1982). The received feedback helped to revise the pilot questionnaire into its final version.

The questionnaire which contained 26 closed questions was sent by e-mail to the organisations with membership in NIMA (Norwegian Association of Purchasing and Logistics) and the companies registered in e-Procurement Secretariat in 2006. The sample size consisted of 1365 companies. The final questionnaire was sent to respondents in two

rounds with the time gap of two weeks. The total number of the answers received and available for analysis was 198. The non-response bias was measured between the first and the second rounds of data collection (Armstrong & Overton, 1977). The results of the t-test showed no significant difference between two groups concerning the annual sales volume, the number of employees and the purchasing volume (Hannås, 2007).

To achieve better information reliability about the investigated problem, key informant approach to the data collection was used. This approach is often applied to examine business-to-business relationships (Heide & John, 1992; Bensaou & Anderson, 1999; Buvik & John, 2000). The study considered key informants as those with knowledge about purchasing or logistic operations because they are related to upstream supply chain activities (Hannås, 2007).

2.2. MEASURES FOR THE REGRESSION MODEL “BUYER DEPENDENCY – STRATEGIC ELECTRONIC COORDINATION”

To cover different aspects of the electronic coordination, various indicators to measure the information exchange between firms via various IOSs were used (Hannås, 2007). The items have been elaborated based on the coordination literature and the IOS literature (Buvik & John, 2000; Joshi & Stump, 1999; Zaheer & Venkatraman, 1995; Subramani, 2004).

Such measures as strategic electronic coordination (COORD) and operational electronic exchange (OPER) were derived from the confirmatory factor analysis (CFA) given the electronic coordination construct. To perform the CFA, AMOS graphics extension to SPSS 22 software was used.

The CFA suggests three-factor solutions for the electronic coordination construct. The results from the CFA for electronic coordination are presented below.

Chi-square = 52.424; degrees of freedom = 24; probability level = 0.001; CMIN/DF = 2.184; CFI = 0.953; NFI = 0.920; TLI = 0.912; RMSEA = 0.078.

Strategic electronic coordination (COORD: 3 items):

- (Q11_4) coordination of production plans (0.73),
- (Q11_5) product and design modifications (0.87),
- (Q11_6) development and testing of new products (0.83).

Operational electronic exchange (OPER: 3 items):

- (Q11_2) ordering process (0.58),
- (Q11_3) invoicing and payments (0.65),
- (Q11_9) active replenishment of our inventories (0.57).

The third suggested construct is not used in our model. It has the following items:

- (Q11_8) tender processing (0.71),
- (Q11_10) document exchange (0.75),
- (Q11_11) product specifications (0.76).

The dependent variable of the regression model “Buyer dependency – strategic electronic coordination” reflects the strategic business information which is exchanged in the buyer–supplier dyad via an IOS. The factor analysis has assigned three items (Q11_4, Q11_5, Q11_6) to COORD variable (Cronbach’s $\alpha = 0.842$).

2.3. INDEPENDENT VARIABLES OF THE REGRESSION MODEL “BUYER DEPENDENCY – STRATEGIC ELECTRONIC COORDINATION”

Buyer dependency (BUYERDEP) refers to the buyer’s switching costs associated with changing the current supplier. The construct was developed based on Heide (1994). Factor analysis confirmed one-factor solution (Cronbach’s $\alpha = 0.678$) with the three following items:

- (Q14_3) buyer makes extensive adaptations in the production system to make use of products from this supplier (0.99);
- (Q14_4) extensive internal reorganisation of our company to collaborate more efficiently with this supplier (0.74);
- (Q23_1) it would be relatively costly for our company to replace this supplier (0.34).

Supplier IT specific investments (SITINV) describe the investments in the IOS made by the supplier to facilitate the information exchange in the buyer–supplier dyad. The items of this construct attempt to cover the most important dimensions of the IT investments, such as personnel training, investments in software and hardware, the efforts undertaken by the supplier to integrate the IT systems of the buyer and the supplier. The factor analysis suggests one construct (Cronbach’s $\alpha = 0.887$) with the four following items:

- (Q13_1) the supplier invests extensively in their own IT competence (0.84);
- (Q13_2) the supplier invests extensively in IT systems by our standards and requirements (0.96);

Tab. 1. Discriminant validity, the four-factor solution

	COMPONENT			
	1	2	3	4
Ordering processes	0.029	0.028	-0.025	0.846
Invoicing/payment processes	0.205	0.128	0.076	0.769
Replenishment systems	0.373	0.286	0.115	0.469
Production plans	0.101	0.784	0.116	0.215
Product/design	0.034	0.904	0.151	-0.004
Development/testing	0.154	0.836	0.198	0.098
Supp_ITspecinv_upgrading IT skills	0.889	0.076	-0.006	0.043
Supp_ITspecinv_IT systems	0.902	0.100	0.006	0.120
Supp_ITspecinv_training supplier's personnel for e-coordination	0.800	0.192	0.137	0.184
Supp_ITspecinv_integrate buyer/supplier's IT system	0.791	-0.024	0.110	0.105
Buyer_specinv_adapting internal production system	0.168	0.177	0.876	-0.028
Buyer_specinv_reorg internal routines for supplier collaboration	0.185	0.067	0.873	-0.020
IT would be relatively costly for us to replace this supplier	-0.126	0.198	0.546	0.152

- (Q13_3) the supplier invests substantially in training of their employers (0.79);
- (Q13_6) made extensive investments to integrate their IT systems with our IT systems (0.69).

Chi-square = 1.316; degrees of freedom = 2; probability level = 0.518; CMIN/DF = 0.658; CFI = 1.00; NFI = 0.997; TLI = 1.00; RMSEA = 0.000.

Operational electronic exchange (OPER) aims to describe the information flow on the very first level of the IOS sophistication (Premkumar, 2000). This factor is obtained from a broader construct called "Vertical electronic coordination". Three items have been assigned to this factor (Cronbach's $\alpha = 0.619$)

Other variables, such as *Purchasing relative turnover* (purchasing importance (RELPUR)), *Length of IT cooperation with the supplier* (LNITCOOP), and *Buyer's industry type*, are included in the model as control variables and are not subject to reliability tests.

The factor analysis was used to assess the discriminant validity for the 13 items which describe strategic electronic coordination (COORD), buyer dependence (BUYERDEP), operational electronic exchange (OPER), and Supplier IT specific investments (SITINV). The factor analysis with varimax rotation suggested the four factors. The factor loadings are presented in the Tab. 1.

All the loadings of the constructs are above the 0.40 level which is often considered a cut-off point as a rule of thumb (Buvik & Haugland, 2005). Standardised variables were used, namely, strategic electronic coordination (COORD), buyer dependence

(BUYERDEP), operational electronic exchange (OPER), and supplier IT specific investments (SITINV).

3. SPECIFICATION OF THE REGRESSION MODEL "BUYER DEPENDENCY – STRATEGIC ELECTRONIC COORDINATION"

An OLS-regression model in SPSS statistics 22 software was built to test the hypotheses. The suggested model is presented in (1). Here, COORD is strategic electronic coordination, SITINV is supplier specific IOS investments, BUYERDEP corresponds to the buyer dependency, OPER is the operational electronic exchange, RELPUR is the relative purchasing turnover, LNITCOOP corresponds to the length of IT cooperation with the supplier, and BUYIND is the buyer's industry type.

$$\begin{aligned}
 \text{COORD} = & b_0 + b_1 \cdot \text{SITINV} + b_2 \cdot \text{BUYERDEP} \\
 & + b_3 \cdot \text{BUYERDEP} \cdot \text{SITINV} + b_4 \cdot \text{OPER} + b_5 \cdot \text{RELPUR} \quad (1) \\
 & + b_6 \cdot \text{LNITCOOP} + b_7 \cdot \text{BUYIND} + b_8 \cdot \text{SITINV} + \varepsilon
 \end{aligned}$$

H1 was analysed as a partial derivative of the equation (1) based on Schoonhoven (1981). An estimate was made of the effect of the supplier specific IT investments on strategic electronic coordination during an increase in the buyer dependency (BUYERDEP), as shown in equation (2).

Tab. 2. Correlations matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
SITINV X BUYERDEP (1)	Pearson Correlation	1	0.131	-0.025	-0.018	-0.070	-0.098	-0.007	-0.101
	Sig. (1-tailed)		0.079	0.393	0.422	0.227	0.147	0.472	0.137
COORD (2)	Pearson Correlation		1	0.369**	0.159*	-0.051	0.251**	0.356**	0.236**
	Sig. (1-tailed)			0.000	0.043	0.291	0.003	0.000	0.005
BUYERDEP (3)	Pearson Correlation			1	0.052	0.016	0.255**	0.180*	0.192*
	Sig. (1-tailed)				0.290	0.432	0.003	0.025	0.019
BUYIND (4)	Pearson Correlation				1	0.131	0.027	0.150	-0.129
	Sig. (1-tailed)					0.079	0.388	0.053	0.082
RELPUR (5)	Pearson Correlation					1	0.227**	-0.138	-0.022
	Sig. (1-tailed)						0.007	0.069	0.407
LNITCOOP (6)	Pearson Correlation						1	0.157*	0.146
	Sig. (1-tailed)							0.046	0.058
OPER (7)	Pearson Correlation							1	0.367**
	Sig. (1-tailed)								0.000
SITINV (8)	Pearson Correlation								1
	Sig. (1-tailed)								

Note: * correlation is significant at the 0.05 level (1-tailed); ** correlation is significant at the 0.01 level (1-tailed).

$$\frac{\partial COORD}{\partial SITINV} = b_1 + b_3 \cdot BUYERDEP \quad (2)$$

According to H1, an increased level of the buyer’s specific IT investments should contribute to a more extensive strategic electronic collaboration as the level of the buyer’s dependency increases.

H2 was tested as a direct effect of operational electronic exchange on the strategic electronic coordination.

4. RESULTS

The model has been tested for heteroscedasticity. No heteroscedasticity has been found ($F = 0.975$; $p = 0.453$).

The correlation matrix and the descriptive statistics are presented in Tab. 2 and 3, respectively.

The model demonstrates the acceptable goodness of the fit $R^2_{Adj} = 0.243$ ($F = 6.306$; $df = 7$; $p < 0.01$). Since the main hypothesis H1 is to test the interaction effect, there is a need to test whether the interaction adds the explanatory power to the regression model (Akien & West, 1991). Hierarchical multiple regression was used to estimate the statistical significance of

Tab. 3. Descriptive statistics

	MEAN	STD. DEVIATION	N
COORD	3.0150	1.54354	118
SITINV X BUYERDEP	0.3159	1.65405	118
BUYERDEP	2.8503	1.27497	118
BUYIND	0.4200	0.49600	118
RELPUR	8.3287	13.80267	118
LNITCOOP	1.2588	0.73352	117
OPER	4.4266	1.45779	118
SITINV	2.9776	1.30576	118

the interaction effect. The results show that the R2 change is 0.027 ($F = 4.135$; $df = 1$; $p < 0.05$) which means that the interaction term is significant in the model.

The results of the regression analysis presented in Tab. 4 demonstrate the support of the hypothesis H1. The impact of the interaction effect between the supplier IT specific investments and the buyer dependency on strategic electronic collaboration is positive and significant ($b_3 = 0.157$; $t = 2.033$; $p < 0.05$), refer to Fig. 1.

Fig. 1 illustrates that the supplier’s specific investments are well protected against the buyer’s oppor-

Tab. 4. Regression analysis

MODEL	UNSTANDARDISED COEFFICIENTS		STANDARDISED COEFFICIENTS	T	SIG.
	B	STD. ERROR	BETA		
(Constant)	-0.493	0.282		-1.745	0.084
Supplier IT investments (SITINV)	$b_1 = 0.143$	0.108	0.120	1.324	0.188
Buyer dependency (BUYERDEP)	$b_2 = 0.316$	0.105	0.259	3.021	0.003
SITINV × BUYERDEP	$b_3 = 0.157$	0.077	0.166	2.033	0.044
Operational electronic exchange (OPER)	$b_4 = 0.224$	0.097	0.211	2.306	0.023
Purchasing relative turnover (RELPUR)	$b_5 = -0.008$	0.010	-0.070	-0.818	0.415
Length of IT cooperation (LNITCOOP)	$b_6 = 0.345$	0.185	0.163	1.862	0.065

Note: dependent variable: Strategic electronic coordination (COORD); n=118.

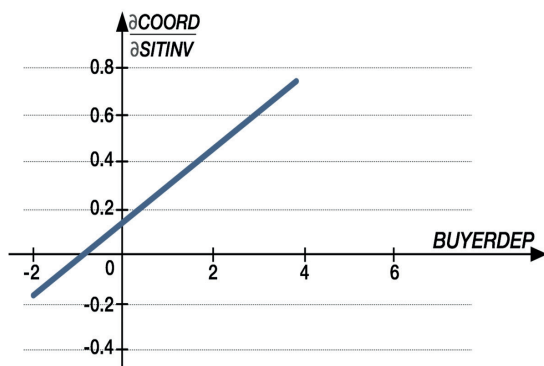


Fig. 1. Association between the supplier specific IT investments and the strategic electronic coordination for different buyer dependency levels

Source: results received by the author from the model run.

tunistic behaviour at the level of buyer's dependency greater than -0.91 (the mean centred value). Given that the mean value of the buyer dependency is 2.85 (Tab. 3), it can be concluded that in approximately 84% of cases (-0.91 is close to one standard deviation which corresponds to 34% confidence interval to the left from the Oy axis) strategic electronic coordination is strongly enforced by the buyer dependency's value of 1.94 on a seven-point Likert scale ($1.94 = 2.85 - 0.91$). This result is interesting. The minor change in the level of the buyer dependency from 1 (i.e. the buyer being very powerful) to ≈ 2 (i.e., the buyer is still powerful, but the magnitude of the buyer's power is slightly less) changes the value of the strategic electronic collaboration from negative (i.e. lower than the mean value) to positive (i.e. above the mean value).

The main effect of the independent variables which constitute to the interaction effect is statistically significant only for BUYERDEP ($b_2 = 0.316$; $t =$

3.021 ; $p < 0.05$). The effect of SITINV is positive but not significant. It may indicate that the IT investments per sé are beneficial only if they are coupled with other factors, such as, for example, trust (Ibbott & O'Keefe, 2004), IT infrastructure (Premkumar & Ramamurthy, 1995), power-dependency issues (Allen et al., 2000), and shared vision of the IOS goals between the firms (Poon & Wagner, 2001).

As suggested by H2, the relation between the electronic exchange of operational information and the strategic electronic coordination is both positive and statistically significant ($b_4 = 0.224$; $t = 2.306$; $p < 0.05$). This result indicates that the success of strategic information exchange between the firms depends on the success of the initial stage of the IOS deployment when the two companies start to exchange with the simplest transactional type of information.

As for effects of the control variables on COORD, not all of them demonstrated expected results. Only the LNITCOOP had a significant positive relation to COORD ($b_6 = 0.345$; $t = 1.862$; $p < 0.1$). The effect of the variable RELPUR on COORD was close to zero and insignificant ($b_5 = -0.008$; $t = -0.818$; $p = 0.415$). The dummy variable BUYIND had a positive effect on COORD but was insignificant ($b_7 = 0.419$; $t = 2.306$; $p = 0.115$). The next section of this paper elaborates on the possible reasons for the statistical insignificance of these two control variables in the regression model.

CONCLUSIONS

The results of the research presented in this paper contribute to one of the main domains in the supply

chain literature, namely the coordination literature. Also, an important role of structural dependencies in the information sharing within buyer–supplier dyads is highlighted for the decision-making units. These two aspects are discussed in the following two subsections concluding this paper.

The empirical analysis aims to explain the mechanism of electronic information exchange of the strategic business information in the buyer–supplier dyad.

The research shows that SITINV by itself does not enhance the strategic electronic coordination (COORD). This result supports the IOS literature stream claiming that IOSs may only have a neutral impact on firms' goals and objectives unless other specific characteristics of transactions are considered (Grover & Ramanlal, 1999). This result also indirectly reveals close agreement with the TCE assumption that unilaterally made specific investments may increase the risk of opportunism and the dependency on the non-investing party. In such conditions, the companies' willingness to create long-term connections with others reduces significantly (Heide, 1994).

However, the effect of SITINV on COORD becomes significant and positive when the buyer dependency (BUYERDEP) increases. It can be observed that BUYERDEP relaxes the problem of opportunistic behaviour caused by SITINV and forces both parties to share the sensitive strategic business information. Our results support the theoretical predictions that mutual dependency improves the coordination between the firms (Vijayasathy, 2010; Kembro et al., 2014). In our example, bilateral dependency is created by the supplier's specific IT investments on the one side and the buyer's dependency on the other.

The statistical results of testing H1 demonstrate that when the level of BUYERDEP is higher than 1 on a seven-point Likert scale, COORD takes the values which are above the mean (Fig. 1). It can, therefore, be concluded that regardless of the BUYERDEP level (low or high) it has a strong impact on the companies' decision to share the strategic information via an IOS.

It has also been observed that the direct effect of BUYERDEP on COORD is positive and significant. This finding evidently supports the idea of the dependency created by the adjustment of a company's business routines to its partner's business processes. This is the situation when the dependency is set up by a non-monetary type of switching costs like routines and procedures (Dick & Basu, 1994; Heide

& Weiss, 1995). When the dependency is high, a buyer has a strong incentive to share the strategic information with a dominant supplier.

It should be admitted that the scope of theoretical implications in our findings is restricted to a specific type of coordination (induced and conducted via an IOS) and a specific kind of dependency. The latter, however, represents the synthesis of the two types of the dependency: the technical adaptations and the structural dependency (Heide & John, 1992). It has also been noted that the technical component is incorporated in the variables which constitute the interaction effect ($SITINV \times BUYERDEP$) and in the dependent variable COORD. It is reasonable to assume that the other types of dependencies, the specific investments or coordination mechanisms might create cause–effect relationships that may differ from the ones suggested in our model.

Our study also attempts to look somewhat deeper into the nature of the inter-organisational information exchange and test for the existence of the cause–effect relationships between some of its levels. The IOS literature proposes that the higher is the IOS development level, the more benefits the IOS users reap. However, the literature is not clear on whether the companies can reach the highest level of the IOS development which corresponds to the strategic coordination without having a well-established and functioning information exchange on its lowest level. Our research finds a positive association between low and high levels of information exchange via an IOS. This association can be explained by the technical factor and the features of the inter-firm coordination.

From the technical standpoint, less technical failures should be expected in the IOS functioning at the stage of strategic information exchange if the IOS has been previously tested and used at the stage of operational information exchange. Also, if the operational collaboration via the IOS precedes the strategic one, less personnel training should be expected for the staff to be able to work with the IOS. Thus, the risk of human factor mistakes may also be mitigated.

The connection between the operational and strategic levels of information exchange can reflect a situation when the operational information exchange represents a background for collaboration over the strategic issues. For instance, two stages of interaction between the firms can be specified in a collaborative product development process which refers to the strategic level of collaboration. At the first stage, the companies exchange their design ideas about the new product, use visualisation and

simulation tools within an IOS. The verification and testing of the new product are done on the following stage when ideas get materialised, and the physical transfer of the new product (its components or materials) between firms becomes required. The implementation of this stage is closely related to such routine business operations as invoicing, ordering, and payments. It is reasonable to assume that these operations are performed in the most efficient way when they are conducted via an IOS, thus, positively contributing to the collaborative product development process.

A few words of comment are necessary concerning the control variables: the relative purchasing turnover (RELPUR), the length of IT cooperation (LNITCOOP), and the buyer's industry type (BUYIND). Remarkably, these control variables which are not directly related to the use of IOS, demonstrated no significant correlation with COORD while the effect of the IOS-related variable LNITCOOP on COORD turned out to be as expected.

The non-significance of BUYIND variable is attributed to the statistical properties of our study sample. The observed buyer–seller dyads demonstrate a high level of operational electronic exchange (i.e. mean value of 4.4, mode value of 5 on a seven-point Likert scale) and low level of strategic electronic collaboration (mean value of 3, mode value of 1 on a seven-point Likert scale). Based on the mentioned concept of the IOS development and the mean values of OPER and COORD, it can be concluded that most dyads in the industrial sector are located at the initial stage of the IOS development. A larger number of dyads in the manufacturing industry which employ the IOS both for the operational and the strategic purposes could have altered statistical results of testing the BUYIND control variable.

Statistical non-significance of the relative purchasing turnover (RELPUR) variable can be explained by an ambivalent impact of this variable on COORD, i.e. it depends on the level of BUYERDEP. For example, increasing the level of RELPUR may shift power-dependency balance towards the buyer. If the high level of RELPUR is combined with the low level of BUYERDEP, it creates a strong incentive for the buyer's opportunistic behaviour and can hamper COORD. On the contrary, a mutual dependency that favours the strategic information exchange can be set up if the high level of RELPUR is coupled with the high level of BUYERDEP.

From a managerial standpoint, the results underline the importance of understanding the role of

the structural dependencies in strategic information sharing in a supply chain. Sharing the sensitive strategic data (such as forecasts and product design) can be considered by various companies as a threat if they expect an opportunistic behaviour from other actors. On the other hand, if long-term buyer–supplier relationships are preferred to the arms-length ones, an extensive information exchange becomes a prerequisite to successful cooperation. So, practitioners may want to know which partners pose the most and least risk in sharing the strategic information. In our study, suppliers who invested heavily in the IOS are at risk. Furthermore, if the buyers are powerful, they represent an additional threat to the suppliers. These two factors, when coupled together, can easily block the suppliers' managerial decision to share certain sensitive strategic information with the buyers. One solution could be to search for less powerful buyers, although it might be difficult to do. Also, the suppliers can use different marketing tools to increase the buyer dependency and therefore to mitigate the risk of opportunism from the buyer side.

Another strategy could be to establish an extensive exchange of strategic information with those buyers, with whom the company has been long cooperating via the IOS. In this case, the practitioners may expect more trusting relationships between the partners who cooperate with via IOSs for many years. That may have a positive effect on the strategic information sharing (Yigitbasioglu, 2010).

The presented results also highlight the importance of the B2B market research conducted by specialists of a marketing department. Market indicators that can directly or indirectly describe the power-dependency structures as, for example, the market share Herfindahl-Hirschman Index, should be monitored on a regular basis.

The presented study has certain limitations. First, the developed model is based on the two theories while there are at least seven other theories which attempt to find the pre-requisites and drivers for information sharing in the supply chains (Kembro et al., 2014). Second, the level of the supplier's IT-specific investments from the buyer's perspective was estimated. Another result could have been obtained if the suppliers made their own evaluation of the IT-specific investments. And third, R-square of our model is relatively low which means that more antecedents of COORD may have been included into our model to increase its explanatory power. In turn, the bigger sample size is required to test the model with a bigger number of COORD antecedents.

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CLOUD MANUFACTURING: A SERVICE-ORIENTED MANUFACTURING PARADIGM. A REVIEW PAPER

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ABSTRACT

This paper introduces cloud manufacturing (CMfg) as a new manufacturing paradigm that joins the emerging technologies – such as the Internet of Things, cloud computing, and service-oriented technologies – for solving complex problems in manufacturing applications and performing large-scale collaborative manufacturing. Using scientific publications indexed in Scopus database during the period 2012–2017, the concept and fundamentals of CMfg are presented and discussed given the results of the most recent research. While focusing on the current state of the art, the recent research trends within CMfg concept were also identified. The review involved the methods of bibliometric analysis and network analysis. A prototype of CMfg and the existing related work conducted by various researchers are presented, and the map of co-occurrence is introduced to indicate the most commonly occurring issues related to the “cloud manufacturing” term. The VOSviewer software was used for this purpose. Finally, cloud-based manufacturing areas for further research are identified.

KEY WORDS

cloud manufacturing, concept, co-occurrence, service-oriented, manufacturing resources, paradigm

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INTRODUCTION

As the global competition in the manufacturing sector is constantly rising and at the same time the exploitation of Big Data can dramatically increase the manufacturing efficiency, a completely new manufacturing paradigm, namely, cloud manufacturing, which received much interest from researchers, is gaining a growing attention in the industry sector

(Mourtzis & Vlachou, 2016). The present paradigm assumes that the modern manufacturing industry is currently being transformed into global manufacturing networks and supply chains allowing the common use of globally distributed manufacturing systems and resources. The cloud manufacturing concept is considered as one of the main directions in the development of the manufacturing industry (Yuan et al.,

2017). Among other researchers, Zhang studied three core components for constructing a CMfg system, namely, CMfg resources, the manufacturing cloud service, and the manufacturing cloud. They also investigated the constructing method for the manufacturing cloud (Zhang et al., 2014).

Cloud manufacturing is an emerging paradigm in which dynamically scalable and virtualised manufacturing resources, abilities and capabilities involved in the whole lifecycle are provided to the users in the form of services over the Internet in a pay-as-you-go manner. Based on novel technologies like SOA (service-oriented architecture) and cloud computing, cloud manufacturing is a solution where users can request services ranging from product design, manufacturing, testing, management and all other stages of a product lifecycle (Talhi, 2015). The emergence of cloud computing initiated a new paradigm of servitisation, assuming the change of a physical product (software or hardware) into a service. Cloud manufacturing, as a model integrating innovative technologies (the Internet of Things, cloud computing, service-oriented technologies, virtualisation, semantic web, advanced high-performance computing technologies) with advanced manufacturing, enables and supports cooperation, sharing and management of manufacturing resources. These resources and know-hows – e.g. software tools, knowledge, applications, equipment, fabrication – capabilities, etc. – of manufacturing companies can be inserted into the cloud and thereby become accessible to presumptive consumers (Adamson et al., 2017).

This paper is organised as follows: Section 1 determines the methodology involved in the research process, including bibliometric analysis and the use of the VOSviewer software. It also proves that the cloud manufacturing concept has been gaining growing attention among the academia and the industry. Section 2 provides a brief discussion of cloud manufacturing paradigm and presents definitions of this concept selected from the literature. Sections 3 and 4 pose the analytical part of the paper. Section 3 presents the results of the conducted review, mainly including the identification of the top authors researching the cloud manufacturing concept as well as their affiliated universities or research centres. This part of paper also indicates the most popular journals chosen by the authors. All those results reflect increasing attention among researchers in Europe and all over the world. Section 4 introduces the network of co-occurrence with research areas related to the scope of cloud manufacturing. On this basis, it

was possible to identify the sub-areas of research in the field of cloud manufacturing as well as the strength of connections, relations and the co-occurrence between them. Section 5 introduces service-oriented future directions of research, related to cloud manufacturing concept. Conclusions are given in Section 6.

1. METHODOLOGY

To analyse the current interest of researchers in the field of cloud manufacturing, the authors explored publications collected in three leading scientific databases: Web of Science (WoS Core collection), IEEE Xplore Digital Library, and Scopus. As the term “cloud manufacturing” appeared for the first time in the scientific literature in 2010, the bibliometric analysis was conducted based on data accordingly from 2010 to 2017. Fig. 1 presents the number of publications indexed in the databases in the specified period. The figure indicates the growing popularity of cloud manufacturing research.

In the analysed period, the number of publications indexed in the IEEE database was 110, whereas Web of Science had 458 and Scopus – 811. It can be observed that the interest of scientists in this research area increased rapidly in 2012 and augmented considerably in the past few years. It is worth indicating that the number of papers referring to the cloud manufacturing concept, found in Scopus, was much higher than in WoS and IEEE databases. This identified the trend of the researcher interest and was the premise for the authors to analyse further the publications indexed in the Scopus database released in 2012–2017. 766 matches have been found as the result of exploring the Scopus database, using “cloud manufacturing” as a search phrase in titles, abstracts and keywords, and limiting the publishing period to 2012–2017. In the opinion of the authors, the total number of publications in this field indexed in all explored databases is still low, despite the ever-growing importance of key and innovative technologies within the Industry 4.0. The academia and the industrial sector all over the world consider cloud manufacturing as an emerging and promising paradigm as well as a business model, enabling the transformation of the manufacturing industry towards the digital and smart industrial revolution. This means there should be more scientific considerations on cloud manufacturing concepts.

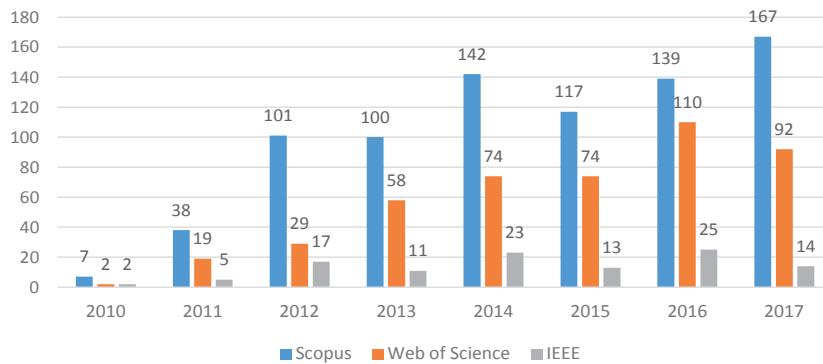


Fig. 1. Number of publications indexed in 2010–2017 in WoS, Scopus and IEEE databases referring to the cloud manufacturing concept

Source: elaborated by the authors based on (<http://bazy.pb.edu.pl>).

The next step of the research process was to export the received set of selected publications to *.csv file and implement those data in the VOSviewer environment. VOSviewer is a software tool for map creation based on network data helping to visualise and explore these networks. Constructed maps may include networks of scientific publications, journals, researchers and affiliations, countries, keywords or terms. Items can be related by co-authorship, co-occurrence, citations (as well as co-citations) and bibliographic links. The VOSviewer software helps to construct and visualise a map of important terms as well as the connections between the elements extracted from the body of scientific publications indexed in Web of Science and Scopus database. The authors examined Scopus database as the most substantial resource to prepare a bibliometric map and visualise the co-occurrence of areas connected with cloud manufacturing. This issue is scrutinised and discussed in detail in Section 4.

2. CLOUD MANUFACTURING: THE CONCEPT SYSTEM AND ASSUMPTIONS

Research on cloud manufacturing mainly revolves around the CMfg concept itself and the architecture and function implementations of cloud manufacturing platforms (Liu et al., 2016). No single commonly accepted and cited definition of cloud manufacturing has been proposed so far in the scientific discourse; however, the researchers elaborated on a comprehensive prospect of what cloud manufac-

turing would comprehend and facilitate (Adamson et al., 2017). The literature review allowed to identify several, frequently cited definitions. The first pioneering attempt to explain and characterise this concept was made by Li (Li, 2010), and since then, this concept attracted much attention. Tab. 1 contains few cloud manufacturing definitions chosen by the authors subjectively as a result of a comprehensive scientific literature overview.

It is worth emphasising that most of the researchers determine cloud manufacturing as an emerging, and thereby up-to-date and open concept of virtualising the distributed manufacturing and assembling resources to provide a coherent, uninterrupted and high-quality transaction of the manufacturing process. Cloud computing emerges as one of the major enablers for the manufacturing industry as it can transform the business model and create intelligent networks that encourage effective collaboration within factors (Xu, 2011). The concept of cloud manufacturing is built on cloud computing, the Internet of Things, cyber-physical systems, the networked manufacturing, service-oriented manufacturing, virtual manufacturing and the virtual enterprise (Ren et al., 2015).

Three categories of key stakeholders were identified: providers, operators, and consumers. Providers publish their resources to the cloud manufacturing platform (the published resources are then encapsulated into the service platform), operators manage all aspects of the platform that are relevant to the platform running and operation, and consumers request services from the cloud platform. Typically, a cloud manufacturing platform consists of five layers, namely, resource layer, virtual resource layer, global

Tab. 1. Selected definitions of the cloud manufacturing concept

AUTHOR(S)	DEFINITION
Li et al., 2010	New networked manufacturing paradigm that organizes manufacturing resources over networks (manufacturing clouds) according to consumers' needs and requirements to provide a variety of on-demand manufacturing services via networks (e.g., Internet) and cloud manufacturing service platforms
Wu & Yang, 2010	An integrated supporting environment both for the share and integration of resources in enterprise. It provides virtual manufacturing resources pools, which shields the heterogeneousness and the regional distribution of resources by the way of virtualization. Cloud manufacturing provides a cooperative work environment for manufacturing enterprises and individuals and enables the cooperation of enterprise
Tao et al., 2011	A new service-oriented manufacturing model, which integrates different technologies, such as networked manufacturing, cloud computing, Internet of Things (IoT), virtualisation and service-oriented technologies to support collaboration, sharing and management of manufacturing resources
Xu, 2012	A model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable manufacturing resources (e.g. manufacturing equipment, manufacturing capabilities and manufacturing software tools) that can be rapidly provided and released with minimal management effort or service provider interaction
Macia-Perez et al., 2012	A new model of manufacturing services, infrastructure and technology that allows users access to a catalogue of standardized services and meet the needs of your business, in a flexible and adaptive form, in case of unforeseen demand or peak workloads, paying only for consumption made
Wang et al., 2014	An integrated cyber-physical system that can provide on-demand manufacturing services, digitally and physically, at the best utilisation of manufacturing resources
Adamson et al., 2017	A network manufacturing model in which locally and globally distributed manufacturing resources for the complete product life-cycle are made available by providers for satisfying consumer demands, and re centrally organised and controlled as manufacturing Cloud services. The model supports unified interaction between service providers and consumers, for trading and usage of configurable resources/services, as well as dynamic and flexible cooperation and collaboration in multi-partner manufacturing missions. Distinct characteristics for the use are that they are scalable, sold on demand, and fully managed by the provider

Source: elaborated by the authors based on the conducted literature review.

service layer, application layer and user interface layer (Xu, 2012).

Most researchers consider the cloud manufacturing concept as an extension of the cloud computing idea to manufacturing, wherein capabilities and resources are componentised, integrated, optimised and provisioned globally. All of them stress the significant role of innovative technologies, such as the Internet of Things, cloud computing, service-oriented technologies, virtualisation, the semantic web, and the need of integrating them with the advanced manufacturing. In this context, cloud manufacturing should be considered as a modern business model enabling the virtualisation of manufacturing resources, sharing and offering them as cloud-based services over the Internet. Consequently, the industry sector is dealing with the transformation from traditional, production-oriented towards integrated and service-oriented manufacturing.

Although the literature suggests different cloud manufacturing definitions and focuses on unique aspects of this concept, it considers similar components, such as the networked manufacturing, resource sharing, service-oriented technologies, virtualisation, collaboration, cloud computing, and everything-as-a-service (IaaS, Paas, Saas, Haas).

Liu et al. (2016) discussed and compared the concepts of the Industry 4.0 and cloud manufacturing based on their basic ideas and research statuses. They concluded that from the perspective of the concept system, the Industry 4.0 is a broader concept than cloud manufacturing because it encompasses both intra-factory and inter-factory integration, whereas cloud manufacturing concentrates on the latter.

3. CURRENT RESEARCH WITHIN CLOUD MANUFACTURING

As shown in Fig. 1, cloud manufacturing paradigm has been growing in popularity among researchers over the past few years. It is significant that the researchers dealing with the issue of cloud manufacturing affiliate mainly with Chinese universities and units. Tab. 2 presents the top 14 global scientists in the field of cloud manufacturing as well as the number of their publications indexed in the Scopus database in 2012–2017. Among all the authors, the following should be undoubtedly distinguished: Zhang, Tao and Ren from Beihang University in China, Wang from the Royal Institute of Technology (Sweden) and Xu from the University of Auckland (New Zealand). It should be emphasised that the majority of all 766 examined publications were affiliated with Chinese universities and units (510), whereas 60 papers were written by authors from the United States, 47 from Sweden, 46 from the United Kingdom, and 43 from New Zealand. A much smaller number of the publication was published by researchers from Germany (19), Taiwan (18), Canada (15),

Tab. 2. Top authors of scientific publications on the topic of cloud manufacturing in 2012–2017

AUTHOR	AFFILIATION	NUMBER OF PUBLICATIONS
Zhang L.	Beihang University (China)	61
Tao F.	Beihang University (China)	44
Wang L.	The Royal Institute of Technology (Sweden)	35
Xu X.	University of Auckland (New Zealand)	30
Ren L.	Beihang University (China)	26
Xu W.	Ministry of Education (China)	19
Wang X. V.	The Royal Institute of Technology (Sweden)	18
Liu Y.	Beihang University (China)	17
Liu Q.	Wuhan University of Technology (China)	16
Yin C.	Chongqing University (China)	16
Zhou Z.	Wuhan University of Technology (China)	16
Kang L.	Chongqing University (China)	14
Yao X.	South China University of Technology (China)	14
Yang C.	Western University (Canada)	13

Source: elaborated by the authors based on the Scopus database.

Finland (11), Greece (11), Iran (10), and Hong Kong (8).

Tab. 3 presents selected authors representing European universities and research centres. Most of them affiliate with Swedish units (the Royal Institute of Technology and University of Skövde) as well as the University of Vaasa in Finland, and the University of Bath and the University of Birmingham in the United Kingdom. The Scopus database has only five papers authored by Polish researchers and one paper by a Jordanian author with “cloud manufacturing” phrase indicated in titles, abstracts and keywords and published in the years 2012–2017.

Tab. 3. Selected European researchers publishing on the topic of cloud manufacturing

AUTHOR	AFFILIATION	NUMBER OF PUBLICATIONS
Wang L.	The Royal Institute of Technology (Sweden)	35
Wang X. V.	The Royal Institute of Technology (Sweden)	18
Schaefer D.	University of Bath (United Kingdom)	8
Pham D. T.	University of Birmingham (United Kingdom)	9
Adamson G.	University of Skövde (Sweden)	6
Mourtzis D.	University of Patras (Greece)	7
Hao Y.	University of Vaasa (Finland)	5
Helo P.	University of Vaasa (Finland)	5

Source: elaborated by the authors based on the Scopus database.

The paper “From cloud computing to cloud manufacturing” published in 2012 by Xu in the journal titled “Robotics and Computer-Integrated Manufacturing” was the most frequently cited article in the area of cloud manufacturing of all times (Xu, 2012). It was cited by 940 researchers accordingly to Google Scholar database and almost 600 times as per Scopus. Professor Xu from the University of Auckland in New Zealand is globally considered to be one of the pioneers in cloud manufacturing research. The index of citation of this paper, considered as a fundamental one in this field, proves the global trend within this concept. However, most academics and industries focus on implementing the Industry 4.0 technologies, mainly IoT, CPS, and Big Data, rather than cloud manufacturing. In the opinion of the authors, the investigations within this concept emerge as an interesting research gap.

Scientific papers related to the field of cloud manufacturing were published in the analysed period 2012–2017 in various journals indexed in the Scopus database. Tab. 4 presents the most popular journals to which considered papers were submitted. Among all studied publications, the largest number was published in the following journals: Computer Integrated Manufacturing Systems (103), International Manufacturing Science and Engineering (58) and International Journal of Advanced Manufacturing Technology (45). The following journals also attracted great interest among researchers: Applied Mechanics and Materials, Procedia CIRP and Advanced Materials Research.

Among all 766 investigated publications referring to the cloud manufacturing concept, two main research areas of publication qualification were easy to identify, namely, engineering (581 papers) and computer science (451). The publications were also assigned to the areas of mathematics (107), decision science (69) as well as business, management and accounting (50). Only a few of them were ranked among material science, energy and physics and astronomy.

In their papers, a vast majority of authors mentioned above introduce the platform technologies, ontologies, multi-task scheduling (Liu et al., 2017), programming models, file systems as well as system architectures (layers) for the development of cloud manufacturing platforms (He & Xu, 2015). They also often investigate information and communication models and new business models referring to this concept (Wu et al., 2014). Several examined publications mentioned the issues of manufacturing resources and capabilities. All manufacturing capabilities require support from the related manufacturing resources, including soft resources (software, engineering knowledge, skills, experience, business networks, etc.) and hard resources, for instance, manufacturing equipment, computational resources, monitoring resources, storage, etc. (Wang & Xu, 2013).

Tab. 4. Most popular journals of cloud manufacturing publications indexed in Scopus

TITLE OF THE JOURNAL	NUMBER OF PUBLICATIONS
Computer Integrated Manufacturing Systems CIMS	103
International Manufacturing Science and Engineering	58
International Journal of Advanced Manufacturing Technology	45
Applies Mechanics and Materials	34
Procedia CIRP	28
Advanced Materials Research	23
IFIP Advances in Information and Communication Technology	20
International Journal of Computer Integrated Manufacturing	19
Mechanical Engineering	19
Journal of Intelligent Manufacturing	14
Journal of Manufacturing Science and Engineering	14
Lecture Notes in Computer Science	13
Robotics and Computer Integrated Manufacturing	11
Journal of Manufacturing Systems	8
Advances in Transdisciplinary Engineering	8
Communications in Computer and Information Science	8

Source: elaborated by the authors based on the Scopus database.

4. CO-OCCURRENCE OF RELATED AREAS

The crowning step within the conducted bibliometric analysis was to identify the relations among cloud manufacturing research areas as well as the co-occurrence links between this phrase and other connected items as well as to determine co-authorship links between researchers. Fig. 2 presents the map of research sub-areas, and their contents, related to cloud manufacturing, prepared with the use of the VOSviewer software. The network was developed based on keywords indicated by authors of examined publications. Individual items (areas) are represented by their labels and circles. The size of the item is determined by its weight. The higher the weight of each considered item (the higher the frequency of occurrence of the term), the larger the circle of it. Moreover, the most frequently occurring keywords are situated in the central part of the map (Gudanowska, 2017b).

The distance between those areas approximately indicates their relatedness in terms of co-occurrence links. In general, the closer two terms are located to each other, the stronger is their relatedness, measured by co-occurrences. Moreover, the strongest co-

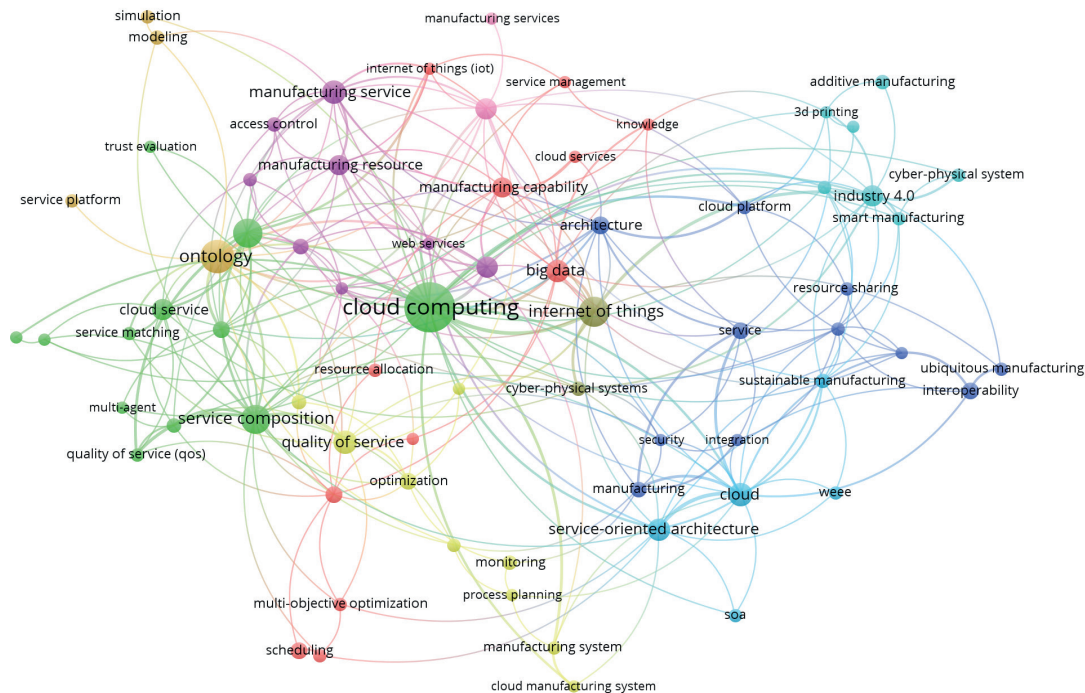


Fig. 2. Map of co-occurrence with research areas related to the scope of cloud manufacturing from the Scopus database in 2012–2017
Source: elaborated by the authors based on (<http://bazy.pb.edu.pl>) with the use of the VOSviewer software.

occurrence links between terms are also represented by lines. Each link has a strength, represented by a positive numerical value. The higher this value, the stronger the link. For the purpose of this paper, the strength of the link indicates the number of publications, in which terms occur together. The horizontal and vertical axes have no special meaning, and the maps can be freely rotated and flipped. Colours indicate clusters of closely related terms (van Eck & Waltman, 2017).

To ensure the map's transparency, the authors have chosen five as the minimum number of keywords considered for the purpose of this analysis (Gudanowska, 2017a). Among all of 1676 keywords indicated by authors of analysed publications, 73 met this threshold. For each of these 73 keywords, the total strength of the co-occurrence links with other keywords was calculated.

Fig. 2 presents the map of co-occurrence representing the items referring to terms found more than five times in all analysed publications. The results should be analysed considering the size of the circles as well as the distance between them. In general, the bigger the circle, the higher is the occurrence of a term (Olszewska, 2016). Analysing Fig. 2, it is noticeable that in the considered papers the most frequently occurring terms are as follow (the largest

circles): cloud computing (84), ontology (38), cloud manufacturing-cmfg (28), Internet of Things (30), service composition (27) and cloud (19). Worth specifying are also other frequently occurring items: manufacturing service (18), quality service (18), big data (16), service-oriented architecture (16), Industry 4.0 (15), cloud service (15), manufacturing resource (14) and manufacturing capability (13). The number of occurrences of each phrase is given above in brackets. Moreover, the thickness of the line connecting the items should also be considered. The more significant is the weight of a co-occurrence, the thicker is the line. The total link strength includes the items as follow: cloud, cloud computing, service-oriented manufacturing, ontology, service composition, resource sharing, service-oriented architecture and the Industry 4.0. It should also be emphasised that the network of co-occurrences consists of many connections, reflecting and confirming numerous coexistences between those keywords.

The construction of the co-occurrence network presented in Fig. 2 allowed concurrently to point out 10 areas (clusters) gathering the terms most frequently appearing together in publications related to the cloud manufacturing concept. Considering scientific interests of the authors and further research areas the selected and most important of them included

the following items: cluster 1 (red): big data, cloud service, genetic algorithm, Internet of Things, knowledge, manufacturing capabilities, multi-objective optimization, particle swarm optimization, product design, resource allocation, scheduling, service management; cluster 2 (green): cloud computing, cloud manufacturing (cmfg), cloud manufacturing platform, cloud manufacturing service, cloud service, optimal selection, multi-agent, quality of service (qos), semantic web, service composition, service matching, trust evaluation; cluster 3 (dark blue): architecture, cloud platform, integration, interoperability, interoperable manufacturing, resource sharing, ubiquitous manufacturing; manufacturing system, manufacturing resource, manufacturing, security, service; cluster 4 (yellow): cloud manufacturing system, knowledge management, manufacturing resource, manufacturing system, monitoring, optimization, process planning, quality of service, service selection; cluster 5 (pink): access control, cloud manufacturing service, manufacturing cloud, manufacturing cloud service, manufacturing resource, manufacturing service, virtualisation, web services; cluster 6 (cyan): 3D printing, additive manufacturing, collaborative manufacturing, distributed manufacturing, smart manufacturing, cyber-physical system, industry 4.0, cluster 7: cloud, SOA, service-oriented architecture, sustainable manufacturing, weee; cluster 8: modelling, ontology, service platform, simulation.

5. FUTURE RESEARCH TRENDS

The cloud manufacturing concept focuses on the configuration and modelling of manufacturing services. The authors identified key service-oriented technologies, enabling cloud manufacturing: service-oriented architecture (SOA), web service, enterprise service bus, semantic web, ontology (He & Xu, 2015). Considering and acknowledging the service-oriented character of CMfg, the authors also explored the current and topical literature to identify up-to-date and promising research areas within cluster #5 mentioned above, referring to services, gathering following items: cloud manufacturing service, manufacturing cloud service, manufacturing service, virtualisation and web services. Among the essential directions of the future research, related to services, the following should be mentioned:

- efficiently and cost-effectively converting manufacturing resources and capabilities into services

and placing them in cloud-based platforms (Zhong et al., 2017);

- the development of effective algorithms of managing resource service transactions (Tao et al., 2012);
- the development of optimisation algorithms and strategies to support comprehensive QoS management to achieve high quality and efficiency (He & Wu, 2015);
- QoS-based service composition selection in a cloud manufacturing system (Zhong et al., 2017);
- the introduction of semantic models for manufacturing resources and capability servitisation and data sharing (Xie et al., 2017);
- the development of the algorithms for data quality management (Song et al., 2017);
- the elaboration of optimisation algorithms for optimal service composition in the cloud environment with the consideration of service correlations (Zhou & Yao, 2017);
- manufacturing services configuration (Zhong et al., 2017);
- robust service compositions that are autonomously reconfigured with minimal human intervention (Wu et al., 2013);
- service encapsulation and virtualisation access models for manufacturing machines, combining the Internet of Things techniques and cloud computing (Zhang et al., 2017);
- protocol, safety and security, reliability, and management techniques of application in CMfg systems (Yuan et al., 2017);
- the development of the trust evaluation models increases the credibility of service transaction trust evaluation in CMfg systems (Yan et al., 2015).

Beside cloud-based manufacturing, the authors also identified the most recent manufacturing concepts that appeared in literature: smart manufacturing, sustainable manufacturing, green manufacturing, social manufacturing, nanomanufacturing, additive +3d printing manufacturing, advanced manufacturing, remanufacturing and cyber-physical systems. These paradigms rely on new technologies that enable flexibility, agility, and reconfigure-ability (Esmaeilian & Behdad, 2016).

The future development of the cloud manufacturing concept will face many challenges in key enabling technologies mentioned above. Besides the integration technologies of cloud computing, IoT, semantic web, high-performance computing and

embedded systems, several important technical issues must also be solved, such as knowledge-based resource clouding, cloud management engines, collaboration between CMfg applications, and visualisation and user interface in cloud environments (Adamson, 2017).

CONCLUSIONS

Major of researchers treat cloud manufacturing as an intelligent and collaborative manufacturing service model. Distributed manufacturing resources (e.g. machine tools, 3D printers, computer-aided design, computer-aided manufacturing, mass storages, software, model repository, databases, etc.) and manufacturing capabilities (e.g. design capability, fabrication capability, assembling capability, simulation capability, testing capability, etc.) are interconnected and constitute a shared pool in cloud manufacturing platform. Through cloud manufacturing, customers have on-demand access to services, such as design as a service (Wu et al., 2012), social networking as a service (Wu et al., 2013), simulation as a service (Ren et al., 2011), production as a service, assembling as a service, test as a service, logistics as a service (Ren et al., 2015).

Based on examined publications indexed in the Scopus database during the period 2012–2017, the authors recognised the current global interest of researchers in cloud manufacturing area. Moreover, the conducted literature review enabled the identification of the top authors, journals as well as universities and research centres in Europe and all over the world leading in disseminating the knowledge and latest achievements in the area of cloud manufacturing. The conducted literature overview also allowed to identify current areas of research in the field of issues referring to the cloud manufacturing concept, including and emphasizing mainly the service-oriented features of the CMfg paradigm. This identification of trends was possible based on the created network of co-occurrence between this term and other related phrases.

The conducted comprehensive literature review allowed to recognise the current state of the art within cloud manufacturing. Cloud manufacturing concept is still a poorly defined field of study and would benefit from detailed research in many areas. The authors of publications referring to the cloud manufacturing concept introduced mainly the platform technologies (Ren et al., 2015; Zhang et al., 2014), ontology (Talhi

et al., 2015), hard and soft manufacturing resources (Yuan et al., 2017), system architectures (layers) for the development of cloud manufacturing platforms. Some of them proposed several new techniques and approaches to encapsulate virtualised manufacturing resources and capabilities as cloud-based services (Ren et al., 2015). They also provide some research trends within cloud manufacturing concept, discuss potential opportunities, barriers and challenges within the discussed paradigm (Wu et al., 2013; Adamson et al., 2017).

Although the cloud manufacturing concept emerges as the consequence and evolution of existing technologies, it is also widely accepted to be the future-oriented, innovative paradigm, which will reform the manufacturing industry. However, the application of cloud manufacturing is still in the initial experimental and testing stage. Many proposed models and algorithms in this area have not been strictly tested in a large-scale cloud manufacturing environment to evaluate their effectiveness, efficiency and feasibility (He & Xu, 2015). The authors of examined publications focus primarily on theory and framework. Thus, it is necessary to provide the characteristics of actual implementations in practice and introduce some successful approaches and implementations in this area.

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QUANTITATIVE ASSESSMENT OF URBAN TRANSPORT DEVELOPMENT – A SPATIAL APPROACH

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ABSTRACT

Urban transport is considered the basis of properly functioning cities and their development. The main aim of the paper is to attempt the assessment of urban transport development in selected voivodeships (provinces) as a crucial factor of macro logistics. The research also aimed to identify the underdeveloped areas of urban transport in Poland as the basis for the implementation of support policy. The source of information in the investigation process was data drawn from the Central Statistical Office in Poland for 2013–2016. In the scope of dealing with the research problem, chosen classical and order multivariate statistical measures were implemented into the research process. Next, the taxonomic measures for the years of interest served as the basis for the construction of the total (general) synthetic measure applicable to the entire period. The main results and findings of the research indicate that the level of urban transport development is correlated with the whole transportation system which affects the socio-economic development of some regions of Poland. The research can lead to a better understanding of Polish urban transportation development in selected regions. Hence, the results can be helpful in the investment process and for shaping the right transportation policy to improve the use of financial resources.

KEY WORDS

cities, urban transport, voivodeships, synthetic measure, variable

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INTRODUCTION

The accession of Poland to the European Union obligated the introduction of required policies to improve the development level of the whole country as well as its regions. Poland is diverse, and this is reflected in the level of socio-economic development of voivodeships. These regions have large disparities among regions. Among others, this situation depends

on the size of a settlement, i.e. an urban area.

Cities generate many positive external effects, e.g. they are considered both the heart of the economy and its driving forces. They are treated as human, economic, technological and cultural centres. As most of the highly remunerated professions concentrate in the largest urban areas (Kozera et al., 2014); this tendency affects the distribution of wealth among

local administrative regions (Madras & Mitura, 2014). Hence, it should be noted that the value of a region value depends on its cities (Cheba & Saniuk, 2015).

On the other hand, transportation systems of urban areas also have negative effects, such as congestion, air pollution, traffic noise, etc. (Gratiela, 2013).

All of the effects are strictly determined by the quantity and quality of delivered public services in the urban areas of voivodeships. Moreover, the potential and the level of the regional development are mainly determined by the existing urban transportation systems, which influence the quality of life.

Urban transport relationships are mutual and very hard to quantify because urban transport can be considered as a complex phenomenon where indirectly observable interactions and relations play a key role.

Therefore, it is necessary to make a reliable diagnosis of the development level of urban infrastructure and its changes as one of the measures of socio-economic development of selected areas in Poland.

The paper aims to assess the state and changes of urban transport development in selected voivodeships as the important factors of the macro logistic system of the country. Also, the article aims to identify the regions underdeveloped in the research field.

The elaboration was based on the literature studies and multidimensional analysis using the chosen taxonomic methods.

1. LITERATURE REVIEW

The literature review showed that transport is considered as the basis of our economy and society. The mobility is very important to the internal market as well as the quality of life of the citizens who can freely travel (European Commission, 2011). Furthermore, it is perceived as a universal and irreplaceable element of both economic and social processes. Therefore, the transportation system is considered as a factor that influences regional development, settlement network, production location, etc. (Liberadzki, 2013). Moreover, transport plays a key role in the strategy development for cross-border regions (Mun & Nakagava, 2010; Lewczuk & Ustinovichius, 2015) and is especially important for cooperation with other countries and regions (Ustinovichius et al., 2017).

All in all, policies ensuring the availability of a properly developed transport infrastructure is one of the basic fields of activity of a state. The mobility of people and things is ensured by infrastructure whose maintenance and modernisation mean incurring high financial costs (Paprocki, 2013).

Nowadays, transport is considered to be one of the corner stones of globalisation (Kumar & Hoffmann, 2002). Globalisation and investment processes of a modern world can and should influence multifaced regional development including the transport industry (Максимцев et al., 2017) where innovative investments play a key role in the economic life. The implementation and development of technical infrastructure is not possible without meaningful investment projects (Бездудная et al., 2016).

Transport accessibility and connectivity are considered an important factor affecting investments in big cities, e.g. Wrocław (Ignacy, 2016). One of the EU documents, namely the Green Paper, states that citizens expect quality, effectiveness and accessibility form the public transport. The public transport, which is considered attractive, is not only accessible but also fast, reliable, comfortable and offers frequent connections (Solecka, 2011). In the case of cities, all of these issues are strictly connected with overcoming barriers that hinder the smooth functioning of traffic, e.g. congestion (Cheba, 2015).

All in all, public transport as an element of the national logistics system can be considered a complex and multidimensional phenomenon. Consequently, in the area of the logistics infrastructure, urban public passenger transport has to achieve aims that contradict one another (Korczak & Kijewska, 2016).

Hence, selecting indicators for the research of the transportation system is considered an extremely difficult issue mainly due to the wide variety of indicators and its multidimensionality (Cheba & Saniuk, 2016; Persia et al., 2016). Nevertheless, it is worth mentioning the descriptors (features) that are commonly used for the construction of spatial models for passenger and freight transport, such as the density of inhabitants, the accessibility and connectivity of the work network, spatial location, distance and different types of routes, the width of streets (Ewing & Cervero, 2001; Stead & Marshial, 2001; Sanchez-Diaz et al., 2014) as well as economic variables, such as population incomes (Ducret et al., 2015). The literature review found the following variables used in urban infrastructure research: the total length of roads to

the city area, the ratio of asphalt roads to the total roads, the ratio of asphalt roads for every 100000 people, the ratio of city roads to the area of the province, the ratio of inter-city roads to the area of the city, and the ratio of main roads to the area of a city. All the features were the basis of the assessment process of regional development of border cities (Fanni et al., 2014).

The research problem can be addressed using two different approaches.

An analysis can be carried out according to separate and single variables. This is a one-dimensional approach. It can be considered defective because of difficulties in a clear assessment of analysed objects.

The use of multivariate tools creates a possibility to support the logistics policy by implementing the ordering and classification procedures for research objects which are described by the set of diagnostic variables (Figura, 2013).

On the one hand, the empirical investigations with taxonomic tool have already been introduced into the analysis of transport development in the European Union countries (Tarka, 2012; Strojny, 2013; Kauf & Tłuczuk, 2014). Some of them dealt with urban transportation system problems in selected European cities (Hajduk, 2016) and were proceeded by literature studies on urban transport (Hajduk, 2017). All in all, the mentioned analysis generally used classical taxonomic tools, e.g. linear ordering which uses the arithmetic mean and standard deviation in its construction.

The further analysis of the condition of transport using the order version of linear ordering tools was carried out among the chosen European Union countries in areas of road, railway and air transport as the three main branches of the transportation system (Czech & Lewczuk, 2017). This taxonomic study was deepened with the implementation of different normalisation methods based on the multidimensional Weber median (Czech et al., 2016). All in all, these analyses allowed making the research immune to the empirical asymmetry of diagnostic variables. Additionally, the implementation of the Weber median allowed considering mutual interactions among diagnostic features, which is very important in the case of a complex phenomenon analysis such as the transportation system.

On the other hand, the literature study proved that taxonomic methods were also introduced into the research of the road and railway transport development in Polish voivodeships (Cheba, 2011; Jarocka & Glińska, 2017). All the investigations were based

mainly on no-pattern classic taxonomic methods which do not consider the interactions in a complex transportation system. Moreover, the research was distorted as the result of skewness of diagnostic features. Hence, to improve the investigation in such an important research field, the Weber median was introduced in the process of the synthetic measure construction (Czech & Lewczuk, 2016). It should be noted that this kind of multivariate median considers interactions. However, the issue of including indirect effects is very important in the case of transportation research in different fields (Hayashi & Morisugi, 2000; Jahanshahi et al., 2015; Matteis et al., 2016; Ward et al., 2016). It should be noted that this research problem is under investigation among experts, and a consensus has not yet been reached (Vörös et al., 2015).

It is worth mentioning that the analysis did neither consider the technological progress in the materials used for the transport infrastructure construction nor its future trends. This issue is crucial because the technological progress that accelerates processes of globalisation is also attributed to the area of transportation (Kherbash & Liviu Mocan, 2015).

Therefore, the transportation system has already been analysed with future-oriented methods, such as foresight (Ejdys et al., 2015). The area of road transportation in combination with environmental protection has been in the spotlight of the interdisciplinary research (Radziszewski et al., 2016). The reason behind such a combination is a significant impact on the quality of life of people inhabiting urban areas as urban infrastructure undergoes the amortisation process much quicker.

To sum up the literature review, it should be noted that there is a lack of multidimensional analysis of urban transport development in Polish cities of some voivodeships, which considers its complex character. However, the existing multidimensional analysis does not include the mutual relations and interactions among particular areas of urban infrastructure, technical resources, etc. Moreover, the research gap is also connected with the construction of the urban transport development model over the entire period. Hence, this kind of taxonomic research could have some positive impact on the correctness of the delivered analysis in the area of the urban transportation system and support of investment decisions as well as the use of tools ensuring greater sustainability of the urban transport (Malasek, 2016). It is also important to form the point of view regarding the trend to decentralise govern-

ment decisions to the local level, properly manage the public urban demand (Puppim de Oliveira et al., 2015) as well as the growing urban populations considering the lack of roads, public transport and non-motorised transport infrastructures (Ahmad & Puppim de Oliveira, 2016).

2. THEORETICAL BASIS FOR THE IMPLEMENTED RESEARCH METHODS AND THE SELECTION OF THE DATA SET AND THE TYPE OF THE TOTAL TAXONOMIC MODEL

The presented research focused on the evaluation of urban transport development based on the construction of the synthetic measure using two basic ways.

The first way implements the classic statistical measures, such as arithmetic mean and standard deviation. This kind of algorithm was first introduced by Polish statistician Hellwig (1968). The synthetic measure is calculated using the following equation:

$$MK_i = 1 - \frac{d_i}{\bar{D} + 2 * S_D} \quad (1)$$

where: \bar{D} — mean of the distance vector,

S_D — the standard deviation of the distance vector.

The second approach to the construction of the synthetic measure includes the multidimensional median vector as well as *mad* (median absolute deviation). It is worth noting that this method was also first implemented by a Polish statistician (Lira et al., 2002).

The normalisation process is usually carried out in the form of standardisation according to the following formula:

$$z_{ij} = \frac{x_{ij} - \theta_j}{1,4826 * mad(X_j)} \quad (2)$$

The elements of θ_j are considered as the values of the multidimensional median vector, which usually takes the form of the border or the Weber median. The values of the Weber median are assessed in the minimisation process of the following objective function:

$$T(\Theta, R^m) = \arg \min_{\Theta \in R^m} \left\{ \sum_{i=1}^n \left[\sum_{j=1}^m (x_{ij} - \theta_j)^2 \right]^{1/2} \right\} \quad (3)$$

Besides immunising the analysis to skewness, this multidimensional median vector considers interactions in the whole set of diagnostic variables, which is especially important from the point of view of the taxonomic analysis of a complex phenomenon, such as the socio-economic development, the living standard, spatial cohesion, etc. More detailed information about its history and the way of estimation has already been presented in the literature (Młodak, 2009). Nevertheless, it should be mentioned that other forms of multidimensional median construction which consider interactions among variables are under investigation (Domański et al., 1998).

In relation to *mad* (median absolute deviation), it should be noted that its particular values are received using the following equation:

$$mad(X_j) = \text{med}_{i=1,2,\dots,n} |x_{ij} - \theta_j| \quad (4)$$

Also, it should be mentioned that there are other normalisation methods in the literature and they were successfully implemented into the research process with classic statistical measures (Jajuga & Walesiak, 2000; Dębkowska & Jarocka, 2013; Olszewska & Gudanowska, 2014) and the multidimensional median vector (Czech, 2014; Czech et al., 2016).

The synthetic measure of the normalised variable is estimated using the following formula:

$$MP_i = 1 - \frac{d_i}{\text{med}(D) + 2,5 \text{mad}(D)} \quad (5)$$

where: *med*(*D*) — the median of the distance vector,
mad(*D*) — the median absolute deviation of the distance vector.

The basis of every proper taxonomic analysis is a set of diagnostic variables. Hence, the data was drawn from the Local Data Bank of the CSO (Central Statistical Office) in Poland for 2013–2016. The set of the following twelve potential diagnostic variables was treated as the research basis: X_1 — the length of bicycle paths in kilometres per 10000 km², X_2 — the length of bicycle paths in kilometres per 10000 citizens, X_3 — the length of bus lanes in kilometres per one million urban citizens, X_4 — the number of public transport passengers per one inhabitant of urban areas, X_5 — the length of the public transport line in kilometres per 10000 urban citizens, X_6 — the length of the public transport line in the countryside in kilometres per 10000 inhabitants of the total population, X_7 — the length of bus routes in kilometre-

Tab. 1. Spatial and time classic variation coefficients of the potential set of diagnostic variables

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}
SPATIAL VARIABILITY												
2013	44.61	41.77	84.48	49.22	41.62	38.56	43.70	3.93	33.80	28.74	33.30	17.03
2014	42.12	40.51	86.42	51.63	41.20	45.26	43.14	5.15	38.22	29.76	34.76	13.88
2015	36.07	36.75	83.60	52.21	39.00	45.49	40.66	4.35	36.82	32.15	35.24	12.96
2016	36.56	36.24	73.11	49.26	37.53	49.02	39.15	4.05	36.29	31.07	35.40	13.51
TIME VARIABILITY												
Dolnośląskie	12.48	12.52	7.59	5.47	7.80	11.89	8.37	5.03	4.89	5.60	2.04	4.41
Kujawsko-Pomorskie	20.59	20.74	56.76	4.88	11.47	68.76	12.58	2.29	7.38	5.77	9.70	10.76
Lubelskie	26.20	26.63	22.64	13.02	4.32	6.95	3.01	3.20	1.81	5.31	6.01	4.14
Lubuskie	11.61	11.78	115.47	7.59	7.71	13.61	7.49	2.78	2.72	2.24	1.67	1.72
łódzkie	12.73	13.20	32.60	15.06	3.90	6.48	3.75	2.72	3.50	3.19	2.35	1.69
Małopolskie	16.47	16.21	5.97	4.02	6.75	8.67	7.00	2.41	2.29	5.25	4.06	8.79
Mazowieckie	18.26	17.89	1.09	4.31	4.51	10.38	4.87	1.56	4.16	4.80	4.50	2.06
Opolskie	9.42	9.89	115.47	6.09	3.65	3.56	3.65	1.29	3.33	3.11	2.28	7.06
Podkarpackie	31.52	31.55	63.74	10.51	9.59	4.14	9.59	3.06	8.01	5.50	3.25	8.70
Podlaskie	31.01	31.26	3.93	4.71	4.64	16.81	4.64	3.08	2.84	1.35	2.82	0.66
Pomorskie	13.92	13.61	46.04	3.22	2.32	6.52	2.66	1.62	1.72	2.92	1.94	0.57
Śląskie	11.91	12.29	9.77	10.61	3.65	3.81	3.86	1.17	1.27	1.81	1.66	10.68
Świętokrzyskie	23.57	24.06	29.89	2.66	4.96	15.03	4.96	0.64	7.89	6.44	2.91	4.12
Warmińsko-Mazurskie	26.17	26.45	37.74	8.76	1.57	2.62	2.07	2.99	4.81	3.07	6.16	11.61
Wielkopolskie	11.47	11.30	17.59	17.59	14.42	25.18	14.97	0.63	5.25	1.82	5.70	4.84
Zachodniopomorskie	13.15	13.42	69.70	0.75	7.52	18.77	7.66	1.58	2.26	1.74	3.60	5.76

tres per 10000 urban citizens, X_8 — buses on the move to their inventoried quantity (in %), X_9 — the mileage of buses in car-kilometres per 1000 urban citizens, X_{10} — the number of buses per 10000 urban citizens, X_{11} — the number of seats in vehicles (buses, trams, trolleybus) per 1000 urban citizens, X_{12} — the share of buses adapted to the needs of disabled passengers in their total number (in %).

All of the analysed variables take the form of intensity or structure indicators. Moreover, it should be noted that the set of diagnostic features includes sixteen objects (voivodeships) as well as four years of the analysis. Thus, a three-dimensional data cube has been created. It should be emphasised that it was impossible to extend the analysis to more periods. However, if more years had been taken into the research, less diagnostic variables would have been included in the constructed synthetic measure of urban transport. It should be noted that obtaining the precision data is especially important in logistic research analysing intermodal transport chains (Caris et al., 2014), modelling the travel demand

generated by people as well as freight (Cools et al., 2010; Roorda et al., 2010).

Next, the potential set of diagnostic variables was put under statistical investigation containing two stages.

The first stage was connected with variation analysis and the choice of the total taxonomic model. Hence, the classical variation coefficient, which is based on the standard deviation and arithmetic mean, was introduced. The results of the research are presented in Tab. 1.

The results of the variation analysis proved that the feature X_8 ought to be removed from the further analysis because the variation coefficients were under the threshold value of ten in every year of the research.

In the scope of the assessment of the urban transport development, over the entire period, the total taxonomic measure should be introduced. Hence, three types of taxonomic models, i.e. spatial-time, time-spatial and aggregate, are presented in the literature regarding the overall level of the complex phenomenon under consideration (Młodak, 2005).

The values of the classic time variation coefficient for every voivodeship over the entire period of analysis are presented in Tab. 1. The investigation proved that the spatial-time taxonomic model should be implemented into the analysis. This situation occurs because the predominance of spatial variation is predominant compared to time variation.

The second stage of the statistical analysis of the potential data set of diagnostic variables is connected with the correlation analysis. In the scope of dealing with that issue, the method of an inverted matrix of Pearson's correlation coefficients was introduced into the research (Malina & Zeliaś, 1997; Panek & Zwierzchowski, 2013). The chosen results of the research, i.e. the main diagonals of inverted Pearson correlation matrixes are, presented in Tab. 2.

Moving to the interpretation of the results which are presented in Tab. 2, it should be mentioned that particular variables were eliminated individually. This procedure of the analysis with the inverted correlation matrix is considered appropriate and has already been discussed at the international conference and implemented into the research of living standards (Czech & Słaby, 2017).

In this case, the research was carried out in four stages separately for each year of the analysis. Nevertheless, the results of stage three proved that more than one variable exceeded the critical and contractual value of ten for all periods. Hence, the feature X10 was excluded from further analysis because of the highest values located on the main diagonal in 2016. Next, the variable X_{11} was eliminated from the set of potential diagnostic variables. However, the results obtained during stage four of the correlation analysis showed that further elimination of

diagnostic features could be stopped with a slight deviation from the contractual rule of ten.

To sum up, the final set of diagnostic variables includes the following features: $X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_{12}$, which were considered as the basis for the construction of synthetic measure for the urban transport in further analysis.

3. RESEARCH RESULTS

To bring the final set of diagnostic variables into comparability, the normalisation process was implemented. Furthermore, this transformation was based on both classic as well as order types of standardisation. The first uses the arithmetic mean and standard deviation in its construction, which means the analysis is not immune to the skewness of empirical distributions of particular diagnostic features.

The second approach implements the multidimensional median vector and median absolute deviation as the equivalent of classical measures. The chosen statistical measures of the final set of diagnostic variables which were implemented to the normalisation process are presented in Tab. 3.

It should be mentioned that the order method with the border median was omitted because this kind of multidimensional median is only immune to skewness but does not consider interactions in the set of diagnostic variables, which is very important from the point of view of the research. Hence, the multidimensional Weber median vector was the basis for normalisation in every year of analysis and supports the construction of the model over the entire period.

Tab. 2. Main diagonals of inverted matrixes of Pearson's correlation coefficients

	STAGE I				STAGE II				STAGE III				STAGE IV			
	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016	2013	2014	2015	2016
X_1	4.5	4.0	3.6	5.9	4.3	3.8	3.6	5.9	2.5	3.0	3.4	4.5	2.5	2.4	2.8	3.2
X_2	6.5	5.1	4.2	3.7	3.9	4.0	3.1	3.1	3.6	3.9	3.1	3.0	3.6	3.5	3.0	3.0
X_3	2.5	3.1	4.4	4.9	2.5	3.1	4.3	4.9	2.4	3.1	3.6	2.6	2.4	2.9	3.5	3.4
X_4	6.4	4.5	8.6	8.8	6.2	4.5	6.9	8.8	6.2	4.4	6.5	8.8	3.3	2.3	2.7	2.8
X_5	1064.6	972.1	855.5	546.4	13.3	15.4	14.1	14.8	5.7	11.5	13.5	12.0	5.3	11.3	11.4	9.9
X_6	8.1	10.8	12.9	10.7	5.9	7.3	6.4	7.0	3.5	6.0	6.3	5.9	2.8	6.0	5.5	4.4
X_7	1264.4	1188.7	1130.3	690.0	-	-	-	-	-	-	-	-	-	-	-	-
X_9	21.5	13.3	40.2	47.1	21.5	12.1	29.9	35.4	7.1	7.3	9.3	10.8	4.8	5.7	5.9	6.0
X_{10}	58.0	29.4	39.7	42.2	37.6	19.4	35.6	41.0	-	-	-	-	-	-	-	-
X_{11}	25.4	21.4	34.3	39.1	10.6	10.2	12.1	23.6	9.0	9.0	12.1	23.2	-	-	-	-
X_{12}	3.9	4.4	8.5	4.8	2.9	3.0	4.1	3.8	2.9	2.9	3.8	3.8	2.9	2.9	3.7	3.8

Tab. 3. Chosen statistical measures of the final set of diagnostic variables

YEAR	STATISTICAL MEASURE	VARIABLE							
		X_1	X_2	X_3	X_4	X_5	X_6	X_9	X_{12}
2013	skewness	0.53	0.54	0.35	1.35	1.06	0.15	0.90	-0.44
	arithmetic mean	251.04	2.15	7.40	134.98	22.61	3.19	25.59	75.87
	border median	257.83	1.88	5.48	130.71	19.74	2.95	23.91	75.90
	Weber median	258.42	1.97	6.78	121.43	22.19	3.59	25.67	76.28
2014	skewness	0.52	0.27	0.46	1.23	0.98	0.11	1.20	-0.80
	arithmetic mean	301.90	2.62	7.44	139.92	22.70	3.19	26.16	80.97
	border median	299.16	2.65	5.60	125.26	19.59	3.03	23.62	83.11
	Weber median	294.62	2.55	8.90	125.14	22.16	3.24	25.48	80.16
2015	skewness	0.64	0.06	0.72	1.19	0.71	0.60	1.17	-0.94
	arithmetic mean	348.48	3.07	9.26	137.78	23.19	3.34	27.03	81.68
	border median	325.13	2.93	8.01	138.60	19.40	3.07	25.13	85.16
	Weber median	327.91	2.86	10.00	130.84	23.18	3.51	26.39	80.37
2016	skewness	0.88	0.05	0.26	0.77	0.64	1.37	1.04	-0.87
	arithmetic mean	361.62	3.18	10.53	138.67	23.24	3.47	27.15	83.17
	border median	338.76	3.05	12.95	138.18	20.14	3.24	26.12	86.19
	Weber median	340.44	3.06	11.59	130.47	20.97	3.52	24.65	85.12

Moving into the analysis of the presented order location measures, i.e. the border median as well as its Weber form, it should be mentioned that the values differed depending on features. It is the result of including interactions among the variables which are implemented into the description process of urban transport development, in particular, voivodeships. For instance, the border median size for the variable describing the length of bicycle paths per 10000 square kilometres was 338.76 km in 2016. However, because of the influence of another variable, the value of the Weber median in the case of the same feature went up and reached 340.44 km per 10000 square kilometres. It should be mentioned that the differences in the values of these descriptive statistics occur for each year of the analysis.

The process of a complex phenomenon analysis with the construction of the synthetic measure needs a definition of the character of particular features. Hence, the final set of diagnostic variables was divided into two subsets. The first one includes the following features X_1 , X_2 , X_4 , X_5 , X_9 and X_{12} , which were considered as stimulants. The other consists of the nominants such as X_3 and X_6 . Nevertheless, it should be noted that destimulants were not recognised in the final set of diagnostic features.

Further, implementation normalized values of the final set of diagnostic features allowed the synthetic measures of urban transport development to be

constructed. Their values in classical and order form for particular years of the analysis are presented in Tab. 4 (a, b).

Additionally, the table includes the total measure (general) for the entire period. It was constructed based on synthetic measures for particular years of the analysis in the classic as well as the order form.

Next, they were ordered monotonically and allowed to make a ranking of the urban transport development in voivodeships according to the classical and the order method.

The analysis of the presented rankings proved that positions of some voivodeships were the same. On the other hand, both methods delivered different positions in the ranking for particular years of the analysis.

The values of the synthetic measures can be implemented in the process of indication of similar areas according to the level of urban transport development. In the scope of dealing with that issue, both the three mean and the three median methods can be used (Młodak, 2006). The classical and order examples of this kind of procedure for spatial-time taxonomic models are presented in Fig. 1 as the background of particular voivodeships.

The values of the synthetic measures of urban transport development in its classical and order forms are presented as the height of histograms representing voivodeships for each year of the analysis.

Tab. 4a. The values of synthetic measures and the positions of voivodships in the ranking of urban transport development

VOIVODESHIP	VALUE OF SYNTHETIC MEASURE									
	2013		2014		2015		2016		TOTAL	
	MK	MP	MK	MP	MK	MP	MK	MP	MK	MP
Dolnośląskie	0.27	0.21	0.32	0.23	0.29	0.13	0.26	0.16	0.53	0.25
Kujawsko-Pomorskie	0.25	0.21	0.26	0.19	0.28	0.14	0.35	0.23	0.53	0.28
Lubelskie	0.18	0.12	0.21	0.12	0.20	0.04	0.26	0.16	0.39	0.11
Lubuskie	0.33	0.25	0.28	0.16	0.25	0.06	0.25	0.09	0.51	0.15
łódzkie	0.30	0.24	0.27	0.20	0.27	0.15	0.27	0.19	0.51	0.28
Małopolskie	0.25	0.24	0.24	0.21	0.21	0.11	0.20	0.14	0.42	0.23
Mazowieckie	0.52	0.54	0.51	0.50	0.53	0.52	0.59	0.61	1.00	1.00
Opolskie	0.05	-0.02	0.04	-0.06	0.02	-0.16	0.01	-0.13	0.05	-0.31
Podkarpackie	0.10	0.03	0.05	-0.03	0.11	-0.06	0.12	0.01	0.17	-0.13
Podlaskie	0.16	0.13	0.18	0.11	0.26	0.13	0.27	0.18	0.40	0.18
Pomorskie	0.48	0.45	0.51	0.43	0.47	0.34	0.50	0.37	0.91	0.68
Śląskie	0.36	0.34	0.33	0.29	0.36	0.26	0.41	0.37	0.67	0.53
Świętokrzyskie	0.21	0.19	0.20	0.18	0.16	0.11	0.21	0.25	0.36	0.26
Warmińsko-Mazurskie	0.07	-0.02	0.13	0.02	0.09	-0.10	0.10	-0.06	0.18	-0.19
Wielkopolskie	0.36	0.31	0.42	0.34	0.32	0.14	0.33	0.17	0.66	0.34
Zachodniopomorskie	0.24	0.20	0.26	0.17	0.23	0.08	0.30	0.17	0.47	0.20

Note: MK – classical measure, MP – order measure.

Tab. 4b. The values of synthetic measures and the positions of voivodships in the ranking of urban transport development

VOIVODESHIP	RANK									
	2013		2014		2015		2016		TOTAL	
	MK	MP	MK	MP	MK	MP	MK	MP	MK	MP
Dolnośląskie	7	9	5	5	5	7	10	11	6	8
Kujawsko-Pomorskie	8	8	8	8	6	5	4	5	5	6
Lubelskie	12	13	11	12	12	13	9	10	12	13
Lubuskie	5	5	6	11	9	12	11	13	7	12
łódzkie	6	6	7	7	7	4	7	6	8	5
Małopolskie	9	7	10	6	11	10	13	12	10	9
Mazowieckie	1	1	2	1	1	1	1	1	1	1
Opolskie	16	16	16	16	16	16	16	16	16	16
Podkarpackie	14	14	15	15	14	14	14	14	15	14
Podlaskie	13	12	13	13	8	8	8	7	11	11
Pomorskie	2	2	1	2	2	2	2	2	2	2
Śląskie	3	3	4	4	3	3	3	3	3	3
Świętokrzyskie	11	11	12	9	13	9	12	4	13	7
Warmińsko-Mazurskie	15	15	14	14	15	15	15	15	14	15
Wielkopolskie	4	4	3	3	4	6	5	9	4	4
Zachodniopomorskie	10	10	9	10	10	11	6	8	9	10

Note: MK – classical measure, MP – order measure.

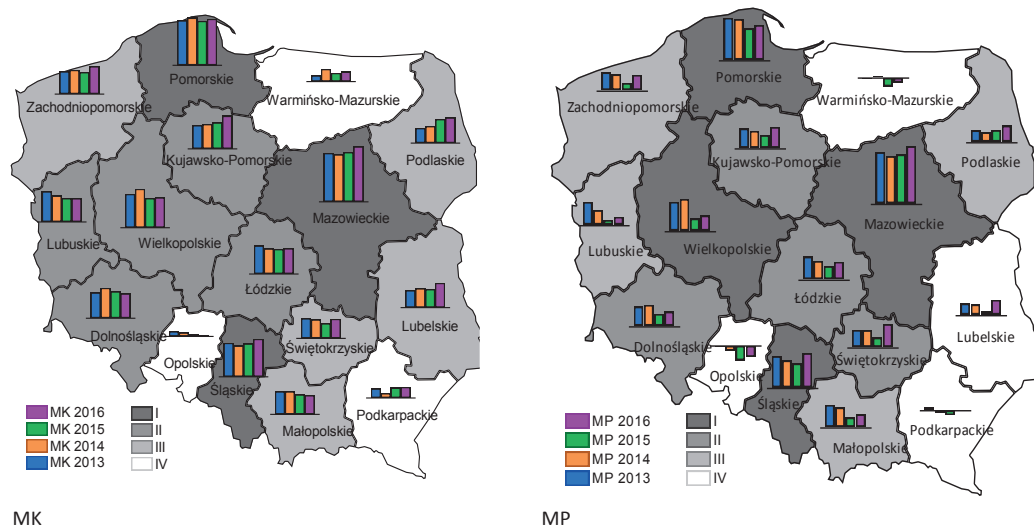


Fig. 1. Diversification of urban transport development in Poland in 2013–2016

Note: the background of voivodeships – the spatial-time model (the total measure), the height of the histogram – the values of synthetic measures in particular years of the analysis, *MK* – the classical measure, *MP* – the order measure.

All in all, the graphical presentation of the research shows that the general (total) classification of provinces to particular groups of urban transport development differs because of the included interactions among diagnostic features.

4. DISCUSSION OF THE RESULTS

The research with the use of the synthetic measure of the urban transport development in selected Polish provinces has brought up some interesting findings in two main areas, namely, logistics and statistics.

The first area includes comments regarding the spatial objects, i.e. voivodeships which were included in the research. It should be noted that the quantitative assessment of the urban transport development in selected voivodeships is somewhat a complex task. The research targeted the period 2013–2016 and proved the disparity among development levels of the urban transport development in all sixteen provinces.

Both the classical as well as the order synthetic measures can be considered as the most important indicators which can be used in the assessment process. Furthermore, the analysis proved that the leaders of urban transport development were the same voivodeships over the entire period.

On the one hand, both the classical as well as the order measures indicated that the Mazowieckie voivodeship was the leader over the whole period. However, this province was ranked second according to the classical measure only in 2014. The first place was occupied by the cities located in the Pomorskie voivodeships.

The second position in the constructed ranking of urban transport development over the entire period was occupied by the Pomorskie province. It should also be noted that the Śląskie province can be considered as the third object in the constructed ranking.

However, besides the mentioned leaders, namely the provinces of Mazowieckie, Pomorskie and Śląskie, the fourth position according to the both of the constructed total synthetic measures of the urban transport development was occupied by the Wielkopolskie voivodeship. It should be noted that its position changed depending on years of the analysis, e.g. it had the third place in 2014 according to both measures, and the fifth and sixth positions in 2016, etc.

In the scope of the analysis over the entire period, i.e. the total measure in the analysis the following voivodeships were indicated: the Mazowieckie, Pomorskie, Śląskie and Wielkopolskie provinces took the first, second, third and fourth positions.

The research demonstrated that the lower positions in the urban transport development ranking constructed using the final set of diagnostic variables

were occupied by the Warmińsko-Mazurskie and Podkarpackie provinces.

Opolskie voivodeship took the 16th position in the ranking both according to the classical and the order measure. The Warmińsko-Mazurskie voivodeship took the 13th position in 2014. However, it was in the 15th place in the general classification, which is based on the total synthetic measure. The Podkarpackie province occupied a distant position.

The analysis of the data presented in Tab. 4 proved both the fluctuations and significant differences in the level of the urban transport development among some voivodeships. The Świętokrzyskie voivodeship can serve as an example. It takes the 13th position in the general classification according to the classic measure. However, it ranked the seventh using the order measure with the Weber median.

Similar differences can be observed in relation to the Łódzkie province which takes the eighth and fifth positions according to the classical and the order measures, respectively.

To sum up, the analysis of the general (total) classification proved that the same positions in the ranking of urban transport development were observed in six analysed provinces. Hence, the Mazowieckie, Opolskie, Podlaskie, Pomorskie and Wielkopolskie provinces can be considered as such spatial objects. All in all, the differences in the constructed rankings are observed in the remaining ten regions of Poland. This phenomenon can be noticed in the following provinces, such as Zachodniopomorskie, Warmińsko-Mazurskie, Podkarpackie, Małopolskie, Lubelskie and Kujawsko-Pomorskie. Nevertheless, the difference between the two positions appeared only in the Dolnośląskie voivodeship.

The latter set of findings reflects the statistical observations related to the construction of the synthetic measure of the urban transport development in selected voivodeships.

However, the research was strongly limited by the availability of data. Adding more years to the analysis would have included less diagnostic variables.

The analysis of the variation demonstrated that the variable X_8 , which was connected with the share of buses on the move to their inventoried quantity, poorly differentiated the research objects. The values of that indicator for provinces were very high, which reflects good use and low failure rate of the bus fleet. Moreover, the variation analysis of the potential set of diagnostic variables proved that the spatial-time

approach should be introduced in the construction of the total synthetic measure.

However, it should be noted that the potential set of diagnostic features was mainly limited during the correlation analysis and particular features should be eliminated individually.

The research results showed that the implementation of the order synthetic measure with the Weber median allowed including additional indirectly observed information in the complex urban transportation system and made some differences in the constructed rankings.

CONCLUSIONS

The results obtained in this research produced several synthetic conclusions about the urban transport development in particular voivodeships as a part of the national logistics system.

In the total measure, i.e. the spatial-time, the higher and more stable positions were occupied by the Mazowieckie, Pomorskie and Śląskie provinces. One should expect that the level of the following variables $X_1, X_2, X_4, X_5, X_9, X_{12}$ that are considered as stimulants is relatively high.

The research demonstrated that such voivodeships as Opolskie, Warmińsko-Mazurskie and Podkarpackie remain at the other end of the development level and take the last three positions in the ranking. In conclusion, they require special attention of the local and state governments. It should also be emphasised that the urban transport in these areas reached a relatively low level of development. Hence, an improvement could be expected following investments in the development of stimulants that were introduced into the synthetic measure construction.

To sum up, the research shows some correctness of the spatial development of the country which can be reflected in the urban development level. The voivodeships located in the eastern regions of Poland can be considered as more underdeveloped. Nevertheless, the Opolskie province can be treated as the exception to the rule. This is due to the observed emigration of the local citizens to Germany as well as low level of investments.

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BINGE DRINKING IN RELATION TO SERVICES – BIBLIOMETRIC ANALYSIS OF SCIENTIFIC RESEARCH DIRECTIONS

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ABSTRACT

The article aims to identify scientific research areas within which the subject matter of binge drinking in relation to services is addressed, based on bibliometric data analysis characterising scientific publications indexed by the Scopus database. To achieve the aim, authors use different techniques of the bibliometric analysis with the support of the VOSviewer software. Results of the literature review on binge drinking show that harmful binge drinking behaviour is a subject of intervention services, which are undertaken by governmental and non-governmental institutions. As a theoretical contribution of the research part of the paper, it was proposed to qualify five categories containing the issue of binge drinking in relation to services, such as binge drinking consequences, the culture of alcohol consumption, alcohol versus risky sexual behaviours, alcohol intoxication and binge drinking, and the use of other substance among young people.

KEY WORDS

bibliometrics, scientific research, binge drinking, services, alcohol

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INTRODUCTION

Binge drinking has become one of the most pressing social problems throughout the developed world (e.g. Szmigin et al., 2008; Banister & Piacentini, 2006), attracting much attention from researchers, regulators and legislators. While British authors define binge drinking as a rapid consumption of large quantities of alcohol, especially by young people

(Pratten, 2007), earlier American work more precisely described binge drinking as five or more drinks in one sitting in a two-week period for males (four or more drinks for females) (Wechsler et al., 1994). The quantitative definitions of binge drinking and its conceptualisations vary across countries (Oei Tian & Morawska, 2004). The understanding of binge drinking may also be based on the term “extreme

drinking” proposed by Martinic and Measham (2008), which is culturally-defined and includes intoxication, motivation to get drunk, enjoyment of the process, the desirability of its outcomes, and long-term experience with alcohol enabling an individual to control their drinking. The social marketing perspectives on binge drinking are related to fostering the change of this harmful behaviour in the direction of responsible alcohol consumption. Many government and non-government institutions offer services/programmes of interventions, especially amongst groups of people, who binge drink and who are particularly at risk of binge drinking.

The aim of the article is to identify scientific research areas, within which the subject matter of binge drinking in relation to services is addressed, based on of bibliometric data analysis characterising scientific publications indexed by the Scopus database. In the study, the authors use different techniques of the bibliometric analysis with the support of the VOSviewer software.

1. LITERATURE REVIEW

A significant number of studies investigating excessive alcohol consumption has been carried out over the last three decades (e.g. Wechsler & Nelson, 2008). Binge drinking behaviour has been widely studied by researchers from a variety of disciplines, most notably preventive health, sociology and social marketing. Research has largely focussed on understanding the factors that are related to higher and lower incidences of binge drinking. Research focusing on binge drinking in young people suggests many individual, economic, social, political and organisational factors that contribute to binge drinking (Dowdall & Wechsler, 2002; Wechsler & Nelson, 2008). Locality is another factor that may influence binge drinking being unexplored (Korff, 2003; Siemieniako et al., 2010; Kubacki et al., 2009).

Individual factors that have been widely studied and reported in the literature include demographic (Presley et al., 1996; O'Malley & Johnston, 2002), cultural (Menagi et al., 2008), psychographic (Camatta & Nagoshi, 1995), related behaviours (Kushner & Sher, 1993), and involvement in other activities (Wechsler et al., 2002; Weitzman & Kawachi, 2000).

For example, previous research shows that demographic variables, such as age below 21 (Schulenberg

et al., 2001), male gender (Presley et al., 1996), initial years in the university (Schulenberg et al., 2001), white race (O'Malley & Johnston, 2002), residence on campus (Wechsler et al., 2002; Siemieniako et al., 2010) and lower academic performance (Wechsler et al., 2000) have all been associated with higher levels of binge drinking. Additionally, religiosity has been negatively associated with binge drinking among young people (White et al., 2006). Psychographic factors including trait anxiety (Martsh & Miller, 1997), social anxiety (Tran & Haaga, 2002), self-esteem (Larkins & Sher, 2006), neuroticism (Vicary & Karshin, 2002), thrill, adventure seeking, and impulsivity (Grant, 1998), and risky sexual behaviours (Kubacki & Siemieniako, 2011) have been associated with higher levels of binge drinking. Among related behaviours, alcohol consumption in high school (White et al., 2006) and early onset of first binge drinking (Perkins & Berkowitz, 1991) positively influenced binge drinking among young people. Genetic reasons have been found to have a relationship with drinking among young people. Children of alcoholics reported increased rates of alcohol use (Kushner & Sher, 1993), and alcohol-related problems (Pullen, 1994; Murgraff et al., 1999) as compared to other children. Other factors that lowered the incidence of binge drinking on college campuses include involvement in sports (Wechsler et al., 2002) and volunteering (Weitzman & Kawachi, 2000).

In terms of economic and political factors, studies show that higher taxes on alcohol (Levitt & Porter, 2001) and effective control over its price (Wechsler et al., 2002) lead to reduced consumption. Wechsler and colleagues (2002) also pointed out that strict rules regarding the legal drinking age effectively curb binge drinking among young people. Other restrictions, such as severe penalties imposed on vendors selling alcohol to minors, have a similar effect (Willner et al., 2000). Further evidence indicates that social marketing campaigns can be effective in reducing alcohol abuse amongst young people (Yanovitzky & Stryker, 2001) as well as the number of incidents involving drink driving (Cismaru et al., 2009).

When it comes to organisational factors, schools have been shown to influence student health-related behaviours, particularly in the areas of initiation to alcohol and its heavy use (Bisset et al., 2007).

The importance of locality in alcohol consumption has been identified in previous research. For example, in the collection edited by Martinic and Measham (2008), the authors explored the cultures of

extreme drinking among young people in several different countries. Although country-specific social settings in which alcohol consumption occur are important factors influencing binge drinking, our understanding of location goes beyond national boundaries or physical space. Research on ethnicity and migrant cultures (Korff, 2003) suggests that locality is a form of social construction, which connects three dimensions: space, local knowledge and social organisation.

While a myriad of variables has been extensively studied, research efforts to date have failed to assist in a reduction of a proportion of people who choose to binge drink (Johnston et al., 2006). This reduction might be considered because of services involvement proposed by government or non-government institutions. In limitation of the size of binge drinking behaviours, these services might be considered as interventions. In the systematic literature review of interventions aimed at reducing binge drinking among college students, Bridges and Sharma (2015) recognised 18 interventions, amongst which 14 were found to be effective in changing behaviours. There are also other examples of successes among such interventions (e.g. Dietrich, 2015; Hanewinkel, 2017).

2. RESEARCH METHODS

To achieve the aim of the article, a systematic review of scientific literature was conducted, or more specifically of scientific articles containing references

to the phrases “binge drinking” and “services” and at the same time indexed by the Scopus database. This review consisted of the following stages: (1) selection of the research subject, (2) bibliometric analysis of papers selected as the research subject, (3) frequency analysis of keywords indicated by authors of selected papers, (4) content analysis – examination of connections/links between keywords considered to be most important by the authors of selected articles. The research process is presented in Fig. 1.

In the first stage of the research process, a list of articles was generated, which in its bibliographic description, including the title, keywords and abstract, contain references to two phrases: “binge drinking” and “services”.

The generated list contained 484 records. In the next step of the research process, a bibliometric analysis was made. It included: identification of the number of articles dealing with the analysed topics considering the year of their publication, scientific disciplines, in which the authors of the articles conducted the research, the most popular journals publishing articles related to binge drinking as well as identification the most cited works on binge drinking in the context of services.

The next stage of the research procedure involved the analysis of the most common keywords indicated by the authors of the publications included in the generated list.

In the last stage of research, the results were processed and presented with the help of VOSviewer software which allowed to prepare a map showing

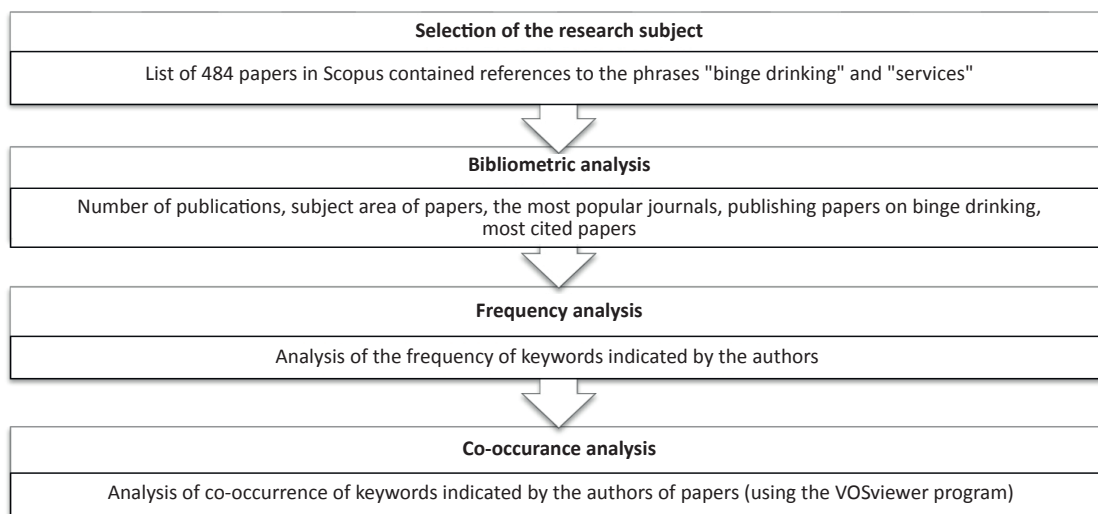


Fig. 1. Stages of the research process

the existing relationships between keywords indicated by authors of articles chosen for the analysis.

Using the VOSviewer software, it was possible to highlight the frequency with which given elements appeared in the network as well as the frequency with which they appeared together. The VOSviewer software helped to combine the analysed set of data into clusters, which allowed to identify the main areas of research in the area of binge drinking in relation to services.

3. RESEARCH RESULTS

The first article on binge drinking in relation to services indexed in the Scopus database was published in 1978; however, a clear increase in the popularity of this topic has been visible since the late 90s of the twentieth century. Most articles referring to binge drinking in the context of services were published in 2013–2015 (53 a year on average). In recent years, there has been a slight decrease in the number of scientific publications referring to this topic (Fig. 2).

The binge drinking issue is mainly undertaken by researchers representing medicine. Nearly 91% of scientific articles dealing with this topic indexed in the Scopus database were written by authors representing this discipline of science. About 16% of works are in the field of social sciences, and 15% in psychology (Fig. 3).

According to the results of analysis, the scientific journals, most often publishing articles dealing with

binge drinking, include: “Alcohol and Alcoholism” (16 scientific articles), Addictive Behaviours (15 articles), “BMC Public Health” (13), “American Journal of Preventive Medicine” (12) and “Journal of Adolescence” (11). These are medical and psychological journals.

The Scopus database clearly distinguishes a group of several articles that are particularly often cited by researchers dealing with binge drinking in relation to services. These are articles published in medical journals and referring to services provided to people struggling with the problem of excessive alcohol consumption. The first place among the most-cited items (nearly 750 citations in the Scopus database) is an article that is a guide for medical doctors. Other most cited articles refer to the social and economic costs of excessive alcohol consumption by people representing various social groups (Tab. 1).

For visualisation, keywords which appeared at least five times within the group of analysed publications are presented as a one-word cloud. The size of the word font indicates the frequency of its appearance among keywords indicated by the authors of the analysed articles. The most frequently appearing keywords indicated by the authors of articles covered by the analysis, in addition to the “binge drinking” filter phrase include: alcohol (68 speeches), adolescents (23), substance use (19), emergency department (17), brief intervention (17), adolescence (13), alcohol drinking (13), mental health (13) and prevention (12). Other keywords appeared ten times or less in the material covered by the analysis (Fig. 4).

Tab. 1. Most cited articles in Scopus related to binge drinking

NO	AUTHOR	TITLE OF PUBLICATION	YEAR OF PUBLICATION	SOURCE TITLE	TIMES CITED
1.	Fleming, M. F., Barry, K. L., Manwell, L. B., Johnson, K., & London, R.	Brief physician advice for problem alcohol drinkers: A randomized controlled trial in community-based primary care practices	1997	<i>Journal of the American Medical Association</i> , 277(13), 1039-1045	746
2.	Bouchery, E. E., Harwood, H. J., Sacks, J. J., Simon, C. J., & Brewer, R. D.	Economic costs of excessive alcohol consumption in the U.S.	2011	<i>American Journal of Preventive Medicine</i> , 41(5), 516-524	398
3.	Jacobson, I. G., Ryan, M. A. K., Hooper, T. I., Wells, T. S., & Bell, N. S.	Alcohol use and alcohol-related problems before and after military combat deployment	2008	<i>Journal of the American Medical Association</i> , 300(6), 663-675	336
4.	Holder, H. D., Gruenewald, P. J., Ponicki, W. R., Gaumont, G., & Roeper, P.	Effect of community-based interventions on high-risk drinking and alcohol-related injuries	2000	<i>Journal of the American Medical Association</i> , 284(18), 2341-2347	260
5.	Mustanski, B., Garofalo, R., Herrick, A., & Donenberg, G.	Psychosocial health problems increase risk for HIV among urban young men who have sex with men: Preliminary evidence of a syndemic in need of attention	2007	<i>Annals of Behavioral Medicine</i> , 34(1), 37-45	254

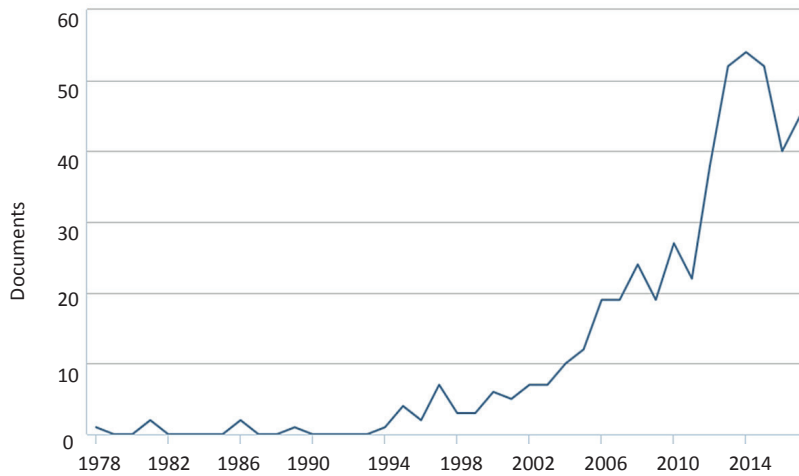


Fig. 2. Number of publications indexed in the Scopus database referring to binge drinking in relation to services

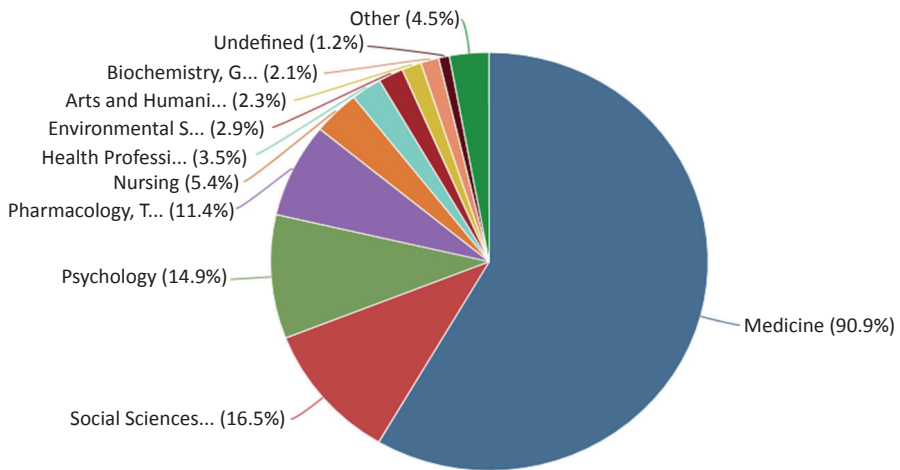


Fig. 3. Most popular subject area of articles indexed in the Scopus database referring to binge drinking in relation to services

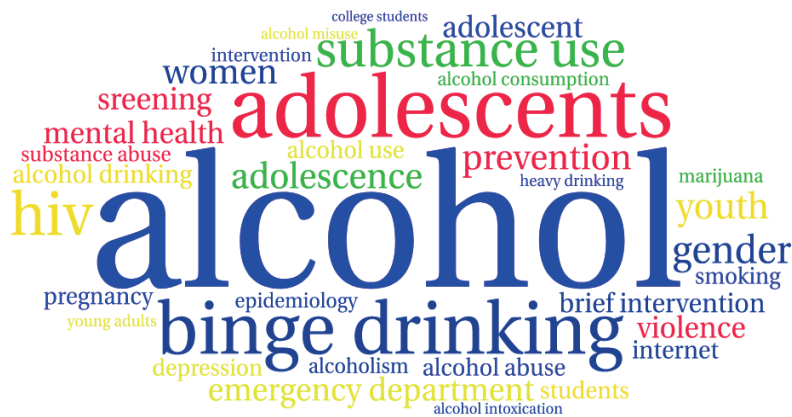


Fig. 4. Key words which come up repeatedly in publications dealing with binge drinking in relation to services indexed in the Scopus database

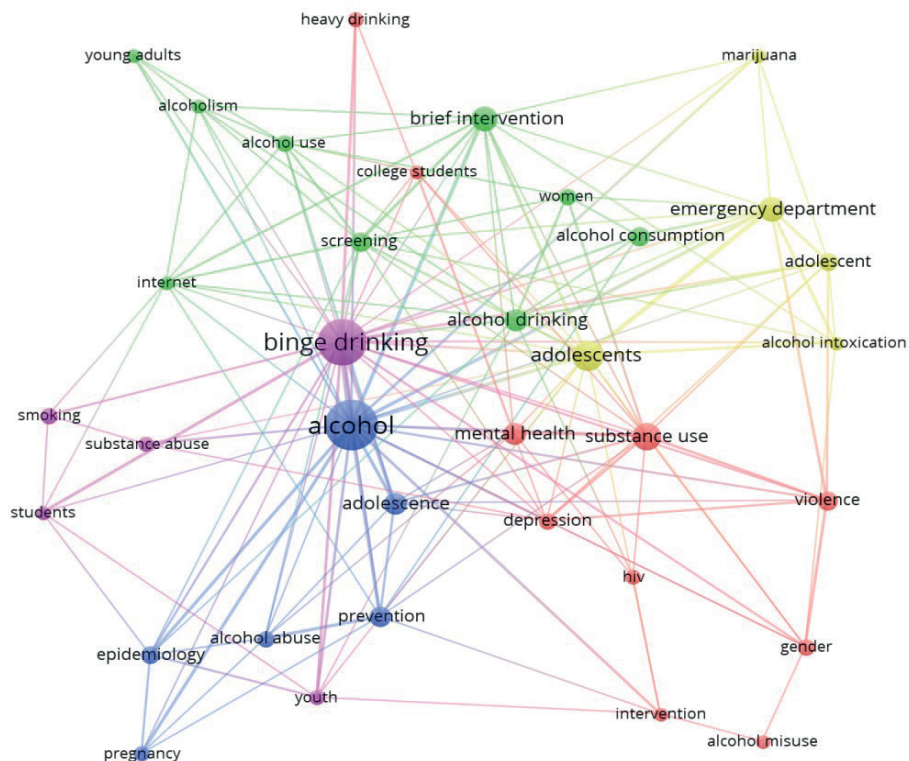


Fig. 5. Map showing the existing relationships between keywords characterising publications dealing with binge drinking in the context of services

In the last stage of the research process, a map presenting relations between keywords indicated by authors was developed. The VOS software allowed to generate the network showing how often each item occurred in the bibliographic descriptions of papers qualified to analysis as well as how often the elements occurred together. The most frequently used words are located in the centre of the map. Each point represents a word, and their sizes as well as the font size of a word or phrase, show the frequency of with that element. Words which have been indicated in most articles displayed the strongest relations with other elements.

VOSviewer also allowed joining elements into related clusters, which were then differentiated using various colours. Members of the same clusters appeared together most frequently which does not preclude them from occurring with other terms (Fig. 5).

The VOSviewer software allowed distinguishing five clusters which, all together, included 35 words/phrases. Proposed cluster names relate to the majority of terms which a given cluster.

Identified in the analysis of co-occurrence of keywords indicated by the authors of articles clusters include:

- Cluster 1. *Binge drinking negative consequences*: alcohol misuse, college students, depression, gender, heavy drinking, HIV, intervention, mental health, substance use, violence;
- Cluster 2. *Alcohol versus risky sexual behaviours*: adolescence, alcohol, alcohol abuse, epidemiology, pregnancy, prevention;
- Cluster 3. *The culture of alcohol consumption*: alcohol consumption, alcohol drinking, alcohol use, alcoholism, brief intervention, Internet, screening, women, young adults;
- Cluster 4. *Binge drinking and other addicted substance abuse among young people*: binge drinking, smoking, students, substance abuse, youth;
- Cluster 5. *Alcohol intoxication*: adolescent, adolescents, alcohol intoxication, emergency department, marijuana.

An influential work on negative consequences of alcohol consumption was published by Wechsler et al. (1994), proposing a 12-item Negative Alcohol Consequences Scale. In the area of binge drinking negative consequences (Cluster 1), two main types of

research can be distinguished: studies employing more holistic approach and trying to investigate a wide range of negative consequences (Cismaru et al., 2008; Park, 2004; Wechsler et al., 1994), and studies focused on in-depth exploration of some specific consequences, such as alcohol addiction (Chrostek-Maj et al., 2005), alcohol related traffic accidents (Murry, 1991), and alcohol influenced sexual behaviour and violence (Hill et al., 2005).

This last one can be categorised within the Cluster 2. Alcohol versus risky sexual behaviours. This area of research on alcohol consumption is narrow, although important. For instance, the research of Young et al. (2005) showed that drinking among female students is not simply about gender equality, but above all emphasises their (hetero)sexuality, attracting positive attention from their male peers, and raising their social position among male drinking groups. Self-control has been identified as an important tool in reducing high-risk drinking (Griffin et al., 2012; Posner & Rothbart, 2000), problems with establishing limits on consumption, and ignorance with respect to internal control mechanisms in the hope of finding sources of external control, pose challenges to social marketers (Siemieniako & Kubacki, 2013). In the works Siemieniako and Kubacki (2013) and Siemieniako and Kubacki (2011), based on projective techniques — collages, risky sexual behaviours appeared as the most important aspect of negative consequences of binge drinking amongst young people. Another important aspect of research on alcohol consumption versus risky sexual behaviours is related to gender identities and women's changing social positions (Lyons & Willott, 2008) and the perception of female bar drinkers (Parks & Scheidt, 2000).

The culture of alcohol consumption (Cluster 3) is a wide area of research, and this is also an area in which researchers analysed the problems qualified to all other clusters, which are distinguished, Fig. 5. Designing research problems, which cover several clusters, can be characterised as a solution of research gap identification. Binge drinking has been widely studied in the last two decades, and there is a considerable body of knowledge relating to drinking motives and negative consequences of binge drinking, much less attention has been directed towards the changes in drinking culture among young women (Wechsler et al., 2002). According to a literature review by Siemieniako and Kubacki (2013), alcohol also used to be considered as a gendered product (Iyer & Debevec, 1986), and gender differences in drinking styles and

the amount of alcohol consumed are still visible in many countries (Dantzer et al., 2006). The changing drinking culture and the convergence of male and female alcohol consumption have been identified by some as increasingly important and relevant with respect to the understanding of young people's drinking (Carpenter et al., 2007).

In their paper, Kubacki et al. (2011) proposed a new approach to defining binge drinking based on cultural aspects of alcohol consumption being grounded on consumer culture theory (CCT). In this approach, binge drinking can be divided into three phases: initiation, indulgence and moderation, which are correlated with age of binge drinkers. This work can be categorised into Cluster 4 (Binge drinking and other addicted substance abuse among young people) because it additionally distinguished type of binge drinking for adolescents, young adults and mature people. It is well proved that binge drinking amongst young people is associated with the abuse of other substances (Kubacki et al., 2011; Bissett et al., 2007).

As part of the works in Cluster 5. Alcohol intoxication, three research trends can be distinguished. The first of these includes articles dedicated to the analysis of psycho-social traits, patterns of drinking, and the circumstances of alcohol consumption by people who came to hospital emergency departments after alcohol intoxication. Important and often cited works that are included in this research trend include Diestelkamp et al. (2015), Wartberg et al. (2016) and Stolle et al. (2010). Some publications relate to research aimed at identifying the state of health and social status of people who become patients of emergency departments after alcohol intoxication after some time from leaving the hospital (Adam et al., 2016). The second stream of research within the Cluster 5 concerns the brief interventions used for people who were hospitalised after alcohol intoxication (D'Onofrio et al., 2012; Diestelkamp et al., 2014; Arnaud et al., 2017). The third trend of research concerns diagnosing the economic costs of binge drinking, which is estimated by including, among others, causes of premature death, increased disease and injury, property damage from fire and motor vehicle crashes, alcohol-related crime and lost productivity (Bouchery et al., 2011).

CONCLUSIONS

The bibliometric analysis of scientific works regarding the issue of binge drinking in relation to word “services” allowed identifying five main clusters, within which there might be the overwhelming qualified majority of the publications covering this issue. It can be proposed to initiate new research projects on binge drinking in relation to services in one of these five main topics, namely, binge drinking consequences, the culture of alcohol consumption, alcohol versus risky sexual behaviours, alcohol intoxication and binge drinking, abuse of other substances among young people.

Short examples of studies within each of the five clusters were presented after cluster identification. As a conclusion, it might be stated that the borders of two clusters make potentially interesting research. Work by Siemieniako and Kubacki (2011) can serve as an example of joining aspects from Cluster 1 (Binge drinking negative consequences) and Cluster 3 (The culture of alcohol consumption). The work presents the student perception of negative consequences of alcohol consumption with deepening exploration of student culture of alcohol consumption. The future direction of research might be broadening of bibliometric analysis through the use of other databases of scientific publications, such as Web of Science, Elsevier, Emerald or EBSCO.

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INTERNAL MARKETING AND ORGANISATIONAL PERFORMANCE OF SMES IN THE EDV INDUSTRIAL SECTOR

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ABSTRACT

Focusing on the industrial sector, this research aims to identify conditions for the implementation of internal marketing concepts among employees and its impact on the organisational performance. Only one study was found simultaneously integrating the two constructs. It concerned the cork processing industry alone, yet considered expanding the efforts – namely, using qualitative exploratory research in the form of 10 in-depth interviews based on a script of generally open questions – to the entire industry in the Portuguese region between rivers Douro and Vouga. The unit of analysis was constructed considering distinct features as well as activity criteria and the geographic location, thus ensuring the necessary heterogeneity. The results inform about the awareness of the internal marketing conceptualisation. The research found that all analysed enterprises had more or less structured model frames and worked with the conceptualisation of the guidance for the internal market, a strategic concern, and in some instances, this concept was an organisational desideratum in the sector. In addition to the lapse of the research according to a qualitative paradigm of exploratory nature, the main limitation is the need for objective sustainability of the results obtained through future quantitative studies to promote an integrated triangulation of their outcomes. The research allowed identifying the companies that use organisational models conducive to the individual well-being of employees and facilitating the desired orientation to the market.

KEY WORDS

internal marketing, performance, industrial production sector, EDV

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INTRODUCTION

The western region of Portugal between rivers Douro and Vouga, known as Entre Douro and Vouga (EDV), is undergoing rapid urban development favoured by the privileged location. In particular, cities São João da Madeira, Santa Maria da Feira and Oliveira de Azeméis are situated on national roads No 1, IC2, A1 and IC1, and their industry represents

around 45% of the total GVA of Entre Douro and Vouga (approx. 6.3% of the national industrial GVA). Compared to the northern region (24%), industrial products of this sub-region make a significant (outstanding) contribution, which shows the importance of specialisation of the industry in Entre Douro and Vouga (Simão et al., 2011).

The purpose of this study is to understand the circumstances for the implementation of the concept of internal marketing among employees and its impact on the organisational performance. Marketing literature recognises that all employees of an organisation are internal customers who must be served in a customer-oriented manner by the employees and management (Conduit & Mavondo, 2001; Jungsun et al., 2016) to maximise individual performance and positively impact on the relationship of the company with its external clients (Richardson & Robinson, 1986; Ceric et al., 2016).

Thus, to facilitate adequate orientation to the external market (Lings & Greenley, 2005; 2010), on which the organisational performance depends, the internal marketing concept needs to focus on the internal staff-management mechanisms (Gray et al., 2002; Ahmed & Rafiq, 2003).

It should be underlined that performance of companies depends on the moderating or leveraging role of a managerial mechanism (its functioning) (Lings, 2004; Lings & Greenley, 2005; Tortosa et al., 2009). The final objective of such mechanisms is the optimisation of results and, consequently, the contribution to the business development (Rafiq & Ahmed, 1998; Conduit & Mavondo, 2001). In other words, to provide superior value to clients, a higher value needs to be targeted in each aspect of organisational processes (Barnes & Morris, 2000).

Qualitative exploratory research with an interpretative position (Yin, 2003b) was developed to empirically explore internal marketing & organisational performance. This type of research focuses on the identification of the relationship between analysed variables to explain the entrepreneurial behaviours that lead to the expected practices resulting from the bibliographic review. The structure of this work is as follows: the introduction is followed by a theoretical framework and the used methodology. Then, the empirical results are presented and analysed. Finally, research considerations are developed with reference to potential limitations and indications for future research.

1. LITERATURE REVIEW

The increase in the economy of developed countries, which occurred in the last decades of the last century, allowed companies and the academy to devote considerable resources to the promotion of

quality levels in service delivery. The “service” delivery process involves the active interaction between clients and employees. The result of this interaction represents a relevant element in the final evaluation of the “product” received by the customer (Malhotra & Mukherjee, 2004; Gounaris, 2006; Várnai & Fojtik, 2008; Lee, 2016). This implies a change in the relational paradigm, moving from the focus on the company as an economic unit of production to its exterior, from the point of view of customer satisfaction, paving the way for internal customer satisfaction issues (Bansal et al., 2001; Rodrigues, 2004; Gounaris, 2006; Jou et al., 2008).

The internal market orientation should therefore be an integral part of organisational culture and guide the attitudes and behaviours of its members through the application of marketing concepts, centred on all employees according to a generalised paradigm (Lukas & Maignan, 1996; Gronroos, 1997; Conduit & Mavondo, 2001; Gounaris, 2006; Chow, 2015).

Internal marketing is a way of promoting the company and its products to its employees, engendering involvement in and commitment to the organisation’s strategic programmes as prerequisites for targeting that can lead to successful results for companies (Greene et al., 2003). Considering this goal, financial capital is no longer perceived as the key success factor and has been replaced by human capital (Shiu & Yu, 2010; Jungsun et al., 2016).

Internal marketing should function as a continuous improvement (Ballantyne, 2003) process, aligning organisational goals with stimulated employee behaviours that lead to better performance and assumed higher levels of responsibility (Quester & Kelly, 1999; Varey & Lewis, 1999; Che Ha et al., 2007), thus improving the performance of the organisation (Vasconcelos, 2008; To et al., 2015).

Based on Kohli & Jaworski (1990), Rodrigues & Pinho (2010) maintained that the internal market orientation through internal marketing conceptualisation and market orientation are a set of activities – generation, dissemination and response to information received from respective markets – that translate the transition from a business philosophy to practice.

Considering this guideline, Lings & Greenley (2005) demonstrated that the internal market orientation has a positive impact (i) on customer satisfaction and (ii) competitive positioning of an organisation. Organisations must focus on the internal market before adopting market orienta-

tion (Ahmed & Rafiq, 2003; Gounaris, 2006; Jou et al., 2008; Tortosa-Edo et al., 2010).

This extended understanding, which according to Arnett, Laverie & McLane (2002) presents various benefits, is relevant to the finding that the satisfaction of certain needs regarding “sellers” (Gounaris, 2008) would imply a direct external customer satisfaction (Greene et al., 1994; Varey, 1995; Varey & Lewis, 1999; Ballantyne, 2004).

Internal marketing crosses the functional boundaries of marketing and human resources. The satisfaction of customers depends on the satisfaction of employees (Lings, 2004; Várnai & Fojtik, 2008; Gray, 2008; Gounaris, 2008; Kaur, Sharma & Seli, 2010; Huang & Rundle-Thiele, 2014), therefore, conditions for the implementation of external marketing strategies depend on the dissemination of internal marketing efforts among employees. This is because the most important capital of companies is their workforce (Lings, 2004; Gounaris, 2006; 2008).

A perspective towards the adaptation of marketing to be used inside an organisation was created, understanding that marketing managers should formalise internal marketing programmes based on the same framework principle used to set goals for the external market (Piercy & Morgan, 1990; Varey, 1995; Varey & Lewis, 1999; Lings & Greenley, 2005; Jou et al., 2008; Rainey, 2014).

The internal marketing orientation specifically contributes to the market orientation in general by the awareness of an internal supplier–client philosophy that leads to a greater commitment to the company’s objectives and greater motivational attitude (Lings, 2000; Panigyrakis & Theodoridis, 2009; Kaur, Sharma & Seli, 2010; Theodoridis & Panigyrakis, 2010). The internal marketing orientation is the internal equivalent of market orientation (Lings & Greenley, 2005; Várnai & Fojtik, 2008; Gounaris, 2008).

The behaviour of managers towards subordinates influences their attitudes and behaviours, and the result of this interaction is perceived as a strategic factor impacting the final product provided to external clients (Ahmed & Rafiq, 2003; Lings & Greenley, 2005; Várnai & Fojtik, 2008; Kanibir & Nart, 2012).

According to Kohli & Jaworski (1990), companies that resort to an internal marketing operation, which is associated with specific management behaviours, aim to construct an appropriate market orientation (Lings & Greenley, 2010). It is important to adopt the principles of market orientation (Gounaris, 2008; Kaur, Sharma & Seli, 2010; Azêdo & Alves, 2013), which is based on results obtained by external

customers (Webster, 1992; Lings & Greenley, 2010; Javadein et al., 2011).

This is how modern marketing management considers customer satisfaction, which should be rooted in all achievements of an organisation through its symbiotic relationship with the internal customer. The intention is to create added value for all parties involved (Foreman & Money, 1995; Piercy, 1995; Seiders et al., 2005; Che Ha et al., 2007). It is important to note that several studies demonstrate the direct relationship between the final performance of the offer and the contact staff (Bouckaert & Peters, 2002; Tortosa et al., 2009; Jungsun et al., 2016).

In this perspective, marketing orientation for the internal market is essential for business success. The satisfaction of employee needs ensures the retention, development and motivation of qualified and best-performing employees. The provision of a systematic framework supports the importance of market orientation (Bouckaert & Peters, 2002; Schneider et al., 2003; Panigyrakis & Theodoridis, 2009; Malik et al., 2010; Rodrigues & Pinho, 2010).

Regarding the relationship between internal marketing practices and organisational performance, most studies have provided evidence that employee attitudes are related to organisational performance and demonstrated that market orientation is related to attitudes and behaviours of employees (Farrell, 2000; Kwon & Hu, 2000; Schneider et al., 2003; Rodrigues, 2004; Lings & Greenley, 2010).

Furthermore, at the end of this chain, market orientation leads to better delivery solutions in relation to customer needs and preferences, which improves performance conditions, giving companies a sense of the market and a special connection with customers, meeting their needs and creating value (Franco et al., 2001; Rodrigues, 2004; Kirca, 2011).

Thus, market orientation as a marketing concept has a positive effect on the profitability of organisations and, considering the potential of this effect on performance; it has a contributory role in the establishment of business strategies (Chang & Chang, 2007).

2. RESEARCH METHODOLOGY

The literature review discovered several studies on the relationship between internal marketing orientation and market orientation in the industrial sector and SMEs. Since little or nothing was known

Tab. 1. Interviewed companies

COMPANY	MAIN PRODUCT	LOCATION
A. Henriques II, S.A.	Rubber components	S. João da Madeira
Abílio P. Carneiro & Filhos, Lda.	Shoe industry	Fiães VFR
Biocutter – Engenharia e Equipamentos Industriais, Lda.	Machines and equipment	Vale Pereiras – Vale de Cambra
Deltamatic – Engenharia e Automação Industrial, S. A.	Machines and equipment	Carro Quebrado – Pindelo OAZ
Kalurcap – Injecção de Peças em Plástico, Lda.	Plastic Products	S. João de Ver VFR

about the studied issue, an exploratory study was deemed to be the most appropriate way forward. Qualitative research was developed integrating recorded structured interviews (Yin, 2003b) based on open or semi-open questions and a methodological approach to the case study, which was especially adaptable and contemplating.

In the exploratory phase, considering that the observation of multiple cases is indicated as preferable and contributes to the robustness and amplitude of the analysis (Carson et al., 2001; Yin, 2003a; Yin, 2003b), the chosen unit of analysis was a company from the manufacturing sector, irrespective of the final product.

In the light of the above and considering that direct qualitative studies aim for an in-depth rather than an extension analysis, it was neither necessary to use very large samples, nor to apply statistical methods to determine the size (Sánchez, 1999). Consequently, five companies were observed and interviewed twice each. Top managers were interviewed in all instances.

Five cases were selected from among the companies listed by the journal *Diário de Aveiro* as 1 500 Largest Companies Aveiro 2015. These cases were selected based on their geographical location and considering they represented different business realities, thus guaranteeing the necessary heterogeneity.

As this study specifically aims to understand how the internal marketing practices impact on the business strategy for the external market orientation and organisational performance, the prevailing issue was decomposed into questions regarding the relationship between analysed variables. During different moments of the analysis, this method contributed to the understanding of the global phenomenon *per se*.

Aiming to identify the ways and reasons management policies are applied in the encouragement of employees to be considered as internal customers and, consequently, to engage them in the application of management procedures leading to good performance results, internal marketing practices and mar-

ket orientation were identified as the analysed constructs.

The interviews were audio-recorded, and their duration varied between one and two. The environment was considered depending on the possibility to have an interview and the availability of the interviewees. This in loco analysis took place between March and early July 2016, and as the research developed in the context of content analysis, qualitative data analysis software webQDA was used.

3. RESULTS AND DISCUSSION

The understanding of market orientation is focused on the ability of companies to collect, distribute and react to information about the market in which they operate or intend to operate, allowing a convergent centralisation for different interventions, thus achieving higher levels of performance (Kohli & Jaworski, 1990; Piercy et al., 2002; Rodrigues, 2004).

The research aimed to describe and identify ways and reasons the market orientation is influenced by the strategic application of the conceptual tools of internal marketing.

To achieve this, the empirical work structure focused on interviewing middle and/or top managers of the focal companies. To facilitate the conversion of internal marketing activities into factors of performance improvement, in general (Sousa & Rodrigues, 2014), and the financial component, in particular (Kirca, 2011), standard interviews aimed to collect personal perspectives regarding the involvement of the interviewed in the organisation and different contributions to the operational results by internal marketing practices as mechanisms of interaction with clients, conducive to their satisfaction and loyalty.

Thus, some management activities carried out in an organisation, such as reward systems, directly

impact the marketing behaviours of the employees. Consequently, activities that are based on a market orientation concept are a major determinant of organisational success (Piercy et al., 2002; Lings & Greenley, 2010). Besides, the orientation to the internal market is important for the development and support of the market orientation. People, processes and policies must be aligned to create superior value for the organisation's relationship with the final client. It must be considered that the reinforcement of client-oriented behaviours is the key to the internal marketing, which in turn translates into increased customer satisfaction and business performance (Conduit & Mavondo, 2001; Rodrigues & Pinho, 2010; Shiu & Yu, 2010; Ceric et al., 2016).

For the interviewees, internal marketing was identified as a common practice in most companies, because the organisational concern for employees as internal customers is transversal and based on the broad concept that all employees and all departments of a company are suppliers and internal customers of each other (Lukas & Maignan, 1996).

In the perspective of the respondents, work should be conceptually interpreted as a product beyond employment. In their opinion, companies should create jobs that incorporate various aspects that allow attracting and retaining the workforce (Greene et al., 1994; Vasconcelos, 2008). This can be achieved by constant care for the well-being of individuals, trying to accommodate different employee needs fostering the understanding of the importance of the performed tasks.

Internal market orientation is, therefore, a prerequisite for satisfying customer wishes and needs, which obviously involves the identification and satisfaction of employee wants and needs (Panigyrakis & Theodoridis, 2009).

The analysed organisations made sure they provided the necessary support to achieve good performance in the execution of tasks, which leads to a well-developed sense of belonging to the organisation. The respondents mentioned that “...the company has acceptably modern facilities, ... well cared for and always spotless ...”, whereas there is a constant “... concern of the staff so that personal identification can be verified in the professional context”, that “...the relationship between the colleagues and their leaders is good, constituting a good way of building the team spirit and the company itself”, the “...work environment is the right one, which allows the right interaction...” and that “there is capacity to positively disagree ...”.

A favourable understanding of the way in which the relationship between companies and their employees takes place is clearly important, as there is always a concern to reconcile the interests of both parties so that the needs of each of them could be better adjusted.

The attitudes and behaviours demonstrated by the working force determine the relational quality perceived by the external customer (Rifai, 2005) and, consequently, their degree of satisfaction. Therefore, it is essential to motivate employees to adopt a marketing perspective, in a sense to promote their attitudes and, thus, to achieve organisational success in the external market (Tortosa et al., 2009).

The satisfaction rates that have been identified in various focal companies are factors that promote the internal organisational environment with immediate and specific implications to the management of the organisation, highlighting the comparative qualities which give them an operational advantage in the general business environment.

Considering the dual relational concept of internal marketing and performance, the analysed companies aim to promote the development of employee skills that contribute to the policies applied to approached external markets. Market orientation is an external relational tool and, consequently, an added value that makes a long-term contribution to organisational success (Deshpandé & Farley, 1998).

Works by Jaakkola et al. (2010), Davis et al. (2010) and Silva (2011) were used to identify a set of economic-financial indicators for the analysis of the performance conditions of the analysed companies to discern the contribution that can be materialised.

Generally, and by interpreting the values considered and provided by the focal companies, in particular, balance sheets designated by IES (Informação Empresarial Simplificada – simplified business information¹), it is possible to look at a set of elements that provide some indication about their management in economic and financial terms as well as their performance.

¹ The IES is delivered by companies by filling single forms approved by Ordinance No 208 of 16 February 2007, with the changes introduced by Ordinance No 8 of 3 January 2008, Ordinance No 64-A of 3 February 2011 and Ordinance No 26 of 27 January 2012. The forms are submitted electronically to the Portuguese Ministry of Finance as a single access point, on the same terms as the current Annual Declaration, Model 22.

From the outset, after a continuous decrease up to 2015, the volume of sales reversed in all companies in the first quarter of 2016, which is significant, given the economic circumstances of the time.

Net results of each company also improved because of the sales evolution, from mostly negative values to growths ranging from 43% to 122%, year on year, from the first quarter of 2015 to the first quarter of 2016.

It should be noted that in all companies, equity – the net value of company assets, i.e. the difference between assets and liabilities or everything the company owns and owes to third parties, which reflects the value of corporate assets – shows an average growth rate of 4.2% from 2014 to 2015, which indicates good levels of organisational performance.

The analysis of the indicator of the average financial autonomy for the five companies revealed a decrease between 2014 and 2015. It can be justified by the economic environment in the country at the time.

Other ratios demonstrated an increase in the net profitability of sales, which is obtained from the net margin after the deduction of all charges. Meanwhile, almost all companies underwent a decline in the operational profitability, which strongly depends on the sector of activity. The need for financing during 2013–2015 suggests the need to reconsider high charges.

However, all companies performed well and had good indicators, showing an interesting evolution, especially considering the conjunctural moment experienced by most Portuguese companies.

In general, the most dissonant indicator in the good performance of companies reflects a reversal in the operational profitability, which can be explained by the impact of the general conditions in their sector of activity as well as the need to reformulate the production model to counteract the economic downturn.

Tab. 2 provides a snapshot of the results contrasted with the literature in the field.

CONCLUSIONS

In companies, the identification of expressly encouraged attitudes towards internal relations depends on a set of constraints that contribute to the conceptualisation of the constructs studied in this work. The identification of orientation for a given variable can be improved, but the analysed concepts should not be entirely neglected in any of the observed organisations.

To the extent that the companies in the sample have different characteristics, their relational operations are conditioned by their diversity, although the analysed concepts are always intelligible in what is the organisation's way of proceeding.

In all the analysed companies, it is possible to identify the organisational will, clearer and more structured in some cases than others, what is meant when considering their DNA, in the transmission of a strategic focus sustained in the generalised diffusion of an internal model which aims to meet the needs of employees as a way to achieve a better individual performance and thus ensure greater adherence to the organisational designation.

Therefore, in the analysed companies, it is possible to identify the use of more or less structured organisational models of internal marketing that lead to the well-being of employees and low staff turnover, allowing to reach the desired market orientation.

The understanding of these conditions established by the organisations allows the availability of high-quality products to the clients, thus contributing to the desired market orientation. This increases and strengthens the quality of the external relationship

Tab. 2. Findings of the previous studies compared to present results

PAST STUDIES	PREVIOUS STUDY FINDINGS	PRESENT STUDY RESULTS
Crick, 2003; Ahmed & Rafiq, 2003	internal marketing is a way to promote the company and its products to its employees, generating involvement and commitment	internal marketing is identified as a common practice in most companies and a cross-organisational concern that employees are understood as internal customers
Gray et al., 2002; Ahmed & Rafiq, 2003; Lings & Greenley, 2005, 2010	the internal marketing concept focuses on internal management mechanisms applied to employees and conducive to organisational performance	companies consider work as a product beyond employment; it is identified through constant care for the well-being of an individual

PAST STUDIES	PREVIOUS STUDY FINDINGS	PRESENT STUDY RESULTS
Lings & Greenley, 2005	the proper practice of internal marketing is expected to be the source of improved performance	organisations made sure they provided the necessary support to achieve good performance in the execution of tasks, which leads to a well-developed sense of belonging to the organisation and a better external relationship
Gounaris, 2006; Chow, 2015	the company's focus, as an economic unit of production, must pass to its exterior, in the perspective of customer satisfaction	a favourable understanding can be verified as to the way in which the relationship with employees takes place, reflected in the concern to reconcile the interests of both internal and external parts
Malik et al., 2010	the internal marketing orientation is essential for business success	the individual satisfaction rates identified in the focal companies are factors that promote an internal organisational environment with immediate and specific implications in the management of the organisation, which gives them an operational advantage in the general business environment
Jungsun et al., 2016	there is a need for internal marketing activities so that final delivery of what is market-visible is fully consistent with the promise previously made by business orientation	considering the double relational concept of internal marketing and performance, the analysed companies aim to promote the development of client-focused relationship skills within their employees
Lings & Greenley, 2010; Javadein et al., 2011	an internal marketing operation produces value for external customers	in all the analysed companies, it is possible to identify the organisational will, clearer and more structured in some cases than in others, in the transmission of a strategic focus based on the generalised diffusion of an internal model that intends to meet the generalised needs of employees and consequently convey value to the customer
Franco et al., 2001; Rodrigues, 2004; Kirca, 2011	the internal marketing activities meet the needs and the creation of value for the consumer	in the analysed companies, it is possible to identify the use of more or less structured organisational models of internal marketing that lead to the well-being of employees and low staff turnover, allowing to reach the desired market orientation
Jungsun et al., 2016	customer satisfaction should be based on all the organisation's achievements with a direct influence on the final performance of the offer	all companies had: a positive evolution of the sales volume; net results also improved; equity, the value of corporate assets, showed an average growth rate of 4.2% from 2014 to 2015, which indicates good levels of organisational performance; net profitability of sales increased; (there was a decrease in the operational profitability, which heavily depends on the sector of activity)
Farrell, 2000; Kwon & Hu, 2000; Schneider et al., 2003; Rodrigues, 2004; Lings & Greenley, 2010	most of the studies that have already been done provide evidence that employee attitudes are related to organisational performance, demonstrating that market orientation is related to employee attitudes and behaviours	it can be verified that all companies performed well and had good indicators, showing an interesting evolution, especially considering the conjectural moment experienced by the majority of the Portuguese companies during the execution of the study
Lings & Greenley, 2005	it has already been shown that the internal marketing orientation has a positive impact: (i) customer satisfaction and (ii) competitive positioning of the organisation	the positive evolution of business indicators of the analysed companies was demonstrated in combination with the practised internal marketing
Kaur, Sharma & Seli, 2010; Theodoridis & Panigyrakis, 2010	internal marketing orientation contributes to market orientation	the identified conditions of internal marketing practice and internal marketing orientation enshrined by the analysed organisations, allowing the availability of high-quality products to the clients, thus contributing to the desired market orientation and its good performance
Shiu & Yu, 2010; Jungsun et al., 2016	financial capital no longer perceived as the key factor for success and replaced by human capital in order to achieve better organisational performance	there is a general trend towards the appreciation of employees as a better way to satisfy customers

(Rodrigues & Pinho, 2010), such as in the same operating line, also facilitating more controlled production costs, in a sales orientation to the market loyalty (Zhou & Li, 2007). In turn, this allows better positioning to adequately meet various customer needs (Matsuno et al., 2002).

The results obtained in this exploratory research are in line with the reviewed literature regarding the effect of the internal marketing behaviours on the market orientation and the consequent level of performance, thus showing consistency and providing credibility to its content.

However, research efforts in this field should be continued considering the size of an analysed business. A qualitative exploratory investigation allows a relativised interpretation of the value of the considered variables, yet presents some limitations that should lead to further investigations. Thus, quantitative research is suggested to confirm the relationship between different analysed variables and contribute to more robust results.

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WHAT COMPETENCIES ARE NEEDED IN THE PRODUCTION INDUSTRY? THE CASE OF THE PODLASKIE REGION

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ABSTRACT

The article focuses on indicating a set of competencies required for production branches based on the data regarding the Podlaskie labour market. The data was collected using quantitative surveys (in the form of questionnaires). Then, the Authors used network analysis to visualise the collected data and indicate the most frequently indicated set of competencies. Based on the opinion of respondents, the most popular competencies were professional knowledge and technical skills. These two competencies were also the most popular combination. Communication, self-reliance, thoroughness/reliability, sharing knowledge and experience, and teamwork/collaboration also proved to be important. The entire set of the competencies is strongly linked, with professional knowledge and technical skills forming the foundation. Knowledge of foreign languages has also been identified as significant as well as decision making, which was, however, less frequently connected with the above. Despite the dominance of the two competencies attributed to the professional group, this group of competencies was the least numerous. Based on the example of the Podlaskie Region, the study informs about the set of competencies sought by manufacturing companies. Also, the most important competencies typical for individual branches are noted. This collection of competencies can serve as a basis for further theoretical considerations in the field of competency identification aimed at the production industry. In some cases, competencies indicated for different industries coincide, while in others they are divergent. The set of competencies indicated by the respondents informs job seekers in the area of production as well as institutions such as Voivodship Labour Office in Białystok, whose task, among others, is to appropriately orientate the development of future employees.

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KEY WORDS

competencies, production industry, Podlaskie Voivodship

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INTRODUCTION

The research presented in this article is based on the data collected in the project entitled “Employer needs in the scope of supporting lifelong learning for deficit professions in Podlaskie Voivodship”, commissioned by the Voivodship Labour Office in Białystok (Dębowska et al., 2017). The main objective of the conducted research was identifying professions,

qualifications and competencies that were deficit/sought after in the Podlaskie labour market, with a special concern for key sectors of the regional economy. The research was also focused on determining the possibility of supporting employers in lifelong learning within the identified structural mismatches. The research methodology involved conducting desk research, quantitative surveys (in the form of ques-

tionnaires), a qualitative survey (in the form of an FGI) and foresight surveys in the form of the STEEPVL analysis, scenario method, visualisation and network analysis as well as the Delphi method. Among other things, the conducted study incorporated a matrix of adequacy and multivariate statistical analysis (cluster analysis, K-means method, correspondence analysis, correlation analysis, and classifications trees). The details of the entire research, its methodology and the achieved results are available in the monograph (Dębkowska et al., 2017). One of the authors of this article was engaged in the project preparing visualisations that – in the form of networks – present sets of crucial competencies in each of the analysed fields, based on the answers provided by the surveyed. The researched branches and sectors included: construction, machine production, metalwork production, woodwork production, production of rubber and plastic products, transportation, food processing, gastronomic and touristic branch, health care and social care sector and trade sector.

Considering their interests and trends signalled in the literature, the authors of this paper decided to take a closer perspective of competencies searched in the field of production branches. As of today, the widely debated transformation in the direction of Industry 4.0 makes essential production competencies uncertain. Iwański and Gracel claim that the transition to the level Industry 4.0 requires, for instance, greater investments in the education of managers and engineers as certain competencies are required to implement and maintain the latest technologies (Iwański & Gracel, 2016). According to the report (McKinsey Digital, 2016), one of the most significant barriers to implementing Industry 4.0 is the lack of the necessary talent, as emphasised by the producers at the first stages of implementation. Hence, the article focused on indicating a set of competencies required for production branches based on the data gathered during the delivery of the project mentioned earlier. Thanks to questions asked during the conducted research, it was possible to take an outlook on the competencies needed at present and in the period of the following five years (2018–2022). To achieve the formulated objective, from among the data that concerned the branches analysed during the delivery of the project, the authors selected information obtained from representatives of five production branches (machine production; metalwork production; woodwork production; production of rubber and plastic products; and food processing). Based on the selected data, the authors prepared visu-

alisation depicting sets of competencies that are vital for the production branch today. The visualisation is expressed in the form of a network, thanks to which it was possible to illustrate not only the most important competencies in the eyes of the respondents but also their coexistence.

1. LITERATURE REVIEW

The notion of competency is an issue that sparked interest in the scientific literature already at the beginning of the 20th century (Volpentesta & Felicetti, 2011). The colloquial, everyday approach uses the notions of competencies, skills, qualifications, authorisations and duties interchangeably. The enumerated terms are treated as synonyms. However, these notions are not identical. On the contrary, they remain in a certain relation (Kubat, 2014). It is also problematic to make a clear-cut differentiation among competencies, knowledge and qualifications (Kinkel et al., 2017). Fig. 1 illustrates the relation among these three notions according to Hertle, Siedelhofer, Metternich, and Abele. Moreover, in the presented approach, the authors indicated four classes of competencies: (1) technical and methodological, (2) social and communicative, (3) personal and (4) activity and implementation.

A competency may be understood as a relation between an individual and tasks to be done within professional work; consequently, it is knowledge and skills that are required for effective execution of a specific task (Volpentesta & Felicetti, 2011). Kinkel et al. claim that a competency is “the individual dispositional ability and readiness to act successfully and self-organised when facing novel, unstructured or complex situations or tasks and the ability to develop solutions for future situations” (Kinkel et al., 2017, p. 324). According to Filipowicz, the simplest possible understanding of a competency is interpreting it as a disposition within knowledge, skills and approaches that allow for executing professional tasks at a proper level (Fig. 2). Such a notion of a competency means that it is expressed in the readiness for a specific sort of behaviour (Filipowicz, 2011). Literature also mentions fundamental features of competencies, such as their relation towards a specific task or professional activity; their changeability, which means their susceptibility to development (competencies are not stable features, they change together with experience as well as professional and personal

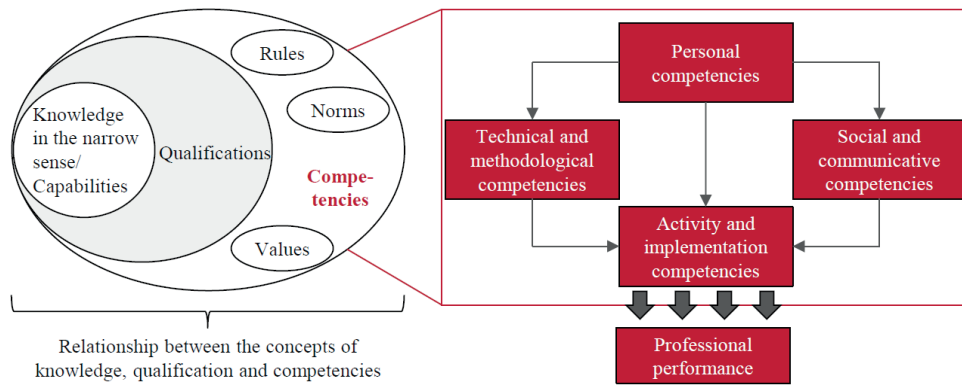


Fig. 1. Concept of competency and its relationship to knowledge and qualification

Source: (Hertle et al., 2015).

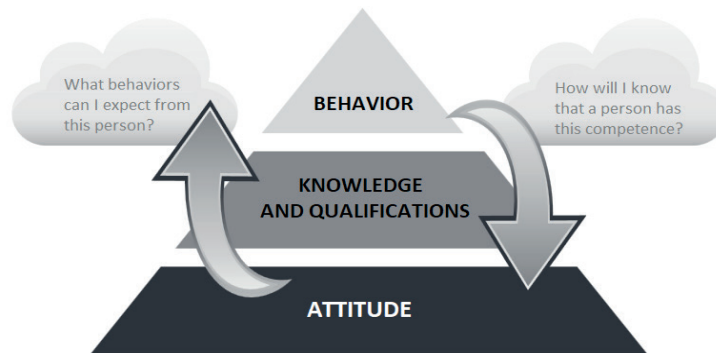


Fig. 2. Definition of competency

Source: (Filipowicz, 2011).

development) and measurability, namely aptitude for measurement (measuring competencies is a complex process itself but most theoreticians agree with the fact that it is possible to make an objective measurement of a competency) (Kubat, 2014; Filipowicz, 2011).

Competencies can be identified with the use of various methods. These methods can be grouped into five categories: (1) quantitative methods, such as tests, surveys, interviews or regular observations, (2) qualitative methods focusing on the social features of an individual (these include unstructured observations or biographical methods), (3) comparative descriptions, e.g. competency biographies highlighting retrospective events that are relevant for a professional competency development, (4) the use of a simulative device (replacing real experiments to record competencies) and (5) work samples, which are used in order to focus on an individual and the work environment. While identifying competen-

cies, it is recommended to combine quantitative and qualitative methods into a hybrid (Hertle et al., 2016).

Filipowicz and his team of researchers developed a universal model of competencies (a map of competencies) that constitutes a certain closed set of competencies that can be used as a good starting point in the process of their measurement. Based on the analysis of competency-oriented description of posts and sets of competencies in various companies, they developed a list of the most frequently used professional competencies. The entire set of competencies was divided into four categories (Tab. 1).

The skills and knowledge of design team members and engineers are very important. Thanks to their participation in various projects, they develop specific skills which should be aimed at achieving a certain optimal level. Only core competencies require continuous improvement and development, which nonetheless requires time and resources (Durkacova et al., 2012).

Tab. 1. List of competencies in the universal model of competencies

SOCIAL COMPETENCIES	PERSONAL COMPETENCIES	MANAGERIAL COMPETENCIES	PROFESSIONAL COMPETENCIES
building a relationship	pursuit of results (entrepreneurship)	building an efficient organisation	administering/maintaining documentation
sharing knowledge and experience	innovativeness and flexibility	team building	negotiating
identification with the company	analytical thinking	ability to delegate	orientation in business
communication	self-reliance	motivating	procedures - knowledge and application
customer orientation	decision-making	strategic thinking	IT skills
teamwork/team collaboration	troubleshooting	planning	technical skills
solving the conflict	thoroughness/reliability	leadership	professional knowledge
cooperation within the company	professional development/readiness to learn	project management	process management
exert influence	managing each other	team management	knowledge of foreign languages

Source: (Filipowicz, 2016).

The authors of the article drew particular attention to the field of production and the aspect of competencies that are needed among production employees. With the advancing subsequent industrial revolutions, the issue of competencies sought within the field of production also changes. Despite the noticeable ongoing preponderance of technical competencies, it should be noted that technical basics are merely one of the attributes of the engineers of the future as they must be supplemented with skills so far perceived as soft ones (Gudanowska, 2017a). The aspect of competency development in the production sector is even more difficult since it takes place directly in work environment, at the production hall. And if it does take place in such environment, there is no mention of the formal framework of learning. The development of competencies in such a case is randomised and incalculable despite being systematic and stable. From this perspective, it seems crucial to support competency development at the production hall (Hertle et al., 2015).

The significance of competencies in the production branch is highlighted by the observation that developing employee competencies in a production enterprise is a key determinant of competitive, future-oriented production since it allows for quick problem solving and continuous improvement in the entire production process (Hertle et al., 2015). It is a capable human-being who makes rational decisions in the scope of improving the organisation of production and its optimisation, quality management or optimal settings in case of an automated production

process. From such a perspective, employee competencies are ones of the most important resources in an enterprise that determine its competitive advantage (Wirkus et al., 2015; Krawczyk-Dembicka, 2017). Moreover, the fourth industrial revolution involves the impact on satisfying new customer requirements and applying advanced technologies, which in turn requires qualified human resources for today and in the future (Li et al., 2017).

2. CHARACTERISTICS OF THE SURVEYED AND THE RESEARCH METHOD

The analysis conducted in the publication that incorporates a set of competencies required in production enterprises was based on data gathered from 95 Podlaskie-based enterprises. Fig. 3 illustrates a breakdown of the researched enterprises into branches. The most numerous group, consisting of as many as 25% of the surveyed (24 enterprises), were organisations dealing with woodwork production. Another significant group that totalled nearly 21% of the surveyed subjects (20 enterprises) were food processing companies. A similar share (20% or 19 units) were enterprises from the machine production sector. The branches of the production of rubber and plastic products and metalworks production were

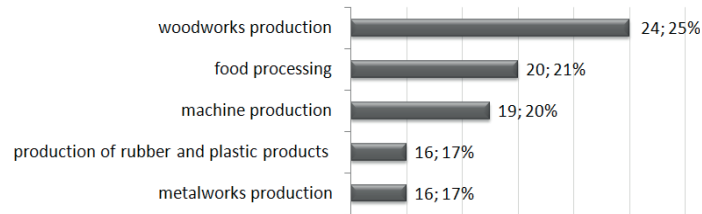


Fig. 3. Researched enterprises by branches

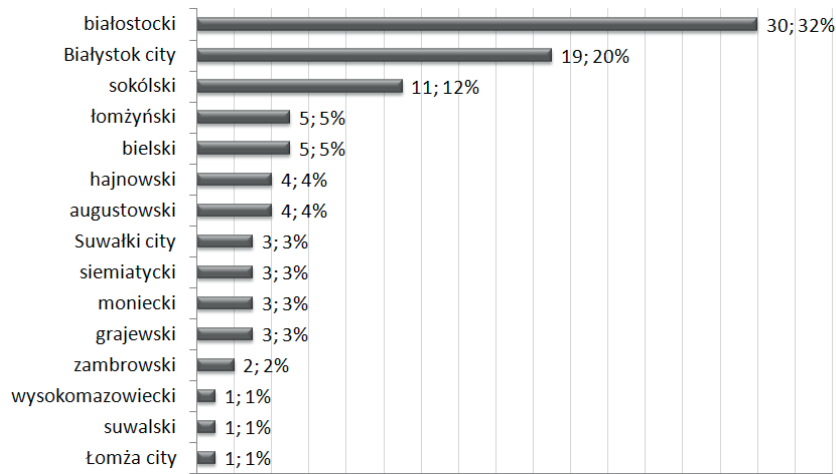


Fig. 4. Researched enterprises by county

analysed the last and represented by 16 enterprises (17%) each.

Fig. 4 illustrates the quantitative and percentage share of the researched enterprises with regard to the location of their business activity (county). Most of the surveyed companies were situated in Białystok County and the City of Białystok. These companies comprised more than half of the researched entities. Enterprises that represented Sokolka County constituted 12% of the population under study. The share of enterprises from other counties was significantly smaller, where companies from Lomza, Bielsk Podlaskie, Augustow Counties numbered from 4% to 5% of the researched units. The companies from the remaining counties did not exceed 4% of the total number.

The resultant research study was diversified with regard to the period of a company's operation in the market (Fig. 5a). The majority or as many as 60% of the researched organisations operated in the market for more than 10 years. The less numerous group, 24% of the surveyed, was comprised of companies that operated from 3 to 10 years, and the remaining part – 16% – were the enterprises with less than 3 years of business operation.

The territorial range of the activity of the researched enterprises is illustrated in Fig. 5b. Most of the surveyed enterprises operate in the international market (55%). The organisations that conduct business activity in the international market included those that cooperate with the European Union member states, Poland's Eastern neighbours and also those whose territorial range covers almost all continents. 21% of the researched companies localised their business activity in the domestic market. 16% of the surveyed enterprises function in the local market, and the remaining 8% operate on a regional or voivodship market.

The results of the surveys related to enterprises from the selected sectors of the Podlaskie Voivodship allowed indicating the sought employee competencies in the analysed branches. In the part of the survey dedicated to the identification competencies, the respondents indicated those competencies that were deficit/sought after in the represented branch. In the subsequent part of the survey, the surveyed defined their demand for deficit competencies in the period of the nearest five years (2018–2022) according to a scale from one to five, where one denoted very low demand and five – very high

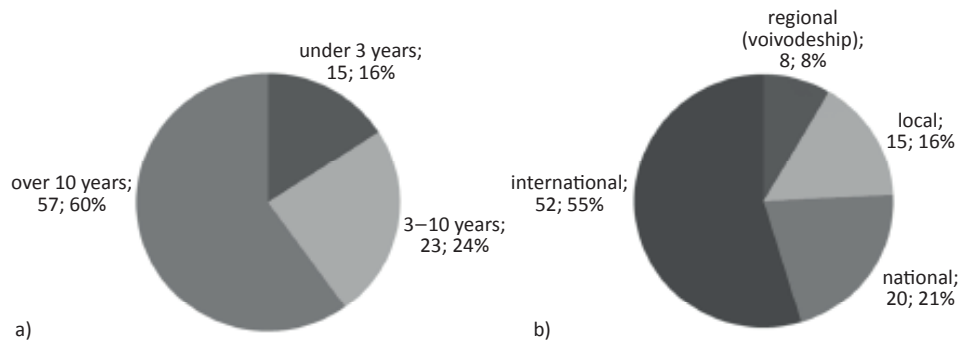


Fig. 5. Researched enterprises by the period of a company's operation in the market (a), the territorial range of the activity of the enterprise (b)

demand for a given competency. The authors of the survey assumed the list devised by Filipowicz (Tab. 1) as the starting list of competencies.

Based on the statement that the notion “competencies” usually appears in the plural form, similar to *glasses, trousers or scissors*, it is worth noticing that in deliberations on competencies, it is highly difficult to isolate a single competency and treat it as a completely independent feature that is separated from other dispositions. It is, hence, justified to analyse sets of competencies, in particular with regard to organisations that, in fact, employ many people (Filipowicz, 2016).

The authors used a network to present a set of sought competencies. Network analysis is considerably popular in the scientific world. It is an interdisciplinary research approach that is used while analysing complex systems and processing relational data (Wasserman & Faust, 1994). In fact, network analysis is present in almost every scientific field. Its essentials are comprised of graphs and mathematics, but also statistics and matrix algebra. This issue plays a vital role in the area of information and computer technologies as well as artificial intelligence, contemporary theories that concern free-market economy, geographic and transport networks, studies connected with analysing citations in bibliometrics or studies on social relationships (Gudanowska, 2017b). The authors decided to use a form of a network as the one that can reflect both the significance of competencies in the assessment of the surveyed, as well as their coexistence in choices made by a given respondent. Visualisation also included markings of the categories of specific competencies (according to the categorisation presented in Tab. 1).

3. RESEARCH RESULTS AND DISCUSSION OF THE RESULTS

One of the steps of the conducted analysis was the examination of deficit competencies pointed out by respondents, considering the aspect of their coexistence in the indicated area. Bearing in mind the previous statement that the competencies, required by employers do not occur individually but rather make a cluster of interconnected elements, the aim was to find the most preferred group of competencies in the field of production. Respondents could select competencies from the list or add others; however, none of the considered respondents added competencies to the list. This may suggest that the Filipowicz's model of competencies is somewhat complete.

The network (Fig. 6) case presents deficit competencies pointed out as such by at least 15% of respondents representing manufacturing industries. The size of an element stands for the percentage of employers from this sector, who thought a given competency was unprofitable. The larger the element, the more people considered the given competency as important in the field of their branch. Given next to each name, the percentage value indicates the number of times a competency was chosen.

The existing connection between two competencies within the network means that the two competencies were chosen as valuable by the same responder. The more employers chose a certain pair, the stronger and more noticeable is the connection between them (marked with a darker and thicker line). Considering the density of connections within emerged networks as well as the clarity of figures, it was also assumed that for a connection to be visible, a pair of competencies had to be selected by least 15% of people.

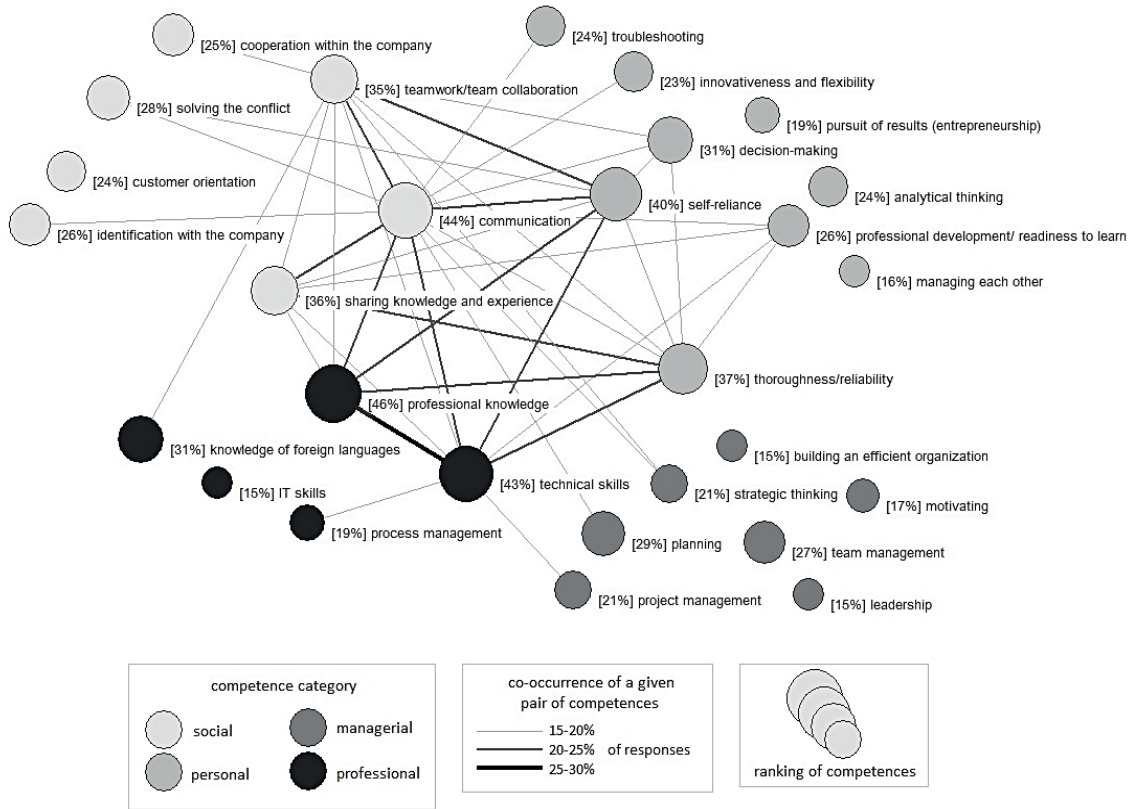


Fig. 6. Network of competencies sought after in production (in all analysed production branches) in the opinion of representatives of production enterprises in the Podlaskie Region

Source: author’s elaboration on the basis of (Dębkowska et al., 2017).

The colouring of network elements is a result of their classification into four groups, namely, social, personal, managerial and professional. Furthermore, the meaning of the shading is described in the figure.

According to the respondents, professional knowledge and technical skills were the competencies that seemed to be the most sought after. It was also the most popular combination (chosen by over 25% respondents). Communication, self-reliance, thoroughness/reliability, sharing knowledge and experience, and teamwork/collaboration also proved to be important. The entire set of the competencies is strongly linked, with professional knowledge and technical skills forming the foundation (connections at 15–20% or 20–25% indications level). Knowledge of foreign languages has also been identified as significant (having the only connection with teamwork at 15–20%) as well as decision making, which, however, was less frequently connected with the above. The starting set of competencies had an equal number in each category. It is interesting to note that despite the dominance of the two competencies attributed to

the professional group, this group of competencies was the least numerous.

Analysing the respondent answers as to competencies to be required over the next five years (2018–2022) it was noticeable that the current set seems to have no tendency for change. The Authors prepared a corresponding network, this time saying that the connection between competencies should appear if a respondent thought a given pair of the competencies as of high or very high demand. Despite slightly different numeric results, it was apparent that relations between and the importance of certain competencies will remain unchanged. Consequently, the presentation of the described network would not bring any new perspective.

While analysing the obtained data regarding individual manufacturing industries, some differences can be noted as presented in corresponding networks prepared for the project "Employer needs in the scope of supporting lifelong learning for deficit professions in Podlaskie Voivodship", shown in (Dębkowska et al., 2017). A summary of respondent

choices regarding the extent, to which a given competency is sought after in certain industries (based on the level of indications in percentage) was presented in Tab. 2. Cells indicating the choice of at least 40% of respondents from a given field are marked with the darkest colour. Cells representing a competency selected by at least 30% of respondents from a certain area are marked with a medium-dark shade.

The machine production sector had the densest network of deficit competencies. Thoroughness/reliability was the most sought-after competency in this branch. It was often selected together with strategic thinking, technical skills and teamwork. In this sector, there were several less connected competencies. The network of machinery production branch has a large number of nodes, which means that most of the proposed competencies were thought to be the sought after. Also, no category seems to be dominant. Metalworks production was the other analysed sector. Technical skills, professional knowledge and self-reliance were the most popular competencies. Also, they appeared to be the most strongly linked deficit competencies. Slightly fewer respondents suggested thoroughness/reliability and communication, which were also strongly connected with professional knowledge and technical skills. Problem solving and troubleshooting were also popular; however, these competencies were not as strongly linked with the others. Managerial competencies had the lowest number of mentions. The woodworks production sector was yet another analysed industry area. Technical skills and communication were thought to be the most important competencies, followed by professional knowledge, self-reliance, sharing knowledge and experience, and teamwork. The most strongly linked competencies included technical skills and self-reliance. Technical skills were often mentioned together with professional knowledge; however, the self-reliance was usually indicated together with teamwork. Deficit competencies in the field of production of rubber and plastic products comprised one of the smallest competency groups. Self-reliance was the most sought after. In this industry, job-seekers should also be thorough/reliable and able to troubleshoot. Decision making, teamwork, communication and professional knowledge were considered deficit competencies; however, they were less frequently paired with any other deficit competencies. Personal and social competencies were predominant. In the case of the food processing sector, the network had weakly-connected nodes. Nonetheless, half of the respondents chose professional knowledge as

a sought competency. Communication (linked to professional knowledge), team management and knowledge of a foreign language were also thought to be deficit (Dębikowska et al., 2017).

CONCLUSIONS

The success of a production company in realities of the 21st century is based on three pillars. Firstly, the rational and effective decision-making process considering management and functioning of the manufacturing industry. Secondly, innovative methods and tools, improving production processes, together with a constant improvement of production machines performance. Thirdly, improvement and continuous development of workers and their competencies (Wirkus et al., 2015). The knowledge of the competencies in a company – being one of the bases for the competitive ability of manufacturing industries – helps the company identify its qualities as well as market imperfections. The significance of issues related to competencies required in the industry 4.0 is even greater due to the change in working conditions as well as requirements for employees.

In the article, the Authors focused on the identification of the set of competencies sought after by modern companies. The identification of the set of competencies desired by employers from Podlaskie Voivodship was conducted using the data obtained from the project “Employer needs in the scope of supporting lifelong learning for deficit professions in Podlaskie Voivodship” (Dębikowska et al., 2017). The analysis revealed that workers should have a better professional knowledge as well as technical skills. Employees should have highly developed communications skills, be dedicated to precise task completion and be able to work autonomously as well as in a team. They should also be open to exchange and sharing of knowledge and experience. The article also presents competencies depending on representatives of each analysed manufacturing sector (machine production, metalworks production, woodworks production, production of rubber and plastic products and food processing).

In the Author’s opinion, the comparison of competencies, which were indicated as important for the development of production sectors, and in the light of literature, the obtained results reflecting the opinion of the surveyed manufacturing enterprises can be considered an interesting direction for

Tab. 2. Percentage number showing the opinion of respondents from production enterprises in the Podlaskie Region regarding the extent to which a given competency is sought after

	MACHINE PRODUCTION [%]	METALWORKS PRODUCTION [%]	WOODWORKS PRODUCTION [%]	PRODUCTION OF RUBBER AND PLASTIC PRODUCTS [%]	FOOD PROCESSING [%]
SOCIAL COMPETENCIES					
building a relationship	21	0	8	13	20
sharing knowledge and experience	42	25	46	25	35
identification with the company	42	19	21	19	30
communication	42	38	54	38	45
customer orientation	21	38	17	25	25
teamwork/team collaboration	42	19	42	38	30
solving the conflict	32	25	29	25	30
cooperation within the company	32	31	17	19	30
exert influence	5	0	4	13	5
PERSONAL COMPETENCIES					
pursuit of results (entrepreneurship)	16	19	17	25	20
innovativeness and flexibility	32	31	17	19	20
analytical thinking	42	19	17	25	20
self-reliance	26	50	46	56	25
decision-making	32	38	21	38	30
troubleshooting	26	38	17	38	10
thoroughness/reliability	63	38	25	38	25
professional development/ readiness to learn	37	31	17	19	30
managing each other	11	19	29	19	0
MANAGERIAL COMPETENCIES					
building an efficient organisation	21	25	17	0	10
team building	16	6	8	13	20
ability to delegate	16	0	4	0	15
motivating	26	0	25	6	20
strategic thinking	42	13	17	6	25
planning	42	25	29	25	25
leadership	11	13	8	13	30
project management	21	31	21	13	20
team management	32	13	29	19	40
PROFESSIONAL COMPETENCIES					
administering/maintaining documentation	16	13	4	0	5
negotiating	26	0	13	0	5
orientation in business	16	19	4	6	10
procedures - knowledge and application	21	13	0	0	20
IT skills	11	31	17	6	10
technical skills	37	56	54	31	35
professional knowledge	42	50	50	38	50
process management	16	25	29	0	20
knowledge of foreign languages	42	25	25	19	40

Source: author's elaboration on the basis of (Dębkowska et al., 2017).

further research in the subject matter. From the perspective of the literature review, the aspect of competency measurement and proper assessment seems to be important as well. The development of this issue should enable the determination of key points in the area of employee development, underlining the importance of human capital.

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