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SUPPLY NETWORKS AND INNOVATION ACTIVITY IN MEDIUM-HIGH TECHNOLOGY MANUFACTURING INDUSTRIES IN POLAND

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ABSTRACT

Increasing market dynamics requires the involvement of an increasing number of partners, including suppliers, customers and competitors located near the company and in its further surroundings. The interaction between participants in such networks leads to the exchange of knowledge and information, and this process takes on unique forms specific to the participants and the environment in which they occur. The study aims to determine the influence of distance and type of relationships with a competitor, supplier, and customer on the type of innovative activity in medium-high technology companies in Poland. The work assumes that close contacts with a competitor, supplier, and customer operating within a short distance support innovative activities. Domestic and foreign suppliers, customers and competitors are favored to undertake innovative activities, and the most positive influence on the stimulation of innovative activity is the cooperation with suppliers and foreign customers.

Key words: innovation, innovation activity, industry, medium-high technology

INTRODUCTION

Industrial activity is becoming an increasingly integrated network process involving national or international supply networks. The enormous variety of knowledge and information exchanged between entities that are part of such systems makes this process takes on various forms specific to the participants and the environment in which it takes place [Edquist et al. 2001]. Innovation in such a context is perceived as a result of the interaction between the company and other market participants as well as the process of acquiring knowledge [Malerba 2002]. The essence of the network's operation are the relationships between its entities belonging to three groups: enterprises, science, and state administration. As a result of mutual interaction in the process of knowledge and information exchange, participants create various relationships that shape the pace and direction of knowledge flow [Storper 1995]. This phenomenon is particularly important in the medium- and high-technology sectors [Dzikowski 2015]. Connections can take the form of vertical or horizontal interactions. Taking into account the fact that the communications are unpredictable and require direct contact, the process of creating the network focuses on the close relationships between the involved partners [Świadek et al. 2016]. Moreover, the very process of setting them up is the most important, as it contributes to the creation of close relations of understanding and deepening of joint work [Wang et al. 2014]. However, the learning process is not always facilitated by spatial proximity, which affects the intensification of collaboration between companies and other institutions. The critical role plays the existing knowledge base unique for a type of industry [Malerba 2005]. From this perspective innovation is defined

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as the implementation of a new or significantly improved product (product or service) or process, a new marketing method or a new organizational method in business practice, workplace organization or relations with the environment. Technical innovations concern changes in technology and technology and includes product, process, and organizational innovations [OECD 2005]. The study aims to determine the influence of distance and type of relationships with a competitor, supplier, and customer on the type of innovative activity in medium-high technology companies in Poland. The work assumes that close contacts with a competitor, supplier, and customer operating within a short distance (locally or in the region) support various innovation activities. The starting point of the work is the theoretical introduction including the relational and spatial conditions of industrial enterprises in supply networks. Then, the methodology of the study is discussed. The practical part includes logit models and incentives and impediments both investment and implementation of innovation. Finally, the summary contains conclusions, limitations and further possibilities.

LITERATURE REVIEW

Networks are structures defined by specific conditions that mean cooperation, coordination, communication, and sometimes a community of goals [Czakon 2012]. Linkages created by network actors affect both the relationships and the space in which individual network nodes operate [Dzikowski 2015]. Boschma [2005] argues that the importance of geographical proximity cannot be assessed in isolation, but should always be examined concerning other dimensions of proximity including cognitive, organizational, social, institutional and geographical proximity. Short distances allow employees to meet more frequently, which increases the likelihood of establishing closer relationships and the chance for faster informal cooperation, which will turn into formal cooperation of the organizations they represent [Bell 2005, Gilbert et al. 2008]. These factors are necessary to develop the appropriate level of confidence that is required for the exchange of knowledge [McCann and Folta 2011, Dyba 2016]. The described process of developing mutual trust, due to the rapidly progressing internationalization, went beyond the national framework [Binz and Truffer 2017]. Hence, the importance of having personal contacts for establishing innovative cooperation decreases [Freel 2003]. Direct interactions can be helpful in crucial moments of the innovation process, but in the remaining time communication based on electronic means of communication such as e-mail, communicator or telephone is sufficient [Gallaud and Torre 2005]. As a supply network, we will understand a relatively permanent grouping of independent, specialized companies that participate in a market-based cooperation system, with at least three organizations oriented towards the implementation of convergent goals [Czakon 2012]. A network defined in this way may take on various forms, sizes and organizational character, determined by the degree of complexity and quality of connections. Cassiman and Veugelers [2006] show that a firm's internal innovation activities including internal R&D and external knowledge acquisition are complementary and impact on their innovative collaborations with external partners. Many potential innovation partners can be distinguished and different types of innovations can result from these partnerships. The network with actors caring out innovation activities is called the innovation network. The events of the innovation network include creation, exchange, transformation, absorption and exploitation of resources in connection with broadly understand formal and informal relations [Ahuja 2000]. A characteristic feature of the innovation network are relationships [Etzkowitz and Leydesdorff 2000]. In the era of global economy, spatial proximity does not always contribute to the intensification of cooperation between partners [Leischnig et al. 2014], but may under certain conditions support the transfer of hidden knowledge [Wal and Boschma 2011]. The keys are a place occupied by the enterprise in the network [Bell 2005], the type of industry to which the enterprise belongs, the network structure it co-creates and the type of shared information is of great importance [Zaheer and Bell 2005]. Innovative activities involve expenditure on: research and development; intangible technologies; purchase of advanced machinery, equipment, hardware or software, as well as land and buildings (including improvements and repairs); staff training and marketing of new and improved products; other activities including design

work, planning and testing of new products and services, production processes and delivery methods [Janasz and Kozioł-Nadolna 2011]. This paper focuses on supply networks, and the role proximity and relationships of competitors, suppliers, and customers have on shaping innovation activities.

MATERIAL AND METHODS

The scope of the research relates to innovation activity in medium-high technology (MHT) industry. It concerns both product and process innovations new only to the firm. The survey was based on a questionnaire sent by email and then a telephone interview was conducted with the owner or manager of the given company. All data were gathered between 2008 and 2013. Explained variables include R&D expenditure, investments in new fixed assets including buildings and land, machinery and technical equipment and computer software, implementations of new or improved products or technological processes, including production methods, nonproduction systems, and support systems. In turn, explanatory variables consist of distance from a competitor, supplier and customer-defined from the local, regional, domestic and foreign perspective and a relationship with a competitor, supplier and customer including no contacts, cooperation, good neighborly relations and hostility. In this study, the model of logistic regression was estimated to assess whether and at which level each of the independent variables contributes to each kind of innovation activity [Lemeshow and Sturdivant 2013, Stanisz 2016]. The multinomial logit model estimates the effects of explanatory variables on a dependent variable with unordered response categories [Aldrich and Nelson 1984, Liao 1994, Stanisz 2016]. The significance of the independent variable coefficients was tested by using the Wald test, and it was considered a valid coefficient for the model when the level of statistical significance was $P < 0.1$. The calculations were performed in Statistica software.

RESULTS

The collection contains 981 enterprises operating in Poland, including 252 micro (25.69%), 350 small (35.68%), 275 medium (28.03%) and 104 large (10.6%) entities. Due to the nature of ownership, domestic enterprises dominate 313 (80.63%), foreign enterprises represent 110 companies (11.21%), and mixed capital is represented by 80 enterprises (8.15%). Table 1 shows the structure of firms due to the manufacturing sector.

The most firms invest in new fixed assets (78.6%) and implement new technology processes (76.5%). In contrast, both investments in buildings and land (29.6%) and implementations of new support systems (29.3%) are held the least. Table 2 includes research and development expenditure (R&D) model. A domestic competitor and cooperation with suppliers increase odds of taking R&D expenditure respectively 1.28 times and 1.35 times. In contrast, both local and

Table 1. The structure of firms due to the manufacturing sector

Sector	Number of firms / Share (in %)
Manufacture of machinery and equipment	480 (35.42)
Manufacture of electrical equipment	227 (16.75)
Manufacture of chemicals and chemical products	156 (11.51)
Manufacture of motor vehicles, trailers and semi-trailers	82 (6.05)
Manufacture of other transport equipment	21 (1.55)
Manufacture of railway locomotives and rolling stock	15 (1.11)
Total	981 (72.40)

Source: Own study.

Table 2. Research and development expenditure model

$\chi^2 = 46.448$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
Domestic competitor	0.2483	0.1406	3.1182	0.0774	1.28
Cooperation with suppliers	0.3016	0.1539	3.8403	0.0500	1.35
Local customer	–0.8006	0.1837	18.9850	0.0000	0.45
Regional customer	–0.2795	0.1575	3.1469	0.0760	0.76
No contacts with customers	–0.6112	0.2306	7.0223	0.0080	0.54

Source: Own study.

regional customers decrease a probability of taking R&D expenditure. Firms cooperating mainly with local customers have nearly 0.45 times fewer odds to take R&D expenditure and firms cooperating mainly with regional customers have 0.76 times fewer odds. Firms maintaining no contacts with customers have almost a half fewer odds to take R&D expenditure. Research and development expenditure is both too risky and costly for firms focusing on local and regional customers in Poland. On the other hand, research and development activity requires an appropriate scale of economic activity and consecutive contacts with domestic customers what for local firms can be too challenging.

Table 3 includes investment in new fixed assets (INFA) model. Hostility to competitors supports the probability of investment in new fixed assets the most. Furthermore, firms with good neighborly relationships with competitors and customers and cooperating with foreign customers have about 1.5 times higher odds to invest in new fixed assets. In contrast firms with local and regional suppliers and maintaining basic relationships with suppliers have about a half fewer odds to take this kind of investment. The negative impact of local and regional suppliers and competitors shows the importance of trust and ability to establish good relations on the level of investment in new fixed assets. However, the most important factor is demand, which is insufficient for local and regional customers, and becomes a stimulus when clients are overseas.

Table 4 includes investment in buildings and land (IBL) model. Firms having domestic competitors and cooperating with customers including foreign customers have nearly 1.5 times higher odds to invest in

Table 3. Investment in new fixed assets model

$\chi^2 = 45.285$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
Hostile to competitors	0.9116	0.3922	5.4006	0.0201	2.49
Good neighborly relationships with competitors	0.4541	0.2031	5.0011	0.0253	1.57
Local supplier	–0.6908	0.2347	8.6614	0.0033	0.50
Regional supplier	–0.5121	0.1772	8,3510	0.0039	0.60
Basic relationships with suppliers	–0.6539	0.1890	11.9640	0.0005	0.52
Foreign customer	0.4510	0.2742	2.7043	0.1000	1.57
Good neighborly relationships with customers	0.4207	0.2320	3.2877	0.0698	1.52

Source: Own study.

Table 4. Investment in buildings and land model

$\chi^2 = 37.144$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
Domestic competitor	0.3173	0.1454	4.7598	0.0291	1.37
No contacts with competitors	–0.5704	0.1753	10.5862	0.0011	0.56
Good neighborly relationships with competitors	–0.3671	0.2016	3.3147	0.0687	0.69
Basic relationships with suppliers	–0.4663	0.2152	4.6963	0.0302	0.63
Foreign customer	0.4526	0.1957	5.3484	0.0207	1.57
Cooperation with customers	0.3121	0.1783	3.0613	0.0801	1.37

Source: Own study.

buildings and land. On the contrary, firms with no contacts with competitors and retaining basic relationships with suppliers and competitors have about 0.60 times fewer odds to take this kind of investment. Direct and good contact with customers helps to adjust the level of investments in buildings and land to the current requirements and future needs of customers. From the investors' perspective, the existence of strong national competition is conducive to making investments and may stimulate searching for customers abroad.

Table 5 includes investment in machinery and technical equipment (IMTE) model. Firms cooperating with foreign customers have 1.73 times higher odds to invest in machinery and technical equipment. On the other hand, firms cooperating mainly with regional suppliers and supporting mainly local customers have about 0.7 fewer odds to invest. Furthermore, firms retaining basic relationships with suppliers have 0.59 fewer odds to invest as well. The reason for this may concern both higher requirements of foreign customers and higher profitability of cooperation with foreign customers. In contrast, the insufficient level of technological advancement of both local and regional technology suppliers is the reason why technology transfer from those partners is not supported.

Table 6 includes investment in computer software (ICS) model. Firms cooperating with both domestic and foreign customers have about 1.6–1.82 times higher odds to invest in computer software. In contrast, firms having no contacts with both competitors and customers and cooperating mainly with local suppliers have about 0.55–0.73 fewer odds to invest in computer software. Investments in computer software are made to reduce the costs of cooperation, carry out complex tasks or improve business communication, and most often these tasks are carried out when the customers are domestic or foreign entities.

Table 7 includes launching new products (LNP) model. Firms cooperating with suppliers have 1.7 times higher odds to implement new products. In con-

Table 5. Investment in machinery and technical equipment model

$\chi^2 = 27.182$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
Regional supplier	–0.2579	0.1486	3.0117	0.0826	0.77
Basic relationships with suppliers	–0.5225	0.1730	9.1267	0.0025	0.59
Local customer	–0.3198	0.1730	3.4185	0.0645	0.73
Foreign customer	0.5509	0.2406	5.2439	0.0220	1.73

Source: Own study.

Table 6. Investment in computer software model

$\chi^2 = 40.907$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
No contacts with competitors	–0.3150	0.1427	4.8711	0.0273	0.73
Local supplier	–0.4705	0.2038	5.3270	0.0210	0.63
Domestic customer	0.5038	0.1495	11.3502	0.0008	1.65
Foreign customer	0.6000	0.2266	7.0115	0.0081	1.82
No contacts with customers	–0.6036	0.2175	7.7031	0.0055	0.55

Source: Own study.

Table 7. Launching new products model

$\chi^2 = 21.792$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
Cooperation with suppliers	0.5331	0.1485	12.8825	0.0003	1.70
No contacts with customers	–0.4588	0.2172	4.4636	0.0346	0.63

Source: Own study.

trast to firms having no contacts with customers that have about 0.63 fewer odds to launch new products. Most implementations of new products are based on new materials and technologies, the acquisition of which requires high expenditures. Furthermore, both new materials and technologies are not always possible to purchase or develop basing on firms resources. The easiest way to obtain technology is direct contact and cooperation with suppliers.

Table 8 includes new technology processes (NTP) model. Firms cooperating with suppliers and cooperating mainly with foreign customers have about 1.57–1.74 times higher odds to introduce new technology processes than firms having no contacts with competitors and cooperating mainly with local suppliers that have about 0.51–0.65 fewer odds to implement new technology processes. International competition imposes the use of more and more modern technological processes to meet the customer's requirements, and the cheapest way to achieve this goal is to acquire technology as part of cooperation

Table 8. Implementation of new technology processes model

$\chi^2 = 36.019$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
No contacts with competitors	–0.4355	0.1577	7.6207	0.0058	0.65
Local supplier	–0.6648	0.2092	10.0960	0.0015	0.51
Cooperation with suppliers	0.5541	0.1617	11.7409	0.0006	1.74
Foreign customer	0.4524	0.2494	3.2894	0.0697	1.57

Source: Own study.

with suppliers possessing the latest technological solutions.

Table 9 includes new production methods (INPM) model. Firms cooperating with suppliers and selling mainly abroad have about 1.58–1.8 times higher odds to implement new production methods.

Table 10 includes non production systems (INPS) model. Firms cooperating with suppliers and selling mainly abroad have about 1.35–1.65 times higher odds to implement non production systems, but firms with no contacts with customers have 0.54 times fewer odds.

Table 11 includes new support systems (INSS) model. Firms cooperating with customers, selling mainly abroad and retaining good neighborly relationships with suppliers have about 1.34–1.71 times higher odds to implement new support systems. In contrast, firms having no contacts with both competitors, cooperating mainly with local suppliers and regional customers and maintaining good neighborly relationships with competitors have about 0.48–0.69 fewer odds to implement new support systems. Cooperation with foreign customers forces support systems to meet new

Table 9. Implementation of new production methods model

$\chi^2 = 20.149$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
Cooperation with suppliers	0.4548	0.1440	9.9624	0.0016	1.58
Foreign customer	0.5852	0.1913	9.3537	0.0022	1.80

Source: Own study.

Table 10. Implementation of non production systems model

$\chi^2 = 36.019$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
Cooperation with suppliers	0.3011	0.1575	3.6524	0.0597	1.35
Foreign customer	0.5031	0.1886	7.1135	0.0077	1.65
No contacts with customers	–0.6159	0.2569	5.7464	0.0165	0.54

Source: Own study.

Table 11. Implementation of new support systems model

$\chi^2 = 37.937$, $P = 0.0000$					
Variable	Coefficient	*SE*	χ^2	*P*	Odds ratio
No contacts with competitors	–0.4811	0.1763	7.4449	0.0064	0.62
Good neighborly relationships with competitors	–0.3732	0.2064	3.2695	0.0706	0.69
Local supplier	–0.7247	0.2509	8.3443	0.0039	0.48
Good neighborly relationships with suppliers	0.5359	0.2367	5.1260	0.0236	1.71
Regional customer	–0.3717	0.1790	4.3150	0.0378	0.69
Foreign customer	0.4286	0.2006	4.5635	0.0327	1.54
Cooperation with customers	0.2950	0.1768	2.7853	0.0953	1.34

Source: Own study.

requirements and needs, which increases the quality and standard of service. Nevertheless, the lower requirements and needs of local customers mean that local suppliers are not as competitive as they could.

Tables 12 and 13 include all identified incentives and impediments grouped by innovation activity. Table 12 includes incentives for R&D expenditure, investment and implementation of innovation. The financial attractiveness of customers from developed countries makes it profitable for companies from developing countries to take risks of innovative activities more than for local and regional customers. Hence, the demand generated by foreign customers is the most important incentive. However, conducting innovative activities for demanding customers requires higher technological advancement, which in turn is not only an expensive, but also a long-term and risky task. The surveyed firms increase their techno-

Table 12. Incentives for research and development expenditure, investment and implementation of innovation

Variable	R&D	INFA	IBL	IMTE	ICS	LNP	INTP	INPM	INPS	INSS
Cooperation with customers	–	–	1.37	–	–	–	–	–	–	1.34
Cooperation with suppliers	1.35	–	–	–	–	1.70	1.74	1.58	1.35	–
Domestic competitor	1.28	–	1.37	–	–	–	–	–	–	–
Domestic customer	–	–	–	–	1.65	–	–	–	–	–
Foreign customer	–	1.57	1.57	1.73	1.82	–	1.57	1.80	1.65	1.54
Good neighborly relationships with competitors	–	1.57	0.69	–	–	–	–	–	–	0.69
Good neighborly relationships with customers	–	1.52	–	–	–	–	–	–	–	–
Good neighborly relationships with suppliers	–	–	–	–	–	–	–	–	–	1.71
Hostile to competitors	–	2.49	–	–	–	–	–	–	–	–

INFA – investment in new fixed assets; IBL – investment in buildings and land; IMTE – investment in machinery and technical equipment; ICS – investment in computer software; LNP – launching new products; INTP – implementation of new technology processes; INPM – implementation of new production methods; INPS – implementation of non production systems; INSS – implementation of new support systems.

Source: Own study.

Table 13. Impediments to research and development expenditure, investment, and implementation of innovation

Variable	R&D	INFA	IBL	IMTE	ICS	LNP	INTP	INPM	INPS	INSS
Local customer	0.45	–	–	0.73	–	–	–	–	–	–
Local supplier	–	0.50	–	–	0.63		0.51	–	–	0.48
No contacts with competitors	–	–	0.56	–	0.73	–	0.65	–	–	0.62
No contacts with customers	0.54	–	–	–	0.55	0.63	–	–	0.54	–
No contacts with suppliers	–	0.52	0.63	0.59	–	–	–	–	–	–
Regional customer	0.76	–	–	–	–	–	–	–	–	0.69
Regional supplier	–	0.60	–	0.77	–	–	–	–	–	–

Explanations as in Table 12.

Source: Own study.

logical level in cooperation with technologically advanced suppliers.

Nevertheless, Table 13 consists of impediments to R&D expenditure, investment, and implementation of innovation. The lack of contacts with competitors, customers, and suppliers preclude firms the most. Moreover, local suppliers and customers prevent firms from innovating. Firms, that are unable to keep pace with changes taking place in the world, have become distrustful and reluctant to introduce new products and technological processes. For many years, most of these companies have been cooperating with the same suppliers and customers that do not set too high requirements. However, in the long run, these entities are doomed to failure.

CONCLUSIONS

The study shows the influence of distance and type of relationships with a competitor, supplier, and customer on the type of innovative activity in medium-high technology companies in Poland. The most firms cooperate with customers and suppliers, invest in new fixed assets including machinery and technical equipment and computer software and implement new technology processes including launching new products. The work shows that cooperation with both foreign customers and suppliers support various innovation activities the best. Moreover, models do not show the impact of firm size and foreign capital on innovation activity. However, it may be a subject of further research [Dzikowski 2018]. Nevertheless, local suppliers and customers prevent firms from innovating. The impact is diversified regarding strength and kind of innovation activity. In general, suppliers seem to be more influential than customers. Furthermore, the influence increases as the distance increases. The assumption that the presence of local competition lowers innovative activity has not been confirmed, but both for local customers and suppliers this phenomenon is true. The study has numerous limitations as it does not allow to distinguish between geographical, social, organizational, institutional and cognitive proximity [Boschma 2005]. Therefore, geographical proximity cannot be an independent and direct explanation of the studied phenomena as it can be explained by other factors not included in the study, such as the existence of a technological and demand gap. The study shows that the most important factor of stimulating innovative activity is the demand generated by foreign or domestic customers. The further research can include networks characteristics or factors concerning organizational, institutional and cognitive proximity.

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SIECI DOSTAW A AKTYWNOŚĆ INNOWACYJNA PRZEMYSŁU ŚREDNIOZAAWANSOWANEJ TECHNOLOGII W POLSCE

STRESZCZENIE

Rosnąca dynamika rynku wymaga zaangażowania coraz większej liczby partnerów, w tym dostawców, klientów i konkurentów działających w pobliżu firmy oraz w jej dalszym otoczeniu. Interakcja między uczestnikami takich sieci prowadzi do wymiany wiedzy i informacji, a proces ten przybiera niepowtarzalne formy charakterystyczne dla uczestników i środowiska, w którym występuje. Celem badania było określenie wpływu odległości i rodzaju relacji z konkurentem, dostawcą i klientem na rodzaj działalności innowacyjnej w przedsiębiorstwach średniozaawansowanej technologii w Polsce. W pracy założono, że bliskie kontakty z konkurentem, dostawcą i klientem działającymi w niewielkiej odległości (lokalnie lub w regionie) wspierają działania innowacyjne. Przeprowadzona analiza wykazała, że krajowi i zagraniczni dostawcy oraz klienci i konkurenci wspierają działalność innowacyjną, a największy pozytywny wpływ na stymulowanie działalności innowacyjnej ma współpraca z dostawcami i odbiorcami zagranicznymi.

Słowa kluczowe: innowacja, działalność innowacyjna, przemysł, średniozaawansowana technologia