CASE Network
Studies & Analyses

Knowledge-Intensive Entrepreneurship and Opportunities in Two Polish Industries

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No. 440/2012

Warsaw Bishkek Kyiv Tbilisi Chisinau Minsk

This report was prepared within a project entitled "Advancing Knowledge-Intensive Entrepreneurship and Innovation for Economic Growth and Social Well-being in Europe" (AEGIS) funded by the European Union's Seventh Framework Programme

Keywords: **Knowledge-based economy, Entrepreneurship, Transition, Post-communist, SMEs, Poland**

JEL Codes: **L26; O31; O52; P27**

Graphic Design: Agnieszka Natalia Bury

EAN 9788371785641

Publisher:
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Abstract

Following the broad overview of knowledge-intensive entrepreneurship (KIE), or new firm creation in industries considered to be science-based or to use research and development (R&D) intensively, presented in our previous working paper (Woodward et al., 2012), this working paper presents an analysis of two Sectoral Innovation Systems (Malerba, 2002) in the Polish context, presenting case studies of two industries (software and machine tool manufacturing), based on statistical data, interviews with industry experts, and firm-level case studies. We review three sets of opportunities facing firms in these industries: market, technological, and institutional opportunities. Both of these industries appear to be more innovative, and produce more patents, than Polish industry as a whole; their effectiveness in obtaining public assistance is also above average. The software industry is a young and dynamically growing one everywhere, and Poland is no exception. Companies in the industry tend to be young and very small. In Poland, they are very focused on the domestic market and play the role of "knowledge customizers" rather than "knowledge creators"; in an international comparison, even with other post-communist countries in East Central Europe, the Polish software industry appears to have a low R&D intensity. Companies in the machine tool industry are rather larger and somewhat older, and the industry is stable rather than growing in terms of turnover (and declining in terms of employment). Perhaps surprisingly, they are also more innovative and somewhat more export-oriented. However, an international comparison reveals firms in both of these Polish industries to be less innovative than their counterparts in other European countries.

Acknowledgements

We would like to thank Slavo Radosevic, Mira Lenardić and Slavica Singer for their very helpful comments on earlier versions of this work. The usual disclaimers apply.

1. Introduction

In our previous working paper (Woodward et al., 2012), we presented a broad overview of knowledge-intensive entrepreneurship (KIE), or new firm creation in industries considered to be science-based or to use research and development (R&D) intensively, in the Polish context. This working paper moves to the industry and firm levels of analysis. We present case studies of KIE in two industries (software and machine tool manufacturing), based on statistical data and interviews with industry experts and firm representatives, in order to build up at least a partial description of two Sectoral Innovation Systems (Malerba, 2002),

As in Woodward et al. (2012), we compare the Polish case with those of Sweden, Denmark, the UK, and Germany among the old EU member countries (which we will refer to hereinafter as the EU-15 countries), and the Czech Republic and Latvia among the new ones. The comparisons with Sweden, Denmark and the UK are based on the following reports, prepared within the AEGIS project:

- Bram Timmermans, “Innovation system and knowledge-intensive entrepreneurship: Denmark”
- Jon Mikel Zabala and Charles Edquist, “Innovation system and knowledge-intensive entrepreneurship: Denmark”
- Esin Yoruk, Mila Striukova and Slavo Radosevic, “Innovation system and knowledge-intensive entrepreneurship: United Kingdom”

2. Methods and data sources

For statistical purposes, the two industries – software and machine tools – we focus on in this report are defined as those corresponding to NACE rev 1.1 classifications 72 (computer and related activities) and 29.4 (manufacture of machine tools), respectively.

Looking very broadly at the industrial landscape of the countries concerned, we note, first, that like their Danish counterparts, Polish exporters specialize in relatively low-tech industries, with furniture being one of the country’s main exports. Poland’s exports are quite

diversified in terms of their technology intensity. The country's most important export is furniture, generally regarded as low-tech, but its other important exports range from the natural resource intensive (coal) to medium- and high-tech manufactures such as cars, household appliances, and LCDs (US Department of State, 2011).[1] So software and machine tools can be considered to lie within the mainstream of Polish industry in terms of technology intensity. Turning to the related question of the role of the high-tech sector in the economy, Eurostat data show the similarity of Poland and Latvia (with a very small role of the sector) and of Germany and the Czech Republic (where the sector plays a much more significant role). Germany and the Czech Republic have similar shares of high-tech products in exports – about three times higher than in Poland (the distinction is less pronounced in terms of the share of employment in knowledge-intensive sectors in total employment). The UK is unique in this group of countries in being so specialized in services and the financial sector.

The information presented here regarding the two industries in Poland is based on both statistical data and interviews conducted with industry experts and firm representatives in the spring and summer of 2010.

For the IT industry, eight experts were interviewed, including the following (as well as one who wished to remain anonymous):

- Jacek Czech, Deputy Secretary General, Krajowa Izba Gospodarcza (National Chamber of Commerce)
- Marek Średniawa of the Polskie Towarzystwo Informatyczne (Polish Information Processing Society)
- Jaroslaw Deminet of the Polskie Towarzystwo Informatyczne
- Tomasz Kulisiewicz of the Polskie Towarzystwo Informatyczne
- Dr Łukasz Kulas, secretary of the council of the Pomeranian ICT cluster
- Marita Koszarek of the Gdańsk-based consulting firm BSR Expertise
- Jakub Dąbkowski, a consultant specializing in the areas of e-marketing and project management for SMEs

For machine tools, the following three experts were interviewed:

[1] It should be noted, however, that classifications of industries as high-tech may be misleading in the context of developing and transition countries, which may be specializing in low-tech segments of high-tech industries, or low-end activities within a global value chain, such as assembly (see Srholec, 2007).

- Andrzej Ciszewski, president, Stowarzyszenie Inzynierów i Techników Mechaników Polskich (Association of Polish Mechanical Engineers and Technicians; SIMP)
- Prof. Krzysztof Santarek of SIMP and the Warsaw University of Technology
- Jerzy Stawarz, president of the Gdańsk branch of SIMP

In addition to these interviews with industry experts, we conducted interviews, and prepared case studies, for 12 Polish companies in the software industry and nine companies in the machine tool industry. The software firms were founded between 1986 and 2006, with two founded in the 1980s, two in the 1990s, and eight in the 2000s. The machine tool companies tended to be somewhat older; the years in which they were founded range from 1983 to 2006, with three founded in the 1980s, five in the 1990s, and one in the 2000s. The number of members of the founding teams in software firms ranged from one to nine; in machine tools, from one to three. The number of employees in software firms ranged from 3 to 700; given what we know about the structure of the industry in Poland, microenterprises were vastly underrepresented, with only four such firms among those studied; there were also four small firms (with between 10 and 49 employees), three medium-sized firms (with between 50 and 249 employees), and one large firm. For the machine tool companies, the number of employees ranged from 8 to 220; the group of companies includes one microenterprise, four small firms, and four medium-sized companies.

The statistical data used here come from the Central Statistical Office of Poland (CSO) and Eurostat. The Central Statistical Office provided us with data based on the Community Innovation Survey for the two industries.

3. Computer and related activities

3.1. Structure of the industry

The IT industry In Poland is almost completely a post-transition phenomenon (as are most of the technologies involved). The industry is characterized by a very high rate of churning (that is, high rates of entry and exit of new firms). There are only a handful of large, publicly traded firms in the industry, and these have grown to a large extent by mergers and acquisitions, according to the experts interviewed. As Table 1 shows, this has led to a situation in which the average employment in Polish software firms is very low (three persons).

Table 1. Firms and employment in the Polish software industry, compared with 2 countries

	2002	2003	2004	2005	2006	2007
Avg. employment per firm, Poland	3	3	3	3	3	3
No. of firms, Poland	24,437	25,998	27,536	28,254	29,026	35,288
Employment growth, Poland	na	6.4%	5.9%	2.6%	2.7%	21.6%
No. of firms, Sweden	24,805	27,629	28,9032	30,356	32,173	33,169
Employment growth, Sweden	-6.0%	-4.6%	-10.0%	4.2%	3.7%	7.9%
Avg. employment per firm, Denmark	40	39	43	46	52	56
No. of firms, Denmark	6552	6350	6989	7488	7943	8276
Employment growth, Denmark	na	-5.4%	20.8%	13.5%	21.0%	11.0%

Sources: Eurostat; own calculations based on Eurostat and country reports for employment growth and growth in number of firms. Comparable data for the UK were not available to the author.

The table also shows that Sweden, with a population of a little over 9 million, has almost the same number of firms in this industry as Poland, with a population of 38 million. Denmark has a much smaller number of firms, but the Danish firms tend to be much larger than the Swedish and Polish firms (the overwhelming majority of the latter are microenterprises, whereas the average Danish firm has gone from being a small to a medium-sized enterprise in the 2000s). Based on information in the UK country report, the structure of the British software industry is closer to that of Poland and Sweden than to Denmark's; as of 2007, the UK had 129,555 firms in the industry, with 5.5 employees on the average. Based on the Czech country report, the number of firms in the industry increased from 22,604 in 2002 to 24,348 in 2008; these are numbers similar to Poland's, in spite of a much smaller population, suggesting a similarity to Sweden. In the same period, employment rose from 33,218 to 71,794 (and thus average employment per firm rose from 1.5 to 2.9) – a much higher rate of growth than Poland's. Table 9 also indicates that whereas growth has been constant throughout the analyzed period in Poland, the Scandinavian firms experienced a decline in employment in the early 2000s.

The oldest firms in the industry often started in the early 1990s as distributors of foreign-made PCs and gradually acquired "links" in the value chain, first by moving into the assembly of computers, later creating software, and gradually progressing to the point where they are now producers of specialized programming, computer graphics, internet applications, etc. As the industry has developed, it has become more diversified and its firms increasingly specialized.

According to the experts interviewed, firms tend to be started by people with master's degrees (not doctoral degrees), and these are not necessarily in information sciences. In fact, many entrepreneurs in the industry have no university degree at all.

The interviewed experts agreed that barriers to entry in the industry are low. Bank financing is considered a rarity in the industry, but it is fairly easy to find examples of angel and VC finance. It is important to remember, however, that start-up costs for software firms are generally very low, so a scarcity of external finance is not a significant barrier to entry. Experts also believe that the availability of skilled labor is generally not a problem.

3.2. Entrepreneurial opportunities

Responses to the questionnaire allow us to classify the strategic stances of the respondents' companies. Eight of them describe a product differentiation strategy, three a cost-leader strategy, and one a strategy focused on new markets and segments. The product development strategy of the companies is particularly relevant to the concerns of this project and often represents an intersection of the market and technological opportunities with which we will be concerned in the remainder of this report. Nine of the cases can be described as having dominantly demand-driven product development. Only one characterized itself as having dominantly production- (engineer-) driven product development. In two cases, the roles of demand and production appear to be balanced in product development. The factors most frequently cited as significantly contributing to product development were (previous) knowledge of customer needs and requests from customers; market research was also cited in two cases.

Market opportunities

As described by the experts we interviewed, the Polish software industry is focused on the domestic market, with export mostly limited to a very small number of large firms (though these firms have also started building foreign networks of subsidiaries, including acquired ones). As such, software firms are mostly "knowledge customizers," adapting IT solutions invented elsewhere in the world to the needs of Polish customers, rather than "knowledge creators." Many specialize in producing customized software solutions for clients from a particular industry (e.g., banking), using platforms developed by large multinationals such as Microsoft, Oracle or SAP (see Woodward et al., 2010, 2011). Most firms are small subcontractors of a few large ones, and many operate in very sector-specific niches, focusing on a particular type of customer (e.g., public sector clients, financial sector clients,

etc.). Outsourcing has been an important source of income in the industry in the 2000s, but Poland's competitiveness as location for outsourcing by multinational customers (as opposed to the domestic ones the vast majority of Polish IT firms work for) is highly dependent on the exchange rate (Polish programmers are cheap, but not cheap enough for this to be irrelevant).

According to the Swedish country report, most Swedish firms in this industry also serve the local (domestic) market. However, there is an indication that the internationalization of the Swedish industry is on the whole much more advanced than that of Poland, as the authors write that many firms have moved activities to places like India (although they also state that many of these firms underestimated the cost of outsourcing and have withdrawn from India after being disappointed with the results). The Danish country report also states that most Danish firms in the industry serve the domestic market (which seems rather surprising given the much larger size of the firms in comparison with the Polish and Swedish ones). Foreign investment in the Swedish and Danish software industries is generally considered unattractive, due to high wages and taxes. According to the UK country report, the UK sector is fundamentally different from that in the other three countries analyzed here, as it is largely foreign-owned and export-oriented.

Statistics on turnover in the industry can also be compared to give a picture of market opportunities / demand (Table 2). In all these countries we see the same pattern of growth of demand from 2000 to 2001, then stagnation in the period 2001-2003, followed by strong growth in the period 2004-2007.

Table 2. Turnover in IT (millions of euros; growth rates as percentages in parentheses)

	2000	2001	2002	2003	2004	2005	2006	2007
Czech Republic*	na (14.9)	na (15.4)	na (-3.4)	na (15.1)	na (9.9)	na (37.8)	na (13.4)	na (10.4)
Denmark	5545 (na)	5899 (6.4)	6126 (3.8)	6002 (-2.0)	6615 (10.2)	7358 (11.2)	8705 (18.3)	9684 (11.2)
Poland	2614 (na)	3292 (25.9)	3246 (-1.4)	3281 (1.1)	3692 (12.5)	3982 (7.9)	4545 (14.1)	5504 (21.1)
Sweden	12938 (na)	14,032 (8.5)	12,696 (-9.5)	13,597 (7.1)	14,927 (9.8)	15,930 (6.7)	16,149 (1.4)	17,831 (10.4)
UK	66,629 (na)	74,511 (11.8)	74,459 (-0.1)	74,528 (0.1)	80,366 (7.8)	86,237 (7.3)	88,858 (3.0)	100,113 (12.7)

* Figures refer to sales
Source: Czech country report for Czech data; Eurostat and own calculations based on Eurostat for others

Among the firms interviewed, only one is an exporter (interestingly, and atypically, it is a small company); all the others focus exclusively on local and national markets. The firms

tend to specialize in serving customers from a particular industry (or a small number of industries). The cases included one firm active in the agricultural sector, one in the banking sector, three firms focusing primarily on the municipal sector, two other firms focusing on other public sector customers, one in telecommunications, one specialized in the production of web applications and customers in the IT sector (served by providing programs for programmers), two firms in business software, and one firm (the only exporter) specialized in speech synthesis.

We look at growth in terms of both employment and turnover to gauge the development of market opportunities. Only one company reports decline in both categories, whereas 10 companies reported growth in both categories. For the remaining company turnover was growing, while employment had initially risen and then later declined. So it is clear that almost all of the firms we studied were facing the expanding market opportunities we identified earlier on the basis of national statistics.

Technological opportunities

Given the role, mentioned above, of Polish software producers as knowledge customizers rather than knowledge creators, there is a limited role for technological opportunities (at least in a global sense), which are relevant only for a handful of firms that are creating world-class innovations. Product innovation is almost always evolutionary and incremental; firms have few products, and most new development consists of upgrades. According to the experts we interviewed, Polish universities produce some world-class programmers, but firms seem to show little interest in them (or talk of cases where teams from universities went to firms but were unable to generate commercially successful innovations). On the university side, academics are not interested in problems which are of use for the industry, as software firms are more interested in customizing ERP software than inventing new algorithms; industry-university cooperation is more noticeable with polytechnic institutes in the area of hardware.

This is reflected in the low R&D intensity of the Polish industry compared with other European benchmarks, as shown in Table 3 (demonstrating the low share of R&D staff in employment in the Polish industry) and Table 4 (showing the low share of R&D spending in value added).

Table 3. Share of R&D employment in the number of persons employed (%), software industry

	2004	2005	2006	2007	Average (97-07)
East Central Europe	na	na	na	na	2.71
Western Europe	na	na	na	na	12.51
Czech Republic	6.60	8.06	7.72	7.07	5.45
Hungary	0.88	1.26	1.79	2.23	1.35
Poland	0.90	1.38	1.50	1.47	1.32

Source: Eurostat

Table 4. Share of R&D expenditure in value added, software industry

	2004	2005	2006	2007	Average
EU	na	na	na	na	6.2
East Central Europe	na	na	na	na	2.6
Western Europe	na	na	na	na	8.9
Czech Republic	5.9	6.5	5.5	5.1	5.1
Hungary	1.0	0.9	1. 6	1.6	1.2
Poland	0.7	1.7	1.6	1.6	1.4

Source: Eurostat

The low R&D intensity of the Polish software industry is also demonstrated by Table 5, where we compare IT industry turnover as a percentage of GDP with R&D in the industry as a percentage of GDP. We obtain a measure of R&D intensity by calculating the ratio of R&D spending to turnover in the industry (data in the Czech report were reported in Czech crowns rather than euros and therefore could not be used for the purposes of this comparison). This shows the R&D intensity of the Polish industry to be very low in comparison with its Scandinavian counterparts.

Insofar as they reflect process innovation, data on productivity are also a measure of technological opportunities. Although productivity (Table 6) is roughly similar in all three west European countries (at more than three times the Polish level), for Poland, the Czech Republic and the Scandinavian countries (we don't have multi-annual data for the UK) we see a similar pattern of increasing productivity; we also note that the productivity increase in the Czech Republic and Sweden has been much more dramatic than in Poland.

Table 5. R&D intensity in the IT industry compared (2007)

	A. IT turnover (in millions of euro)	B. GDP (in millions of euro)	C. IT turnover as % of GDP (A/B)	D. R&D as % of GDP	E. R&D intensity of IT (D/C)
Denmark	9684	227,533.9	4.3%	0.31%	0.072837163
Poland	5504	311,001.7	1.8%	0.00012%	0.0000678056
UK	100,113	2,054,237.7	4.9%	na	na
Sweden	17,831	337,944.2	5.3%	0.18%	0.034114719

Sources: Eurostat for A, B, and D; own calculations based on Eurostat data for C and E

Table 6. Turnover per person employed in IT (thousands of euros)

	2000	2001	2002	2003	2004	2005	2006	2007
Czech Republic	na	na	45	na	na	na	na	75
Denmark	126	128	152	153	153	161	167	174
Poland	na	na	47	46	47	50	53	51
Sweden	123	116	111	125	152	156	153	156
UK	na	na	na	na	na	na	na	167

Source: Eurostat

It is worth noting that the dearth of technological opportunities on the Polish market can be related to the poor demand conditions in the country, discussed in Woodward et al. (2012).

Table 7. Innovation in ICT 2006-2008, by number of persons employed

	10-49	50-249	Over 249
Percentage of firms in size category that introduced product or process innovation	27.3	53.7	67.4

Source: CSO

Despite this dearth of technological opportunities, if we compare the figures for the innovativeness of Polish IT firms in various size categories (Table 7) with those discussed for Polish manufacturing in Woodward et al. (2012), we see that firms in this industry are much more innovative than in Polish manufacturing, especially in the medium-sized category; for large firms, the IT percentage is 67.4 versus 60.7 for manufacturing, for medium-sized firms, 53.7 versus 32.7, and for small firms, 27.3 versus 14.6. We also observe in Table A1 in the appendix that software firms file patents somewhat more often than Polish firms in general.

Collaboration for innovation is a subject we discussed in Woodward et al. (2012). What patterns are observed in the Polish software industry, and how do they affect its development? The experts interviewed said that subcontracting and consortia are the dominant (and frequent) forms of cooperation, and that cooperation of small firms is often organized in the form of consortia, but noted that these are not for product development, but

rather for winning and executing contracts. There is very little cooperation with institutions in the S&T sector (the Gdańsk University of Technology is a rare example of a university connected to an IT cluster). One institution of higher learning that an expert we interviewed referred to as using its resources well is the Polish-Japanese Institute of Information Technology in Warsaw, which he said participates in innovative projects.

Table A2 in the appendix shows Polish software firms to enter into contracts for innovation-related collaboration much more frequently than comparably sized Polish firms in general. If we review the data on collaboration in Tables A6.1-A9 (again in the appendix), we can observe some patterns in the software industry and compare them with those for Polish firms with over nine employees. Starting with the picture for the years 2001-2003 in Tables A6.1-A7, it is worth noting first that the number of respondents represents less than 0.5% of the total number of firms in this industry dominated by microenterprises (cf. Table 1); of course, since only firms with at least ten employees were eligible to answer the questionnaire, this eliminates the vast majority of firms in the industry. Bearing that in mind, we observe that firms in the same group and suppliers (in that order) are mentioned most frequently as partners, with customers following at quite a distance, and consultants, competitors and other firms following close behind customers. This provides an interesting contrast to the situation for Polish firms as a whole, where suppliers are dominant. The degree of internationalization observed is significant in all these groups, though lowest in the case of consultants. As in the broader sample, R&D institutes are more frequently mentioned as partners than universities.

Next, we look at the period 2006-2008 (Tables A7.1-A8 in the appendix). What has changed in this time interval? Now suppliers and customers are virtually tied for first place, mentioned twice as often as firms in the same group. (It is worth noting that the greater role of customers probably indicates increased sophistication of demand, and reflects the situation for industry as a whole in most advanced EU countries, where the role of customers and supplies as partners in innovation is much closer to equal than in Poland, where suppliers clearly dominate over customers; see Woodward et al., 2012). Competitors and other firms are now ahead of firms in the same group, and even consultants get one more mention than firms in the same group (in all cases there are significant proportions of foreign partners, though their share among customers is much lower than in suppliers and firms in the same group, and for consultants and competitors and other firms is lower still, lying roughly between 10 and 15 percent). This largely conforms to the developments in the larger sample, where the significance of firms in the same group also fell sharply. Universities have pulled ahead sharply as partners, and are mentioned more frequently than consultants. The

advance of universities as partners was also observed in the larger sample, which reflects two developments of the second half of the 2000s: the increasing sophistication and research intensity of firms in the industry and incentives in EU-financed projects.

Turning to the firms in which we conducted interviews, we find that their founders are very well educated. Two of them have people with PhDs in their founding teams, and only one of the firms has a founder with only secondary education; the founders of all the others have higher education (at the master's level). Moreover, the workforce is also very well educated. The percentage of employees with master's or PhD level qualifications ranges from 13% to 100%, and the non-weighted average in this group of companies is 74%.

None of the software companies we studied has any patents. However, the importance of R&D is illustrated by the fact that four of the firms have a formal R&D unit, and four others stated in the interviews that they felt the entire firm was an R&D unit.

With regard to networking and partnering for innovation efforts, for nine of the software companies we studied, the most important external sources of knowledge used in the innovation process were their customers. Suppliers were found to be more important than customers in one case, and were the second most important partner – after customers – in one case. Consortium partners were named in one case, and commercial labs or R&D firms in one case. Competitors were named among the most important external knowledge sources in six cases. In all cases, these are partners that the companies' respondents ascribed at least a medium level of importance in answering a question on sources of knowledge for the innovation process.

However, inconsistent information seems to be yielded in answers to the question on where the significance of the contributions of external partners to the companies' activities lies. In answering this question, most respondents indicated that partners were important primarily for other reasons than their involvement in the product development process (e.g., finding new customers). Only three out of the 12 respondents assigned external partners a significant role in the product development process in answering this question.

Based on the information reported above on product development strategy, we can say that technological opportunities (technology push factors) are not the primary drivers for product development for at least nine of the companies, where market pull plays a more important role.

Institutional opportunities (and barriers)

There is insufficient comparable information in the reports for the Western European countries to make international comparisons of institutional opportunities for the software industry. For purposes of this report, we will therefore consider the institutional opportunities at the industry level to be identical to those at the national level.

What do national institutions contribute in the way of opportunities for the Polish software industry?

First, one might ask to what extent government is harming the industry (e.g., with its regulatory and tax burdens). There are some mixed opinions among the experts we consulted on this point. One felt that the industry's development (especially with regard to large firms) has been determined less by innovation than by competition for lucrative public sector contracts and related lobbying, though he also admitted that EU accession has helped by making the environment more competitive, and noted that large firms have appeared more recently that are more innovative. However, there seems to be a consensus that the regulatory burden in Poland is not a particularly important problem for this industry; indeed, one expert noted that some regulations (e.g. regarding security) stimulate the development of the industry. With regard to public procurements, one expert complained that the only criterion applied is price, which is not a pro-developmental policy. Another expert noted that by contrast in the private sector, big firms will hire big suppliers even if they are more expensive because they have a proven track record and are therefore seen as less risky. Another problem in dealing with the public sector noted by one expert is the fact that closed code remains the property of the supplier, and as a result public sector customers are often condemned to continue a relationship that has been established with a supplier even if performance is unsatisfactory. Another expert said that Polish practices and regulations in the area of public procurements have a neutral effect on innovation, neither hampering it nor stimulating it, since in any contract the specifications will be precise, the problems to be solved or systems to be delivered are rather standard from the technological point of view, and the supplier cannot change them.

Turning our attention to the programs and instruments that the public authorities use to stimulate economic development, we note that business incubators, which have played an important role in the business support policy repertoire of the Polish authorities in the last two decades (see Woodward, 2001), are not felt by the experts interviewed to be crucial to the development of the industry, but that technology parks often have several IT firms.

Table A10 in the appendix shows us that software firms received public financial assistance for innovation much more often than Polish firms in general in the comparable size category, and the gap between this industry and the larger sample is due to a much higher level of funding from the European Union. As for the larger sample, funding from Polish sources is marginal.

A number of institutional opportunities appear, on the basis of our company interviews, to be particularly relevant for the software industry. One such opportunity is related to the important role of local governments and municipal public service providers (as well as other public sector service providers) as a market for software products; as mentioned above, these markets are the foci of five of the 12 firms studied.

Another institutional opportunity that is relevant to this industry is represented by the publicity provided by awards for product innovations that a number of the firms have received.

We are also concerned with barriers to the development of companies. It is important to note that the most significant barriers to development mentioned by the firms were more often market-related (e.g., limited domestic demand or competition from large companies, including MNCs) than institutional. Six companies mentioned competition from large firms / MNCs, and eight mentioned limited demand.

The most frequently named institutional problem (mentioned by six firms as one of the most significant developmental barriers they faced) was the difficulty in obtaining access to external finance (a seventh firm mentioned it as a secondary barrier). In this context it is worth drawing attention to the opportunities that have been available to a few of these firms to overcome this barrier. One of the firms studied has obtained angel capital, one is publicly listed (on the Warsaw Stock Exchange), and one has been supported by EU research projects (the Framework Programmes). (However, in relation to the latter, another respondent said his company was frustrated by the failure of an application for EU funds, added that he sees the process as overly bureaucratic, and complained about the information available to potential applicants.)

Difficulties with the Polish educational system seem to be implied by the fact that ten companies mentioned difficulties in finding skilled labor as a barrier (albeit most often one of secondary importance), even though, as noted in Section 3.1, industry experts do not believe availability of skilled labor to be a problem in this industry. Problems with networking for innovation purposes in the country are also reflected in the comments of two companies on

the difficulty in finding partners with sufficient technical skills to be of use in product development.

Another set of barriers is technological (e.g., technological risk due to the rapidity of technological change in the industry); two firms named such technological factors as among the most important barriers they faced.

A separate question concerned the most important barriers firms had faced at the time of start-up. Three firms mentioned high taxes; three mentioned the lack of clarity of regulation (including tax regulation); two mentioned bureaucracy (e.g., difficulties in obtaining permits and licenses), and one mentioned burdensome labor regulation. Two firms mentioned corruption and "old-boy networks" that prevented new firms from winning contracts. One firm mentioned lack of respect for intellectual property by the competition; one mentioned the failure of competition law to curb monopolistic practices as well as bankruptcy legislation that makes the cost of failure too great (and thereby increases the level of risk in starting up a company).

4. Machine tools

In Poland – unlike the Czech Republic, where the machine tool industry has a long tradition – there are no associations representing machine tool producers, who tend to belong rather to associations of the industries they produce for. It was therefore difficult to find industry experts to interview.

4.1. Structure of the industry

As just noted, the Polish machine tool industry, although representing a separate NACE classification, is not an industry in anything other than a statistical sense. Whereas in many other countries, such as the Czech Republic, the industry is well-organized (with strong industry associations), and those who work in the industry feel themselves to be linked with other firms in the same industry, in Poland there is no such consciousness, and people in this industry identify rather with the industries of the customers they serve (and belong to their industry associations). The machine tool industry in Poland consists of roughly 1000 firms that are serving a very diverse range of downstream industries. In the nine case

studies, these included such customer industries as agricultural machines, furniture, municipal transport, and mining.

In this industry, as we see in Table 8, in terms of numbers SMEs are dominant (as opposed to microenterprises in the software industry); the biggest producers in the industry are subsidiaries of MNCs (e.g. in the auto industry). Accordingly, the number of firms is smaller, and although the overall trend for the number of firms for the six-year period represented in the table is rising, there are two years in which it fell, unlike the unbroken rise we see for software in Table 1.

The interviewed experts noted that, in contrast to the software industry, barriers to entry in terms of high physical capital requirements are significant in this industry.

Table 8. Firms and employment in the Polish machine tools industry

	2002	2003	2004	2005	2006	2007
Number of persons employed per enterprise	18	16	14	13	14	14
Share of employment in manufacturing total	0.7	0.6	0.5	0.5	0.5	0.5
Number of enterprises	874	843	905	969	946	1031

Source: Eurostat

If we compare this with the other countries, we see that internationally (at least in Europe) the industry has a mixed pattern of decline and growth. In the Czech Republic, the number of firms fell from 436 in 2002 to 368 in 2007 (after having risen sharply between 1998 and 2001). Czech firms in this industry are more than three times larger than Polish ones in terms of employment, with the average firm employing 49 persons in 2007; total employment in the Czech industry fell between 2001 and 2005 before recovering somewhat in 2006 and 2007. In Denmark, which has less than 200 machine tool companies, their number was declining quite steadily throughout the period 1999-2007. In Sweden, the number of firms in the industry increased from 537 to 729 in the period from 1997 to 2007, while total employment fell from 10,463 to 8,915 in that period (indicating that firms are rapidly getting smaller; since the country report also indicates that turnover is growing in the industry, it seems productivity is also rising very rapidly). In the UK, the number of machine tool companies fell from 2285 to 1424 in the period 1997-2007; average employment fell in the same period from 15 to 9.6 persons. We note that total employment fell in Poland as well between 2002 and 2007, but rose quite dramatically in the last two years of that period.

4.2. Entrepreneurial opportunities

With regard to the strategic stances of the companies interviewed, as in the case of the software companies, the product differentiation strategy is dominant, indicated by five companies; two describe a cost-leader strategy, one a mix of cost and differentiation strategies, and one a strategy focused on new markets and segments. The product development strategies can be described as follows: Four of the firms have dominantly production- (engineer-) driven product development; two have dominantly demand-driven product development, and in three, the roles of demand and production appear to be balanced. The factors most frequently cited as significantly contributing to product development were (previous) knowledge of customer needs, requests from customers, and market research (the latter was cited much more frequently than in the case of the software firms).

Market opportunities

The market opportunities facing Polish machine tool manufacturers are specific to the industries the firms deliver to, and the experts we interviewed did not care to make any generalizations on the subject.

As noted in the previous section, an international comparison of data on trends in employment and firm numbers in the industry reveals a quite mixed pattern of growth and decline. Probably the most that can be said is that the demand situation facing the Polish industry seems to be relatively stable in recent years, and most closely resembles that of Sweden's industry, whereas the clearest decline seems to be occurring in the UK. Such an assessment is supported by the data in Table 9, which shows the sharp decline (and only partial recovery) of turnover in the British industry in the period 2000-2007, as opposed to the strong growth in turnover for the industry in the other three countries (including Poland).

Table 9. Turnover in the machine tools industry (millions of euros)

	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	252	315	253	246	na	338	356	350
Poland	383	413	384	337	361	452	557	633
Sweden	1990	1770	1796	1880	1804	2124	2279	2560
UK	3688	3377	2837	2064	2044	2150	na	2494

Source: Eurostat

This is a more internationalized industry than software. Only three of the firms we interviewed focus exclusively on local and national markets; one has 85% of its revenues from exports, and the others depend on exports for between 2% and 20% of their revenues.

Probably to an even greater degree than the software companies, the machine tool companies specialize in a particular product or customers from a particular industry. Our cases included one firm serving the agricultural sector, two serving the furniture industry, one serving the municipal transport industry, one serving the mining industry, one specialized in the production of boilers, and one focusing on machines for the production of screws, and two others producing various other machine tools.

As in the case of the software companies, we use employment and turnover figures to obtain a picture of the evolution of market opportunities. And again just as in the case of software, only one company reports decline in both categories. Six companies report growth in both categories. For one company turnover is growing, while employment initially rose, and then declined. The final company reported growing turnover, but did not report data on employment changes. And so once again we see an overall picture of expanding market opportunities.

Technological opportunities

Not surprisingly, given what we know about R&D spending as a percentage of GDP in Poland generally, the share of R&D spending in value added in the machine tool industry is very low in Poland compared to the three benchmark countries (Table 10). Among the latter, the UK seems to lag far behind the two Scandinavian countries. We see the same pattern with respect to the share of R&D personnel in total employment in the industry (Table 11). Comparing with tables 3-5, although the measures used are not exactly identical, R&D intensity appears to be higher in this industry than in software for the Scandinavian countries and for Poland; however, the gap in Poland is much, much larger. We are unable to explain this.

Table 10. Share of R&D expenditure in value added in machine tool industry

	2005	2006	2007
Poland	1.0	0.6	0.7
Denmark	na	8.2	5.3
Sweden	6.6	6.8	6.6
UK	2.1	na	na

Source: Eurostat

Table 11. Share of R&D personnel in total employment in the machine tool industry

	2005	2006	2007
Denmark	na	9.0	4.5
Poland	1.3	1.1	1.4
Sweden	5.3	5.4	3.9
UK	1.6	na	Na

Source: Eurostat

We find an interesting contrast to this picture in Table 12, which shows the number of patent applications to the European Patent Office per million inhabitants for the four countries. Here the British machine tool industry seems to be in a leading position. However, Poland's position in a distant last place remains unchanged. The fact that Polish machine tool firms file patents somewhat more often than Polish firms in general (see Table A1 in the appendix) reflects all the more tellingly on Poland's performance as a producer of patent applications.

Table 12. Patent applications to the EPO in the machine tool industry (per million habitants)

	2005	2006	2007
Denmark	7.6	5.2	na
Poland	1.1	0.6	na
Sweden	30.1	29.4	na
UK	39.2	29.8	89.2

Source: Eurostat

If we add to this picture the figures on innovativeness in Table A11 in the appendix, it becomes clear that in spite of spending much less on R&D than comparable firms in an international comparison, Polish machine tool producers are introducing innovations more frequently than Polish software firms. It would seem, moreover, that these innovations are successful, by and large, since employment in the industry is quite stable. How is this possible? It is not possible to speculate about this on the basis of the statistical data we have presented here. We can only assume that the country's stock of engineering skill is sufficiently developed to allow the industry to survive (without shrinking appreciably), introducing such innovations as competition makes necessary for such survival. It would also appear that networking contributes to the innovation capacity in the industry.

Table A3 in the appendix shows that Polish machine tool producers enter into contractual relations for innovation-related collaboration more often than the general sample of comparably sized Polish firms. If we review the data on collaboration in Tables A4.1-A9 in the appendix, we can observe some patterns in the machine tool industry and compare them with those for Polish firms with over 49 employees. Starting with the picture for the years 2002-2004 in Tables A4.1-A5 (where we note that the sample of respondents from the machine tool industry is very small), we can see that, as for the larger sample of medium-

sized and large firms, the type of partner indicated most frequently was suppliers, with customers in second place and companies in the same group in third (all of which corresponds to the situation for the larger sample). The only other partner mentioned more than twice is institutions of higher education, again like the situation in the larger sample, where this category is in fourth place. The degree of internationalization revealed in the proportion of foreign partners is quite high, as in the larger sample. Our case studies indicate that machine tool producers are much more frequently exporters than software producers, which is probably the explanation for the higher degree of internationalization of the innovation process in the case of the machine tool producers.

Next, we look at the period 2006-2008 (Tables A8.1-A9 in the appendix) and compare it with the earlier period. Customers have slightly pulled ahead of suppliers as frequently named partners, which contrasts to the situation in the larger sample but is, as we noted in the case of software, in line with the situation in the most advanced European countries. However, as in the larger sample, higher education institutions have moved into third place. Competitors and other firms are in fourth place, followed by firms in the same group. Other partners are insignificant. In the relevant categories, foreign firms continue to represent a large proportion of partners.

Turning to the question of productivity, we see in Table 13 the dramatic growth in labor productivity (gross value added per employee) for all three countries except the UK, where it has remained largely unchanged over the period. (For Poland, most of the productivity gain came in 2002-2005, when employment fell sharply, as shown in Table 8.) We note, moreover, that the tremendous productivity increase in Poland still leaves Polish productivity in this industry far below that of the three Western countries.

Table 13. Gross value added per employee (Full Time Equivalent in the machine tools industry (thousands of euros)

	2000	2001	2002	2003	2004	2005	2006	2007
Denmark	55.0	53.6	55.8	54.5	na	69.4	75.9	82.7
Poland	9.3	12.0	10.9	10.8	12.1	14.7	16.9	18.7
Sweden	75.6	70.8	71.6	80.8	90.9	95.7	101.7	114.4
UK	66.7	59.1	62.3	47.3	53.8	65.3	61.9	69.7

Source: Eurostat

In this industry, as in software, we have a fairly well-educated group of entrepreneurs in the sample of companies we interviewed. One company's founding team includes a person with a PhD. The founders of three of the companies have only secondary education; all others have higher education (at the master's level). The workforce, however, is much closer to the

Polish average. In the companies we interviewed, the percentage of employees with master's or PhD level qualifications ranges from 0% to 70%, and the non-weighted average is 16%.

Patents or utility models have been filed by four of the companies studied. One company reported having both patents and utility models currently; one reported having utility models currently. One reported having had patents in the past, and one reported having had utility models in the past. However, formalized R&D units are a rarity, with only one of the companies having one.

Turning to the question of partnering for innovation and product development, we note that seven of the nine firms named their customers as their most important sources of knowledge for product development. Suppliers were named alongside customers as the most important external knowledge sources by two firms, were considered more important than customers in one, and were named as the second most important external knowledge source – after customers – in two cases. Five firms listed competitors among the most important external knowledge sources, and R&D institutes were among the most important external sources for two firms. In assessing the significance of the contributions of such external partners to the knowledge development process, six of the nine respondents said their partners played a significant role in product development process.

Institutional opportunities

None of the country reports has much to say on the subject of institutional opportunities for this industry. This is probably related to the strong discouragement by the European Commission (in its competition policy) of any industrial policies that are not of a horizontal or regional character. For purposes of this report, we will therefore consider the institutional opportunities at the industry level to be identical to those at the national level (for more information on the subject for our firm-level Polish case studies, see Woodward et al., 2012).

According to the Polish experts interviewed, technology parks and business incubators are irrelevant for this industry, although some presence of machine tool producers in industrial parks can be observed. The irrelevance of industry clusters for this "industry" results from what we said about it at the beginning: firms in this "industry" have nothing to offer each other, and would gain nothing from physical proximity to each other. If physical proximity to anyone is important, it is proximity to their customers, who, as we have noted, are found in extremely diverse industries. So if we were to find them in any Marshallian districts, it would be the districts of their customers' industries, and not of NACE 29.4.

One industry expert said that cooperation is difficult because entrepreneurs are individualists and experiences with cooperation have been negative in the past. Cooperation with research institutes is not promising, because the incentive system in those institutes is based on publications rather than patents or any other industry- or commerce-related metrics. Universities are also not the best partners, as training is not well matched with the needs of industry; moreover, engineering and related subjects are not popular among students.

Table A10 in the appendix shows us that machine tool firms received public financial assistance for innovation more often than Polish firms in general, though in stark contrast to the larger sample, the central government is a much bigger source of this funding than the European Union.

Two types of institutional opportunities that distinguish the machine tool companies we interviewed from those in the software industry we interviewed are university cooperation (mentioned by two machine tool companies) and the EU Structural Funds (from which two of the companies have also benefited).

Turning our attention to developmental barriers faced by this group of companies, we look first at market barriers. Six companies mentioned limited demand (in contrast to the case of software, some linked this to the global downturn, reflecting the higher level of internationalization of the Polish machine tool industry than of the Polish software industry). Three companies mentioned the level of competition in the industry, especially from MNCs.

Institutional barriers seem to be more significant for the firms from this industry than for software firms. Six of them mentioned difficulties in access to external finance. Six mentioned difficulties in finding skilled employees, which seems to be a much more significant barrier for this industry than for software. Again, networking difficulties were indicated by two references to difficulties in finding partners with sufficient skills for technological (product development) cooperation. One firm mentioned burdensome safety regulations as a barrier.

Technology risk was mentioned by two firms; interestingly, one firm indicated the importance of this factor as an incentive for constant innovation.

Asked about barriers experienced when the firms were started up, four respondents mentioned the ambiguity of regulation (in one case regarding labor law, in two others regarding tax law); one of them mentioned the fact that frequent changes in regulations made it necessary to use the services of an accounting firm very frequently. Three companies mentioned the excessive tax burden, although one added that in hindsight this

had not impeded the development of the firm. One mentioned the high costs of labor, one mentioned bureaucracy (the time that had to be spent on obtaining permits and licenses), and one mentioned the lack of effective anti-trust regulation as a minor barrier.

5. Conclusions

How can we sum up the state of KIE in these two industries from the perspective of the various classes of opportunities with which we have been concerned in this discussion (market, technological and institutional opportunities), in the context of Polish KIE as a whole? As we noted in Woodward et al. (2012), all of these sets of opportunities are rather poor in Poland, judging by an international comparison. How do these two industries differ from the picture painted there?

Although, as noted in Section 2, the two industries studied here can be considered to lie within the mainstream of Polish industry in terms of technology intensity, we have seen that both of these industries perform above the average in terms of patents and the introduction of innovations. This would seem to indicate the presence of greater technological and market opportunities in these industries than for the Polish economy as a whole. Moreover, for both industries, the share of R&D spending in turnover is larger than Poland's share of GERD in GDP (in the case of software, well over twice as large), and the share of R&D personnel in employment is also much larger than is the case for the Polish economy as a whole. We have also seen that firms in both industries engage in innovation-related cooperation more frequently than the general population of Polish firms, and that partnering with higher education institutions for innovation purposes has risen significantly in both industries in recent years. All of this indicates that technological opportunities in these two industries are superior to those present in the economy as a whole.

Turning our attention to market opportunities, we unfortunately have less statistical basis for making comparisons between these two industries and the Polish economy as a whole. Certainly it is clear that the market for software has expanded extremely dynamically in the past two decades, and we have seen evidence of increasing customer sophistication. In the case of machine tools, the situation is relatively stable, with employment slightly declining over the five-year period for which data are presented in Table 8.

Finally, with regard to institutional opportunities, we have no evidence about any differences between the regulatory burden facing firms in these two industries and that facing Polish firms in other industries. However, with respect to support from the public sector, we are able to make some observations. As we have seen, cluster formation is irrelevant in the case of machine tools; however, we do observe the emergence of some IT industry clusters in Poland in recent years. Firms in both industries have been more effective in obtaining assistance from the public sector than the general population of firms. However, we observe an interesting difference between the two industries; namely, in the software industry, the source of this funding is predominantly the European Commission, whereas in the case of the machine tools industry, it is national sources.

All of this suggests that these two industries may be among those that are driving the reversal of the long-term trend of declining R&D intensity in industry that we are beginning to see in Poland (see Woodward et al., 2012). However, we have also observed that the Polish machine tool industry is more innovative and R&D intensive than the software industry. This seems to be consistent with the observation of Górzyński et al. (2006) that in Poland industries described as ICT-using are experiencing more rapid productivity growth than those classified as ICT-producing.

How do these two Polish industries stand up in an international comparison?

The IT industry is growing dynamically in all the countries examined. Most of the growing number of firms in Poland and Sweden (most of which are micro-enterprises) serve the domestic market, though the Swedish industry seems to be much more advanced than the Polish one in outsourcing some of its activities. By contrast, the UK industry is largely foreign-owned and export-oriented. However, the large market opportunities in the Polish industry do not translate into large technological opportunities, as we see that Poland's IT industry is much less R&D intensive (in terms of the share of R&D spending in turnover) than its Scandinavian counterparts.

The machine tool industry suffered a decline in all four countries in the early 2000s but has since seen very strong growth in Poland, Denmark, and Sweden, while it has seen only a partial recovery in the UK (which began the decade as the strongest among the four countries, having since been overtaken by the Swedish industry).

With respect to technological opportunities, we observe that R&D and patent activity in the Polish machine tool industry lags behind that in the UK and far behind that in the two Scandinavian countries. So the industry's positive performance in comparison with Polish

industry as a whole reflects very poorly on the technological opportunities for the latter. It appears, therefore, that the upgrading of these industries in Poland in the area of sales and productivity growth does not (yet) translate into comparable technological upgrading, which would close the still large productivity gap between the Polish industries and their counterparts. Entrepreneurship in Poland, even in knowledge-intensive areas, is about growth but is not technology–oriented. We observe cases that constitute exceptions, and note that in Western countries, too, the firms that genuinely operate on the frontiers of technology are exceptional within their industries. However, the exceptions in Poland are still much rarer than in Western European countries, so that while the exceptions in the latter countries actually drive their industries, in Poland they remain quite isolated.

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Appendix

Table A1. Firms that submitted patent applications, 2004-2006 (% of all firms reporting to Central Statistical Office)

Firms with over 49 employees	
Poland total	4.1%
Machine tools (NACE 29.4)	5.8%
Firms with over 9 employees	
Poland total	0.8%
Software (NACE 72)	1.2%

Source: Own calculation based on CSO data

Table A2. Firms with over 9 employees that had contracts for cooperation with other firms or institutions in innovation

	2001-2003	2004-2006	2006-2008
Poland total	9.4%	11.1%	6.6%
Software (NACE 72)	18.1%	26.2%	17.9%

Source: Own calculation based on CSO data

Table A3. Firms with over 49 employees that had contracts for cooperation with other firms or institutions in innovation

	1998-2000	2003	2002-2004	2005	2004-2006	2006-2008
Poland total	12.7%	10.5%	24.6%	24.2%	23.6%	19.6%
Machine tools (NACE 29.4)	13.8%	18.5%	29.6%	34.7%	32.7%	28.1%

Source: Own calculation based on CSO data

Note: Figures in Tables A4.1-A9 indicate the number of firms indicating cooperation with a given type of partner.

Table A4.1. Types of firms with which firms with over 49 employees cooperated in innovative activity, 2002-2004

	Firms belonging to the same group							Suppliers							Customers						
	total	Poland	foreign	EU & EFTA countries	EU candidate countries*	USA	other countries	total	Poland	foreign	EU & EFTA countries	EU candidate countries*	USA	other countries	total	Poland	foreign	EU & EFTA countries	EU candidate countries*	USA	other countries
Poland total	607	241	442	382	42	54	25	1466	1189	683	620	60	63	56	954	756	504	442	92	66	78
Machine tools (NACE 29.4)	5	1	4	2	-	1	1	13	12	5	3	1	1	-	10	7	4	3	-	2	-

* - Croatia and Turkey
Source: CSO

Table A4.2. Types of firms with which firms with over 49 employees cooperated in innovative activity, 2002-2004 (continued)

	Competitors and other firms							Consulting firms						
	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries
Poland total	424	338	190	166	33	22	28	487	422	133	121	8	12	5
Machine tools (NACE 29.4)	1	-	1	1	-	1	1	1	1	-	-	-	-	-

* - Croatia and Turkey
Source: CSO

Table A5. Types of non-commercial partners with which firms with over 49 employees cooperated in innovative activity, 2002-2004

	Units of the Polish Academy of Sciences	R&D institutes	Foreign public sector institutions							Institutions of higher education						
			Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries
Poland total	105	443	77	23	59	42	6	7	10	512	510	12	9	-	-	3
Machine tools (NACE 29.4)	-	2	-	-	-	-	-	-	-	4	4	-	-	-	-	-

* - Croatia and Turkey
Source: CSO

Table A6.1. Types of firms with which firms with over 9 employees cooperated in innovative activity, 2001-2003

	Firms belonging to the same group								Suppliers								Customers							
	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Japan	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Japan	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Japan	Other countries
Poland total	899	602	413	312	80	148	21	92	903	761	350	278	126	189	69	79	454	416	175	146	48	25	5	32
Software (NACE 72)	72	49	35	24	4	22	1	2	70	51	42	20	6	31	1	3	38	30	16	11	8	4	-	9

* - Croatia and Turkey
Source: CSO

Table A6.2. Types of firms with which firms with over 9 employees cooperated in innovative activity, 2001-2003 (continued)

	Competitors and other firms								Consulting firms							
	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Japan	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Japan	Other countries
Poland total	285	189	132	119	16	82	5	11	266	251	77	65	5	10	-	1
Software (NACE 72)	26	23	12	8	5	8	-	-	30	25	8	2	1	5	-	-

* - Croatia and Turkey
Source: CSO

Table A7. Types of non-commercial partners with which firms with over 9 employees cooperated in innovative activity, 2001-2003

	Units of the Polish Academy of Sciences	R&D institutes	Foreign public sector institutions								Institutions of higher education							
			Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Japan	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Japan	Other countries
Poland total	72	317	188	144	94	74	38	23	14	32	185	183	37	28	10	16	3	17
Software (NACE 72)	2	16	17	11	6	-	2	4	-	-	10	10	-	-	-	-	-	-

* - Croatia and Turkey
Source: CSO

Table A8.1. Types of firms with which firms cooperated in innovative activity, 2006-2008

	Firms belonging to the same group							Suppliers							Customers						
	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries
Firms with over 49 employees																					
Poland total	593	283	404	369	59	18	48	1393	1189	763	712	106	73	84	949	807	554	535	80	28	110
Machine tools (NACE 29.4)	5	1	4	1	3	-	-	11	9	6	6	-	1	1	12	9	7	7	-	1	2
Firms with over 9 employees																					
Poland total	402	183	263	246	73	30	35	1143	999	358	323	101	50	21	726	697	177	174	36	13	71
Software (NACE 72)	64	39	38	36	21	6	12	125	94	70	57	47	2	3	124	105	46	44	17	11	17

* - Croatia and Turkey
Source: CSO

Table A8.2. Types of firms with which firms cooperated in innovative activity, 2006-2008 (continued)

	Competitors and other firms							Consulting firms						
	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries
Firms with over 49 employees														
Poland total	504	400	262	244	35	27	42	559	487	168	163	15	2	10
Machine tools (NACE 29.4)	7	5	4	4	-	1	1	-	-	-	-	-	-	-
Firms with over 9 employees														
Poland total	478	441	94	81	16	9	17	438	407	89	78	7	7	1
Software (NACE 72)	79	73	12	12	8	6	5	65	60	7	6	3	-	-

* - Croatia and Turkey
Source: CSO

Table A9. Types of non-commercial partners with which firms cooperated in innovative activity, 2006-2008

	Units of the Polish Academy of Sciences	R&D institutes	Foreign public sector institutions							Institutions of higher education						
			Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries	Total	Poland	Foreign	EU & EFTA countries	EU candidate countries*	USA	Other countries
Firms with over 49 employees																
Poland total	134	458	121	53	78	70	12	1	8	653	646	23	18	1	-	7
Machine tools (NACE 29.4)	-	-	-	-	-	-	-	-	-	8	8	-	-	-	-	-
Firms with over 9 employees																
Poland total	93	162	88	47	44	39	7	4	1	258	244	27	15	3	-	9
Software (NACE 72)	20	18	16	12	5	4	2	1	1	74	71	11	9	-	-	2

* - Croatia and Turkey
Source: CSO

Table A10. Firms that received public financial assistance for innovation-related activity, by source

	2004-2006					2006-2008				
	Total	From local authorities	From central authorities	From EU	6th Framework Program	Total	From local authorities	From central authorities	From EU	6th or 7th Framework Program
Firms with over 49 employees										
Poland total	11.9%	1.6%	4.1%	8.3%	0.9%	9.7%	1.5%	3.6%	6.4%	1.4%
Machine tools (NACE 29.4)	15.4%	-	11.5%	3.8%	-	10.5%	1.8%	8.8%	3.5%	-
Firms with over 9 employees										
Poland total	3.2%	0.4%	0.5%	2.6%	0.3%	1.4%	0.3%	0.3%	0.8%	0.2%
Software (NACE 72)	8.5%	0.6%	0.6%	7.8%	1.2%	4.4%	0.4%	1.7%	2.9%	0.6%

Source: Own calculation based on CSO data

Table A11. Sales of new or improved products as % of total sales in the industry

	2000	2005	2008
Machine tools (NACE 29.4)	38.85	27.22	29.05
Software (NACE 72)	-	19.93*	10.69

* - 2006
Source: CSO