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The impact of firm size and its ownership on innovation cooperation in medium-high and high technology sectors in Poland

1. Introduction

The innovation has become a widely recognized industry standard over past 30 years. As a result of it not only product life cycle has been shortened, but also many industries have gone global (Grudzewski, Hajduk 1999, p. 37). The importance of innovation in shaping the socio-economic development of countries, regions and sectors is steadily growing (Janasz 2009, p. 260). It is common knowledge that innovation activity occurs not only inside the company but also outside. The important role in this process play external institutions such as competitors, universities and R&D units and government institutions. They contribute to new innovative products and services or take part in value creation (Norman, Ramirez 1993, pp. 65-77).

Initially large companies and imperfect competition were presumed to be the key factors behind innovation (Schumpeter 1960, p.50; Stone, Schwartz 1975, pp. 1-37). Later small and medium companies were believed to have the highest level of innovation potential (Drucker 1992, p.20). There are many empirical evidences for a positive relation

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between innovation activities and firm size (Dachs, Ebersberger, Pyka 2008, pp. 200-229). Large firms are more likely to carry out internal innovative activities and, at the same time establish cooperation partnerships, while small firms choose to carry out exclusively internal innovative activities, or to buy them externally (Veugelers and Cassiman 1999, pp.63-80). The decision to cooperate to innovate depends on the characteristics of the industry. The industrial sector variable plays an important role in the process of understanding the behavioral dimensions of the firms. The probability of innovation cooperation concerns technological opportunities of the firms and the accumulation of expertise (Tether, 2002, pp. 947-967).

Firm size and it ownership apart from affecting innovation activity may have effect on innovation cooperation, but it depend on external environment. Large companies are responsible for the whole economy innovation especially in underdeveloped countries where the number of entrepreneurs is quite low (Janasz 2005, pp. 133-174). In this kind of economy, the share of large companies representing high technology is also low (<5%), which directly translates into a small share of high technology products in international trade. This is particularly disadvantageous, because international exchange significantly affects the flow of new technologies and their implementation in national companies (Woodward 2005, p.4). Firm size affects the pace of innovative processes' initiation (Damanpour 1992, p. 375). Recent research shows that large companies are supported by public funds more often than other kind of enterprises to accelerate the creation of solutions that affect all market. Whereas supporting SMEs help to introduce new solutions, which are limited to the given company (Herrera, Sánchez-Gonzalez 2013, pp. 137-155). According to A.N. Link (1980, pp. 771-782) large enterprises gain innovation supremacy in markets with imperfect competition, but small ones are much more agile and have higher innovation advantage in markets with higher level of competition.

The basic element of the concept of "innovation environment" (Aydalot, Keeble 1988, p. 51) is an innovation collaboration, which plays an important role in the flow of knowledge. It is a foundation in the theory of growth (Porter 1998, pp. 77-90) and the concept of national, regional and sectoral innovation systems (Lundvall 1992, pp. 1-19; Cooke, Uranga, Gomez 1997, pp. 475-491). It is also a key element of networks and industry districts (Crevoiser, Maillat 1991, pp. 13-34). The partners of innovative enterprises may be suppliers, customers or other companies (competitors), as well as national or foreign entities from the R&D world.

The main goal of this study is to identify the impact of firm size and its ownership on innovation cooperation in medium-high and high technology sectors in Poland between 2008-2013. It is assumed that large and foreign enterprises are key players in the area of innovation cooperation and they mainly cooperate with foreign research and developments units. Results showed in this paper are a part of results acquired in the project focused on determinants of innovation in industry enterprises in Poland.

2. Medium high and high technology sectors - introduction

One of the types of industry classification is the system based on the intensity of R&D activities. It defines four different industry groups: low technology, medium-low technology, medium-high technology and high technology. The highest expenditure on research and development is in high technology sector. It ranges from 8% to 15% of income. This group includes aircraft and aerospace industry, production of office machinery and computers, consumers electronics manufacturing and pharmaceutical industry and the production of medical instruments, optical and precision equipment. In medium-high technology group expenditure on R&D expenditure is between 2 and 4 percent of income. Table 1 shows the classification based on R&D expenditure.

Table 1. The classification of industries for medium-high and high-level technology

PKD Symbol	Description of Polish Classification of Activities (PKD)	The average share of direct expenditure of R&D in the value of production[1]
	High technology	
35.3	Manufacture of air and spacecraft and related machinery	13,3
24.4	Manufacture of basic pharmaceutical products and pharmaceutical preparations	10,5

1 Państwa na bazie których zbudowano ten wskaźnik to: USA, Kanada, Japonia, Dania, Finlandia, Francja, Niemcy, Irlandia, Włochy, Hiszpania, Szwecja i Wielka Brytania. Dane obejmują okres 1991-1999.

30	Manufacture of computers and peripheral equipment	9,2
32	Manufacture of communication equipment	8
33	Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	7,7
	Medium-high technology	
31	Manufacture of electrical equipment	3,9
34	Manufacture of motor vehicles, trailers and semi-trailers	3,5
24	Manufacture of chemicals and chemical products	3,1
35.2+ 35.4+ 35.5	Manufacture of other transport equipment Manufacture of railway locomotives and rolling stock Manufacture of motorcycles and bicycles	2,9
29	Manufacture of machinery and equipment	2,1

Source: Hatzichronoglou 1996, p. 17

3. Methodology of the study

The methodological part of this analysis is based on probity modeling. This instrument allows the researcher to determine the probability of innovative behaviors in relation to a firm size and its ownership (Świadek 2008, pp. 119-132). All models meet the following assumptions: (1) the data came from a random sample, (2) Y can take only two values: 0 or 1, (3) subsequent Y values are statistically independent, (4) the probability that Y = 1 is defined by normal distribution for the probity or logistic distribution for logit model. There is no perfect linear relationship between the variables in the logit model Xi (Lipiec-Zajchowska 2003, pp.129-30). Parameter estimation is performed using the maximum likelihood method (MLE). It allows us to find a vector of parameters that guarantees the highest probability of obtaining the observed value of the sample (Welfe 1998, pp. 73-6). MLE requires the definition of likelihood function and finding its extreme. The nonlinear estimation procedure uses a quasi-Newton algorithm to find the minimum of the loss function. In this way, a collection of the best estimators for the loss function is calculated (Stanisz 2007, pp.190-191). Maximizing the likelihood function for the probity model is made using the techniques used in the nonlinear estimation (Maddala 2006, p. 373).

All calculations were made by the Statistica package. All relations are linear equations, because both innovation cooperation activities (the dependent variables) and firm size and its ownership (independent variables) are binary. Every model is described by two probabilities. P1 determines the probability of innovation activity in a given group of companies. P2 determines the probability of innovation activity in all other groups of companies. If the function parameter is positive (a>0), then P1 takes higher value in a given group. All statistically significant models include standard error (Std).

4. Research sample

The scope of our study concerns innovation cooperation in medium-high and high technology sectors at the level of firm and new to the firm. The survey is based on a questionnaire send by email or conduct during a telephone interview with a manager or company founder. All data was gathered between 2008-2013 in Poland. Its structure represents the data structure introduced by GUS. Information was collected from every Polish region and stored in a database based on commercial and non-commercial sources of information such as Teleadreson, PKT and others. The success rate is about 15%. The final set includes 1355 questionnaires, including 981 (72,4%) from medium-high technology enterprises and 374 (27,6%) from high technology sector. 695 (48,71%) enterprises declare innovation cooperation including 494 (71,08%) firms from medium-high sector and 201 (28,92%) firms from high technology. Next table introduces the structure of research data by technology sector and firm size.

Table 2. Companies by technology and firm size

Technology sector	Micro		Small		Medium		Large		Total	
Medium-high	107	15,40%	171	24,60%	153	22,01%	63	9,06%	494	71,08%
High	79	11,37%	57	8,20%	40	5,76%	25	3,60%	201	28,92%
Total	186	26,76%	228	32,81%	193	27,77%	88	12,66	695	100%

Source: own study

National capital represent 550 enterprises (79,14%) whereas foreign capital firms include 89 companies (12,81%) and 56 (8,06%) units have mix capital. Table 3 shows survey set by industry (PKD symbol).

Table 3. Companies by industry (PKD symbol)

PKD Symbol	Number of firms	Industry share in sector (%)	Industry share in both sectors (%)
33 Manufacture of instruments and appliances for measuring, testing and navigation; watches and clocks	97	48,26	13,96
24.4 Manufacture of basic pharmaceutical products and pharmaceutical preparations	37	18,41	5,32
32 Manufacture of communication equipment	33	16,42	4,75
30 Manufacture of computers and peripheral equipment	31	15,42	4,46
35.3 Manufacture of air and spacecraft and related machinery	3	1,49	0,43
Total high technology	**201**	**100**	**28,92**
29 Manufacture of machinery and equipment	241	48,79	34,68
31 Manufacture of electrical equipment	113	22,87	16,26
24 without 24.4 Manufacture of chemicals and chemical products	76	15,38	10,94
34 Manufacture of motor vehicles, trailers and semi-trailers	45	9,11	6,47
35.5 Manufacture of other transport equipment	12	2,43	1,73
35.2 Manufacture of railway locomotives and rolling stock	7	1,42	1,01
Total medium-high technology	**494**	**100**	**71,08**

Source: own study

5. Innovation cooperation in medium-high and high technology sectors

374 companies declare innovation cooperation with one type of partner (a type does not represent a number of partners), while cooperation with two partners declare 211 firms. 3 partners are claimed by 88 enterprises. The graph 1 shows innovative partners' structure.

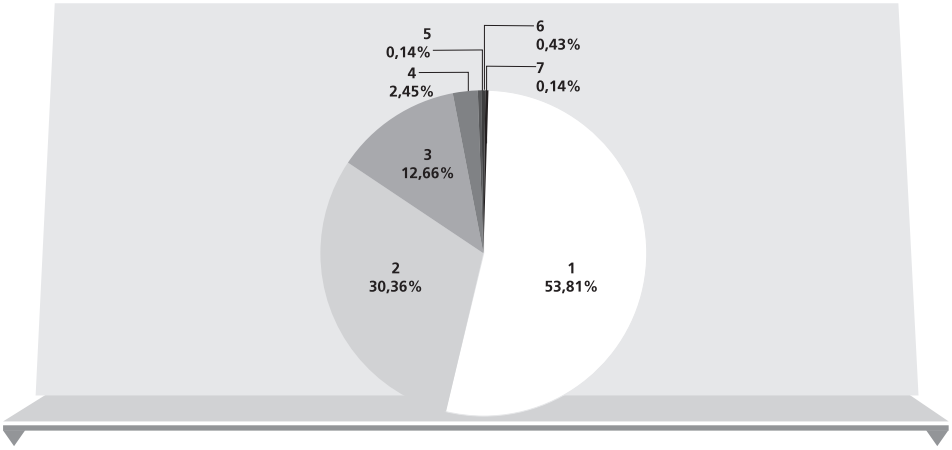

Figure 1. Innovative partners' structure

Source: own research

Suppliers (373) and customers (330) are the most common innovative types of partners. National R&D units (189) and universitites (115) are much less popular. The smallest innovative partners' groups are foreign R&D units (37) and Polish Academi Units (PAN) (42). Graph 2 shows institutions which companies cooperate with.

The next step of the analysis is to examine the relationship between the partners and the size and ownership of the company. For the "firm size" 28 models were built, of which 7 (25%) are statistically significant. Table 4 presents models showing the relationship between the size of the company and its innovative partner.

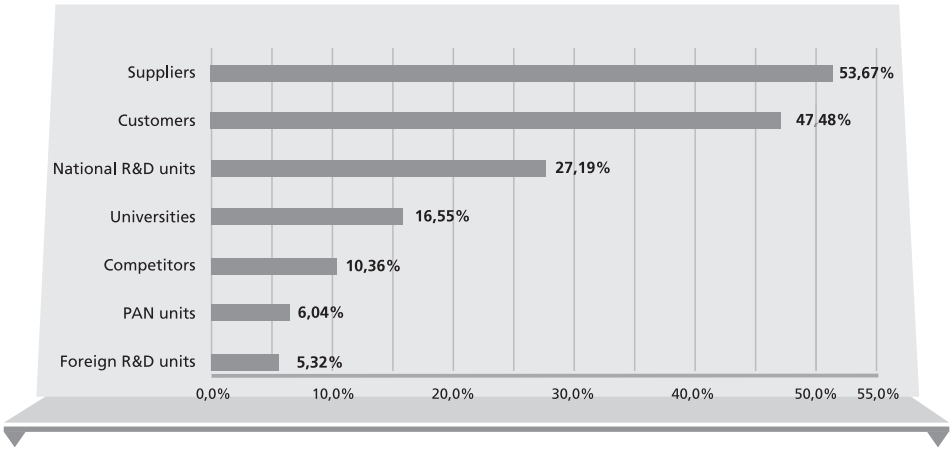

Figure 2. Share of each partner in innovation cooperation

Source: own study

Table 4. Logit models describing innovation cooperation as a function of firm size

Type of innovative partner	Firm size											
	Micro			Small			Medium			Large		
	Std	P_1	P_2	Std	P_1	P_2	Std	P_1	P_2	Std	P_1	P_2
Supplier	+0,34x+0,002			-0,30x+0,19			---					
	0,10	0,63	0,50	0,10	0,46	0,58						
Univeristies	---									+0,35x-1,02		
										0,16	0,25	0,15
National R&D units	-0,34x+0,52			---			+0,22x-0,67			+0,34x-0,65		
	0,12	0,19	0,30				0,11	0,32	0,25	0,15	0,38	0,26
Foreign R&D units	---									+0,57x-1,72		
										0,20	0,13	0,04

Source: own study

The most active in terms of innovation cooperation group of companies are large companies, for which the probability of cooperation with universities is (0.25). In terms of developing new knowledge, this group most frequently collaborates with national research institutes and development units (0.38) and foreign scientific research units (0.13).

Large companies cooperate with the science sector both in staff training and transfer of knowledge as the only group.

Medium-sized enterprises collaborate with national research institutes and development units (0.32). The probability that the smallest businesses will cooperate with national research institutes and development units is 1.6 times smaller (0.30/0.19) than in the other groups of enterprises (negative function parameter). However, this group most frequently collaborated with suppliers (0.63). This kind of activity occurs also in the group of small businesses, but the probability to cooperate with suppliers is nearly 1.3 times smaller (0.58/0.46) than in the other groups of enterprises (negative function parameter).

21 models are built for the variable "firm ownership", of which 4 (19%) are statistically significant. The table 5 lists the models describing the relationship between "firm ownership" and its innovative partners.

Table 5. Logit models describing innovation cooperation as a function of firm ownership

Type of innovative partner	Firm ownership					
	Foreign			Mix		
	Std	P_1	P_2	Std	P_1	P_2
Polish Academy of Science units	-0,79x-1,50			---		
	0,39	0,01	0,07			
National R&D units	-0,40x-0,56			---		
	0,17	0,17	0,29			
Foreign R&D units	+0,97x-1,83			+0,52x-1,67		
	0,18	0,19	0,03	0,23	0,13	0,05

Source: own study

There is no statistically significant models for national companies. In contrast, the most active group of companies are foreign companies, which mostly cooperate with foreign research and development (0.19) units. However, the probability of their cooperation with national research institutes and development units is (0.17) and about 1.7 (0.29/0.17) smaller than in the other groups together. A similar situation occurs in the case of cooperation with Polish Academy of Science units, where the probability of innovation cooperation is (0.01) and is 7 times lower than in the other groups together. The probability of cooperation with foreign research institutions in the group of companies with mixed capital is (0.13).

6. Conclusions

48.71% of the enterprises in the sector of medium-high and high-tech cooperate with external stakeholders in innovation. More than 53% of the companies cooperate with one partner, while nearly 30% cooperate with two partners, and about 12% have three partners. Innovative partners are usually suppliers (53.67%) and customers (47.48%). The least likely referred partners are foreign research units (5.32%) and the Polish Academy of Sciences (6.04%) units.

Large and foreign companies take most frequently innovation cooperation. They mainly work with foreign research and development centers. Large companies as the only group cooperate with the science sector both in staff training and knowledge transfer. The probability of their cooperation with universities is (0.25). In terms of developing new technology large companies most often collaborate with national research institutes and development units (0.38) and foreign scientific research units (0.13). Cooperation with suppliers is most often made by micro enterprises (0.63). There are no statistically significant models for customers what may suggest a high diversity of actions in this area. Cooperation with foreign R&D units is also a common type of cooperation in foreign companies (0.19) or mixed (0.13) capital enterprises. The national capital is not conducive to innovation cooperation.

Abstract

The impact of firm size and its ownership on innovation cooperation in medium-high and high technology sectors in Poland

The main goal of this study is to identify the impact of firm size

and its ownership on innovation cooperation in medium-high and high technology sectors in Poland between 2008-2013. The most open for innovation cooperation are large and foreign enterprises which mainly cooperate with foreign and national R&D units and universities.

Keywords: *medium high technology, high technology, innovation cooperation, firm size, firm ownership.*

Streszczenie

Wpływ wielkości i własności przedsiębiorstwa na współpracę innowacyjną w sektorze średnio wysokiej i wysokiej techniki w Polsce

Celem pracy było określenie wpływu wielkości i własności przedsiębiorstwa na współpracę innowacyjną w sektorze średnio wysokiej i wysokiej techniki w Polsce w latach 2008-2013. Przeprowadzona analiza wykazała, że najczęściej współpracę innowacyjną podejmowały duże i zagraniczne przedsiębiorstwa, które głównie współpracowały z zagranicznymi ośrodkami badawczo-rozwojowymi.

Słowa kluczowe: *współpraca innowacyjna, sektor średnio wysokiej techniki, sektor wysokiej techniki, własność przedsiębiorstwa, wielkość przedsiębiorstwa.*

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