

CASE Network Studies & Analyses

Knowledge-based entrepreneurship in Poland

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No. 408/2010



Warsaw Bishkek Kyiv Tbilisi Chisinau Minsk

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This paper was prepared within a project entitled “Knowledge-Based Entrepreneurship: Innovation, Networks and Systems” funded by the European Union’s Sixth Framework Programme



Keywords: knowledge-based economy, entrepreneurship, transition, post-communist, SMEs, Poland

JEL Codes: L26; O31; O52; P27

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Graphic Design: Agnieszka Natalia Bury

EAN 9788371785184

Publisher:

CASE-Center for Social and Economic Research on behalf of CASE Network

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Abstract

The importance of new firm creation in the post-Communist economies of East Central Europe (ECE) has been subject to extensive research. This paper focuses on an area of entrepreneurship which has received relatively little attention in the transition economy context but which is of particular importance for the modernization of the transition economies: knowledge-based entrepreneurship (KBE), or new firm creation in industries considered to be science-based or to use research and development (R&D) intensively. We begin by sketching the situation in Poland's small and medium-sized business sector, then proceed to outline the National Innovation System, with particular attention devoted to the question of finance and policy initiatives. We then turn to the analysis of a series of case studies in industries such as information technology, life sciences, digital navigation technology (mobile mapping systems), aviation, and other industries considered to be science-based or R&D-intensive. Among the issues treated are the resources and strategies involved in KBE in Poland, the relationships (networks) of the firms in question and how they are used for knowledge acquisition, and barriers to innovation. We find that overall Poland appears to be a relatively poor location for KBE. The knowledge resources of the firms studied here are largely in-house; there is very little evidence of distributed, or open, innovation here. These firms have also managed to achieve their successes with little or no help from the state, and have, in most cases, had to rely on networks of families or friends (including those in local industrial clusters) in order to sustain and develop their business.

1. Introduction

The role of new firm creation in restructuring and revitalizing the post-Communist economies of East Central Europe (ECE) has been explored in a large literature on the subject. It is a well-established fact that much of this entrepreneurial wave has occurred in sectors such as services and trade, neglected under central planning. This paper focuses on an area of entrepreneurship which appears to be both underdeveloped and under-researched in the ECE context, but which is of particular importance for the modernization of these economies: knowledge-based entrepreneurship (KBE), or new firm creation in industries which are considered to be science-based or to use research and development (R&D) intensively. In this paper we will focus on the experience of Poland, the largest economy among the new European Union member states, but also one whose economy is characterized by exceptionally low R&D intensity.

To place KBE in Poland in the larger institutional context, we begin with a brief overview of the environment for its development, examining small and medium-sized enterprise (SME) development, the key features of the country's National Innovation System, and the role of venture capital in financing innovation. We then look at recent innovation policy developments and the work of government bodies of particular relevance for KBE. This is followed by the main substance of the paper, devoted to five case studies of firms that represent good examples of KBE in Poland. Here we examine a number of different types of KBE, including not only the start-ups typically examined in the literature on entrepreneurship and academic spin-offs often treated in the innovation literature, but also corporate entrepreneurship, or the development of highly technologically innovative new ventures by well-established incumbent companies. Among the issues treated are the resources and strategies involved in KBE in ECE countries, the relationships (networks) of the firms in question and how they are used for knowledge acquisition, and barriers to innovation on both the demand side and the supply side.

2. Overview of the environment for Knowledge-Based Entrepreneurship in Poland

2.1. The SME sector in Poland

As Surdej (2003, cited in Aidis, 2005) notes, the number of SMEs (i.e., firms with under 251 employees) in Poland grew from just under half a million at the beginning of the 1990s to almost 2.5 million by 1997. While the dynamic growth in this sector has undoubtedly been the primary force driving Poland's economic growth, it is also true that in some respects there is less than meets the eye here. Many registered businesses do not carry on any economic activity, but exist only on paper. Many others exist only as a second form of income for people employed elsewhere (see Balcerowicz, ed., 2002). In fact, many businesses are a substitute for a formal employment relationship, allowing firms to use subcontracting to employ persons *de facto* while avoiding the social contributions that go with a formal employment relationship. In Poland, we can therefore speak of a large share of survival-oriented, or necessity-based, entrepreneurship, as opposed to growth-oriented, or opportunity-based, entrepreneurship (Balcerowicz, ed., 2002, and Aidis, 2005).

Research also indicates serious problems with the skill base of Poland's entrepreneurs. Sociological research in mid-1990s showed that in Poland (the most entrepreneurial of the NMS) over 64% of entrepreneurs came from working class or farming backgrounds (Polish Foundation, 1997). According to PARP (2004), between 45 and 48 percent of the founders of firms registered in 2003 and 2004 had a secondary or vocational education, while 27% had higher education. Moreover, one half of these persons had either previously worked as or had not previously worked at all. Obviously, the general picture of entrepreneurship in Poland bears no resemblance to anything that one could call knowledge-based entrepreneurship, and KBE can be considered marginal against the backdrop of Polish entrepreneurship as a whole.

Like small business owners throughout the world, Polish entrepreneurs have traditionally complained about poor access to finance (see discussion in Woodward, 2001). However, as it has matured and grown more competitive, the Polish banking sector has shown more and more interest in the SME sector (see, for example, NBP, 2005). The problems of the Polish (and ECE) venture capital industry, which we will discuss in greater detail below, generally reflect worldwide trends. Moreover, not all of the credit barriers in the sector are on the

supply side: demand for credit is very low among Polish entrepreneurs (Balcerowicz, ed., 2002.), which again reflects the dominance of survival orientation over growth orientation.

2.2. Poland's National Innovation System

By National Innovation Systems we mean the system of institutions serving to further innovation and innovativeness in a given country (see, e.g., Lundvall, ed., 1992; Nelson, ed., 1993). This includes, for example, the education system, public institutions supporting or conducting research and development (R&D) activity or technology transfer, and the R&D departments of firms themselves.

The first question that comes to mind in discussing Poland's National Innovation System (NIS) is whether the country can be said to have such a system at all. While all the elements generally considered to constitute such a system are present in Poland, the links between those elements, crucial for bringing them together to constitute a system, are largely lacking. It is worth noting at the outset that this lack of links is not due to a lack of activity on the part of the public sector (i.e., central, regional and local governments) to create them. In fact, the situation in Poland is similar to that in many other post-Communist countries, and one might well ask whether these countries are not the first in history to have developed all the institutions necessary to constitute national innovation systems without actually having such systems in place.

In our discussion we will begin with a look at R&D spending and innovation in the Polish economy, and then briefly consider some other factors which are crucial for the development of the "information society" and knowledge-based economy, including the country's information and telecommunication infrastructure and education and Science & Technology systems. We conclude this section with a look at how firms cooperate with each other and other institutions in the area of R&D and innovation.

2.2.1. R&D spending and innovation in Polish industry

In terms of R&D spending as a percentage of GDP, Poland is one of the lowest-spending countries in the OECD and the European Union. In contrast to the EU-15 average of 1.88% and the OECD average of 2.24%, Poland's R&D spending was only 0.70% of GDP in 2001 (OECD, 2002), and by 2003 had fallen to 0.56% (Central Statistical Office, 2005).

One of the most important reasons why R&D spending in Poland is so low lies in the way it is financed. The majority of spending (63.4%) is financed by the government, whereas only 32.6% is financed by industry. This is typical for less developed countries with low shares of

R&D spending in GDP, but in countries which are world leaders in R&D expenditure (e.g., Japan, the USA, Sweden, and Finland), the proportions are reversed: the share of industry in R&D spending ranges from 65% to 70%, while government spending amounts to only 20-30% (OECD, 2002).

More important than the low levels of R&D spending in total and in industry is the fact that this spending has been declining in recent years. A low rate of R&D spending can be expected given the relatively low general level of development and the dominance of traditional industries in Polish manufacturing¹, which necessitates the prioritization of investment in modernization of production equipment rather than new product development. But as the economy modernizes and firms gradually increase their innovation capabilities, the share of R&D spending in GDP should rise, and precisely the opposite is happening in Poland.

The share of R&D spending in total innovation-related expenditures is relatively low in Poland. It was only 11.1% in 2003, whereas, for example, innovation-related investments in buildings, machinery and equipment represented 78.9% of total innovation-related expenditures (Central Statistical Office, 2005a). In the old European Union member states, on the average, over 60% of innovation-related spending goes to R&D activity, while innovation-related purchases of machinery and equipment represent under 10% of such expenditures.² In Poland, the share of R&D spending in innovation-related spending was higher in the public sector than in the private sector (13.0% and 10.8%, respectively) and much higher in companies with over 500 employees, where it was about 15%, than in SMEs, where it ranged between roughly 5% and 7% (Central Statistical Office, 2005a).

Poland's Central Statistical Office (CSO) periodically carries out survey research on the innovativeness of Polish manufacturing firms. For the period 1994-1996, 37.6% of firms researched declared that they were engaged in innovation (Central Statistical Office, 1998), meaning that they designed or introduced a new or significantly improved product or process.³ In 2003 39.3% of surveyed manufacturing firms with at least 50 employees declared themselves to be engaged in such innovation (Central Statistical Office, 2005a). CSO research consistently shows the percentage of large firms which are innovative to be much higher than in the case of SMEs: it is well over half in the case of the former, but under 20% for small businesses (Central Statistical Office, 1998, 2002a). The industries with the

¹ For example, furniture is Poland's largest export industry.

² 1996 data based on Eurostat (2001).

³ New, that is, for the given firm, but not necessarily for the country or the world.

highest rates of innovative firms are, for the most part, not ones that one would typically associate with a particularly high rate of innovation; they are tobacco, chemicals, coke and oil refining. Another alarming result is the fact that the highest rates of innovative firms (over 50%) are found in state sector (though this seems to be falling strongly, from 56% in 2002 to 51% in 2003). The rate is also higher in foreign-owned firms (47%) than private domestically-owned firms (35%). Geographically, innovation is strongly concentrated in the areas around Warsaw and Poznan and in Upper Silesia (out of Poland's 16 regions or voivodeships, over half of innovation-related spending was made in these three regions in 2003) (Central Statistical Office, 2005a).

Another indicator of innovation activity is the share of innovative products (introduced within the previous three years) in a firm's total turnover. In Polish manufacturing firms this share fell from 20.9% in 1997 to 18.5% in 2000. For firms in EU and EFTA member states, on the other hand, the average value was 31% in 1996 (Eurostat, 2001).

2.2.2. Information and telecommunication infrastructure

Access to telecommunication and information infrastructure is one of the foundations of the information society and the Knowledge-Based Economy. Here we will show how poorly Poland is prepared for the transition to a KBE in terms of access to telecommunication services and computerization.

A number of ECE countries do well with respect to cellular subscriptions (the Czech Republic and Slovenia, for instance, have some of the highest rates in Europe). However, all ECE new EU member states lag quite far behind the old EU member states when it comes to land lines. Among the EU members represented in this table, however, Poland is in last place for cellular subscriptions and next to last place (ahead of Slovakia) for land lines. According to data of the Polish Office for Telecommunications and Post Regulation (OTPR) for 2004, there is a huge disparity between urban and rural areas, with 41 subscriptions per 100 inhabitants in the latter but only 20 per 100 inhabitants in the former.

Table 1. Number of telephone subscriptions per 100 inhabitants, 2002

Country	Cellular	Land lines
Czech Republic	84.88	36.23
Finland	84.50	54.73
France	84.50	57.00
Slovenia	83.52	40.65
Austria	80.89	48.88
Ireland	75.53	50.24

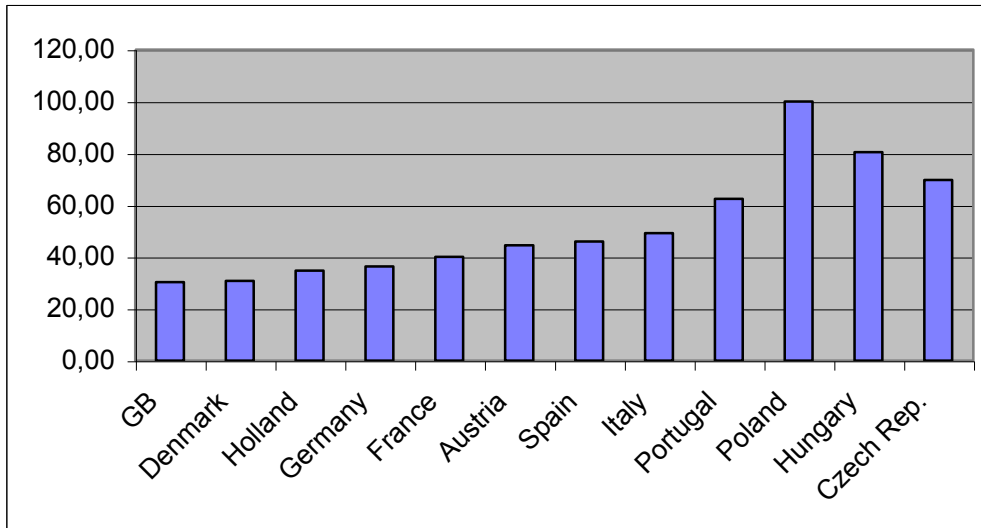
Country	Cellular	Land lines
Germany	72.75	65.09
Estonia	65.02	35.06
Hungary	64.64	36.12
Slovakia	54.36	26.08
Poland	36.26	29.51
Bulgaria	19.12	37.46
Romania	17.17	13.09

Source: International Telecommunication Union (www.itu.int).

As in the case of cellular telephony, there are some new ECE member states that can vie with some old member states in terms of the number of internet users per 100 inhabitants in 2002: this was 42.4 in Germany, 40.1 in Slovenia and 41.3 in Estonia. In Poland, however, it was only 9.8. Like the number of land telephone lines per 100 inhabitants, the number of computers per 100 inhabitants in 2002 followed income per capita more closely. Again Poland found itself deep at the bottom of the heap. The figure was 57.7 in Denmark, 43.1 in Germany, 30.1 in Slovenia, 17.7 in the Czech Republic, and 10.6 in Poland (International Telecommunication Union - www.itu.int). If we look at the percentage of households with a computer in 2003, again we see how far Poland was behind even a fellow ECE country like the Czech Republic: in the latter, the figure was 57%, whereas in Poland it was only 30%. We observe a similar situation with respect to the percentage of households with internet access: 37% in the Czech Republic and 10% in Poland (Progress Report eEurope 2003+).

According to CSO (2005b) data, the most frequently cited reasons for the lack of internet access were the lack of such a need (39% of households), the cost of the equipment (36%), and the cost of access (33%). Indeed, telecommunication connection and service costs in Poland were among the highest in Europe in 2002 (see Figure 1, illustrating the household telecommunication basket, or T-basket, which includes the fixed costs – i.e., installation and subscription costs – and connection costs for households). Data from the Office of Telecommunication and Post Regulation (OTPR) for 2005 show that prices have not fallen in recent years; indeed, some have risen. Similarly, in 1993, 20-hour dial-up access to the internet cost 20% of the average Pole's monthly earnings, as opposed to 5.5% of the average Czech's (Progress Report eEurope 2003+). This hampers the development of internet technologies and services as well as the development of e-commerce, e-learning and e-governance.

Figure 1. Total cost of household telecom-basket in PPP (Poland=100)



Source: Office of Telecommunications and Post Regulation (2002).

The situation in industry with regard to information and communication technology is much better. The vast majority of manufacturing firms (over 95%) use the internet, and a large majority (over 70%) also have Local Area Networks (Central Statistical Office, 2005).

2.2.3. The education and Science & Technology systems

Poland spends 7.5% of its GNP on public education. In the OECD, only Sweden and Finland spend a higher percentage of GDP on public education (UNDP, 2002). Unfortunately, however, the quality of public education is poor. The 2002 Program for International Student Assessment (PISA) report presented research analyzing mathematical and reading literacy among 15-year-olds in OECD countries. The results showed Poland to rank very low on both measures (PISA, 2002).

The results can be seen in the high unemployment of persons under age 25: By the end of 2001, 28.9% of Poland's unemployed were persons under 25 years of age, and 41% of persons aged 15-24 were unemployed, while the overall rate of unemployment was 18.5%. This is due in large measure to the failure to reform the secondary education system, whose graduates were unemployed at very similar rates as persons who had only primary education, in the vicinity of 22% (Central Statistical Office, 2002b).

Problems in the higher education system, however, are more directly relevant to KBE. The number of students in Poland's higher education system tripled in the 1990s, but funding remained largely stagnant, giving Poland the dubious distinction of having the lowest level of funding per student in the OECD (*Gazeta Wyborcza*, 2004). This inevitably meant a drastic

decline in the quality of education, as well as in the quantity of research conducted by faculty members who were under constantly increasing pressure to devote more time to teaching. But in addition to these new problems, the higher education system inherited a number of problems from the Communist era. One of the most important ones is shared with the rest of the education system: a tendency to emphasize rote learning and technical aspects of problems while neglecting the development of creative and independent thinking as well as the ability to work in teams. One of the implications of this is that engineers and persons working in comparable positions responsible for innovation in Poland are well educated only in the technical aspects of their professions, but are very poorly prepared to grasp the larger business implications of innovation.

Of course, the university system could theoretically, like its US counterpart, be a very important part of the National Innovation System, engaging in technology transfer and yielding spin-offs. However, Polish universities suffer from many of the problems often observed in Western Europe, resulting, for example, from the fact that universities are seldom well prepared for cooperation with business and lack the necessary administrative flexibility, professionalism in drawing up contracts, and general awareness concerning business practices (Quevit, 1997).

Another very important component of the Polish S&T system is the country's more than 200 industrial research institutes, created under Communism to take the R&D function out of enterprises. The latter were grouped into industry-wide concerns functioning under branch ministries, with each industry assigned its own institute or group of institutes. Given the fact that the R&D institutes had all too often been engaged in the engineering of imitations of Western technologies, when the central planning system collapsed and the import of Western goods could take place freely, most of the institutes found themselves confronted with a drastic fall in demand for their services. Very often, therefore, they have attempted to cope with the new situation by finding new roles for themselves, with research often being funded exclusively by the state rather than by industrial customers, and relations with industry dominated by provision of services (e.g., the quality testing of materials and products using the institutes' lab equipment) or even engagement in manufacturing activity by the institutes themselves (Radosevic, 2004). We will deal more with this question in the next section.

2.2.4. Innovation-related networks in Poland

Here we briefly summarize the results of research on networks in four Polish industries: automotive, electronics, food and pharmaceuticals.⁴ Of course, it is networks and cooperation that bring together the various components of a National Innovation System to make it a system. The research covered many forms of cooperation between firms and other firms as well as various types of public and not-for-profit institutions, but cooperation related to R&D and innovation was an area of particular interest in this research.

National patterns of cooperation: Relations with customers and suppliers go beyond arm's-length relationships based on price and quality parameters which the firms studied treat as "exogenous"; they work with their partners to improve and learn. Consciousness of quality is high and drives cooperative relationships with customers and suppliers. Foreign-owned companies cooperate with foreign partners (including suppliers) more often than domestically owned companies, but (at least in the case of companies owned by foreign corporations) seem to have well-developed domestic supplier networks. The most important partners in cooperation are suppliers, followed by customers. The most frequently cited areas of benefits from cooperation are delivery terms and timeliness.

What about linkages specifically serving purposes related to innovation and R&D? In R&D activity, the group most often co-operated with is generally suppliers of raw materials; a majority of firms in all industries except food and beverages co-operate with them. Only pharmaceuticals companies co-operate with another group more frequently (in this case, domestic universities). The next two groups most frequently co-operated with are public domestic research institutes and machinery and equipment suppliers. In the innovation process, domestic universities were the partner most often co-operated with, followed by domestic industrial customers. The importance of the latter group is much greater for producers of intermediate goods (automotive and electronics industries) than for producers of consumer goods. Co-operation with foreign industrial customers is much less frequent, and is named significantly more often by electronics companies than by companies in other industries. In general electronics firms engage in co-operation more often than companies in other industries in all stages of the innovation process, whereas the food companies engage in the least. Finally, different stages of the innovation process were analyzed: it turned out that there is a trend to co-operate most in the early stages of innovation and less in later

⁴ This research was conducted by CASE – the Center for Social and Economic Research – with support from the European Commission under the Fifth Framework Programme project entitled "Changes in Industrial Competitiveness as a Factor of Integration: Identifying Challenges of the Enlarged Single European Market." For more details, see Woodward, Gorzynski and Wojcik (2005).

stages, with an increase in co-operation at the end of the process, when results are evaluated. This is the same across all industries.

Thus, these results seem to contrast with much that has been written about cooperation between the science sector and industry in the post-socialist countries of Central and Eastern Europe in general and Poland in particular, indicating that such cooperation maybe more frequent than is sometimes claimed. However, this may be a misleading impression, and further research would be useful in clarifying a number of issues here. First, the researchers did not obtain data that would have enabled them to comment on the dynamics of these relationships. Second, more information about what R&D and innovation-related services are performed by R&D institutes and universities for firms is needed. The research reviewed here produced only sketchy information on this, but there is some evidence that these services very often consist of fairly routine activities such as quality testing of products or of materials and other inputs.

Relationships between the cooperation patterns identified and enterprise competitiveness: Regression results indicated that co-operating with different partners has a positive impact on firm's competitiveness. More specifically, there seem to be a strong positive link between competitiveness and:

- cooperating with suppliers (including acquisition of foreign suppliers) in the areas of product design, access to modern production technologies and increasing production opportunities,
- cooperating with suppliers to improve inventory and delivery management,
- outsourcing related to obtaining new EU suppliers,
- obtaining technical assistance from customers,
- engaging in OEM cooperation and strategic alliances, and
- participating in trade fairs with customers and suppliers.

It is interesting to note that factors relating to R&D cooperation and cooperation with sister companies and subsidiaries did not turn out to have significant effects on the competitiveness of the Polish firms studied.

Differences between foreign-owned and domestically owned companies: Regression analysis showed that foreign ownership appears to be positively related to competitiveness, although there is little difference between domestically owned and foreign-owned companies with respect to the propensity to innovate. Foreign ownership means much greater dynamics than domestic ownership, indicating that domestic players still have a long way to go to

become world players. This is particularly notable with respect to employment growth, including the growth in the numbers of the most highly-skilled employees, which is much stronger in the foreign-owned companies than in domestically-owned ones (though this may be due to the fact that the shares of such workers in their work forces are generally lower than in domestically-owned companies). Importantly, there was no evidence of a low level of backward linkages of foreign-owned companies (for example, the proportions of supplies obtained from the domestic market by companies owned by foreign industrial investors and domestic industrial investors was almost identical).

2.3. Venture Capital in Poland

The underdevelopment of financial tools for financing the development of innovative ventures is often considered to be a serious factor hindering development of KBE in Poland. Nowhere in the world are banks particularly interested in the financing of risky new ventures, so various equity instruments (of which venture capital is the best known) are needed to fill this gap. Venture capital is not a great strength of Continental Europe, but Poland looks weak even compared to its western neighbors.

Poland is no exception. As Ben-Ari and Vonortas (2007) point out, it is difficult to find funds for financing intermediate phases of project or product development (such as preparation for bringing a product to market and marketing it). Finance can be obtained for earlier phases – laboratory work – in the form of research grants (e.g., those given in Poland by the Ministry of Education and Science). Later development phases, in which a new product is launched on the market, are financed by private equity (PE). But the middle phase is particularly difficult to finance, and Poland suffers from this problem as well. The ratio of venture capital to GDP is not only very low (about 0.1% in 2003) in comparison with the giants like the UK or USA, with around 1%. In a PricewaterhouseCoopers (2002) study of venture capital investments in 21 European countries, Poland came out ahead of only two countries – Portugal and the Czech Republic – in terms of absolute volume; in per capita terms, Poland was in last place.

Private equity investments in mature ventures dwarf venture capital. According to a 2003 survey carried out by the European Private Equity and Venture Capital Association (EVCA), private equity and venture capital investments in Poland totaled 177 million euro in 2003, an increase of 47% over the previous year. Buyout and replacement capital investments constituted 76% of this, with most of the investment going to mature companies. This increasing proportion of buyouts mirrors a world-wide trend toward M&As and the increasing size of individual investments; as Ben-Ari and Vonortas (2007) note, “as the average size of

venture capital deals increases and the pressure to provide attractive returns to investors in large funds intensifies, venture capital tends to flow to projects in mature stages of development and to already-proven technologies.”

One of the weaknesses of the Polish market is demonstrated by the fact that only 26 million euro of the funds raised in 2003 – roughly one seventh of the total – was from domestic sources. This contrasts to the situation in the EU, where more than a half of the money gathered by funds in 2003 (15 of 27 billion euro) came from domestic sources (especially banks and pension funds).

There is no shortage of funds available for investments in Poland. The problem is that these funds, coming largely from international sources, are targeted at large, high-return investments, with funds competing with each other all over the world for such projects. But Polish inventors in the Valley of Death have much more modest financing requirements, so they are passed over by the investment funds.

Another problem in Poland, from the point of view of the venture capitalists, is the difficulty in finding suitable exit opportunities. This is primarily due to the weakness of Poland’s capital market, which, although it is the strongest in the region, is still shallow and underdeveloped, often making initial public offerings unattractive.

So the Polish potential Knowledge-Based Entrepreneur is often left to depend on business angels, and here again the Polish conditions are poor. For historical reasons, Poland lacks a strong, well-established class of successful businesspeople with moderate wealth interested in financing up and coming ventures. In North America and Western Europe, these people often provide finance for the intermediate stages of project development.

According to EVCA (<http://www.evca.com/html/home.asp>), private equity and venture capital investors in Poland can be classified into the following groups:

Special funds using public monies, with investment aims that are usually narrowly defined (for instance, supporting SMEs, creating regional infrastructure, or environment protection) and not always based on market principles. They usually manage small amounts of money and offer not only equity investments but also loans, guarantees and consultancy services.

Commercial funds from all over the world, investing the money of private individuals, financial institutions, etc. This group can be divided into two sub-groups:

1. Funds which are active in Poland on a long-term basis, whose investors are foreign individuals. These funds are usually registered outside Poland but have offices in the country.
2. Funds, mainly connected to Polish banks (captive and semi-captive funds), which provide the bulk of the funding.

International funds with global range. Investment activity in Poland is not an express goal of these funds, which simply invest world-wide in projects with the highest possible rate of return.

Informal investors and individuals. Also known as “business angels”. Investors from that group usually make direct investment with the use of capital group. As mentioned above, in Poland this group is very small and invests relatively small amounts of capital in selected projects, often using financial leverage.

3. Recent relevant policy developments and public sector support for KBE

The Polish government has never given policy issues related to innovation and the transition to a Knowledge-Based Economy a high priority – its attention has always been focused rather on the problems of the shrinking “old economy,” in particular extractive and heavy industries. The responsibility for innovation- and technology-related initiatives is scattered amongst various ministries and agencies, no institution with the responsibility for coordinating these initiatives has ever been designated, and no comprehensive and coherent strategy has ever been developed in this area.

Beginning in the late 1990s, the Department of Economic Strategy in the Ministry of Economy began to prepare strategic documents in the area of innovation policy. Some of these were formally adopted by the cabinet, albeit with little effect in practice. However, while a genuine comprehensive strategy has never emerged, certain relevant policy initiatives have made some headway.

Thus, for example, the Ministry of Economy managed to ensure the inclusion of innovation activity and Knowledge-Based Economy development as one of the central priorities in the National Development Plan 2004-2006. The program “Improving the Innovativeness of the Economy in Poland by 2006” (adopted by the cabinet in 2000) was prepared as a supplement to the National Development Program and evidenced a broad approach which targeted not only the diffusion of technology and innovation, but information society development and sustainable development. Consequently, a significant share of Poland’s future Structural Fund assistance has been targeted at innovation-related activity. According to the National Development Plan 2004-2006, the strategic goal of the program is the development of a competitive economy based on knowledge and entrepreneurship. There are three Sectoral Operational Programs (SOPs) dedicated to various types of innovation-related activity: Improving Enterprise Competitiveness, Human Resource Development, and the Integrated Regional Operational Program. The total budget amounts to 7.5 billion euro, which constitutes 50% of Poland’s planned Structural Fund assistance for the relevant period. Moreover, the draft of the National Development Plan for the years 2007-2013 also makes Knowledge-Based Economy initiatives a priority, including a reform of higher education and the development of commercial institutions active in the area of technology transfer (e.g., academic enterprise incubators and R&D centers).

Another important reform in recent years affects the state system for financing research. On April 1, 2003, the State Committee for Scientific Research (KBN) was transformed into the Ministry of Science and Information Society Technologies (merged in October 2005 with the Ministry of Education to create the Ministry of Education and Science). In addition to significantly improving the level of computerization of schools and public services, the main goals of the new ministry include changing science and R&D policy in such a way as to ensure the greater utilization of publicly-funded R&D by industry. Former Science Minister Michal Kleiber, who led the reform effort, emphasized that industry must significantly increase its own funding of R&D activity. One key point of the reforms is reduction of the power of Polish scientists in deciding on the allocation of funding from the ministry’s budget. Under the previous system, KBN – a committee of 60 representatives of the Polish scientific community elected by the scientists themselves – made all decisions on the allocation of grants. This made it impossible for the state to implement a science policy of its own, and also meant that a system of logrolling (a “mutual admiration society”) operated without any effective form of outside control or monitoring. It also made it possible for powerful interest groups within the scientific community – in particular, representatives of the R&D institutes – to ensure that what was ostensibly a project-based grant system in fact became, to a large degree a system of subsidies for inefficient institutions. Under the new system,

representatives of the scientific community evaluate grant proposals, but responsibility for decisions rests ultimately with the minister and his staff, allowing the ministry to develop a policy of prioritization of directions for research (Krzeminski, 2002).

A third important set of reforms is contained in the law on support of innovative activity, drafted by the Ministry of Economy and passed in July 2005, which is aimed at facilitating innovation and technology transfer. The principal reforms introduced by the law, which went into effect in October 2005, are:

- The *Technology Credit* of up to 2 million euro lent at market interest rates for up to six years for the in-house development of a new technology or its purchase from outside (e.g., in the form of patents or licenses).⁵ Depending on the revenues from sales of articles and/or services resulting from investments financed with a Technology Credit, up to 50% of the loan is forgiven (i.e., the state pays it instead of the borrower). Approximately 31 million euros were budgeted for the Technology Credit in 2006. Given the small total amount budgeted and the small size of the maximum loan available, as well as the hurdle of bureaucratic requirements facing potential borrowers⁶, the effect of this instrument is likely to prove marginal in the foreseeable future. Elzbieta Wojnicka, a Polish economist studying innovation, believes that borrowers will be mostly medium enterprises, as the bureaucratic hurdle will prove too difficult for small businesses (Domaszewicz, 2006).
- *R&D center status* is given to a firm if its net income from sales of own research is at least 50% of its total sales revenues (which in turn cannot be less than 800,000 euro). A firm with this status is exempted from paying tax on revenues from sales of its research.
- Changes in the *higher education system*, allowing universities to set up academic enterprise incubators and technology transfer centers. The former are to support the commercial activities of university employees and students which are based on their research results (spin-offs), while the latter are to be sued to diffuse research results to industry, either through service provision, training or research.
- Changes in *tax regulations*, including a revision of income tax exemptions previously available for R&D spending only if it resulted in a successful new

⁵ The law defines a new technology as one which has not been used anywhere in the world for more than five years.

⁶ Among other things, the borrower must submit an opinion from an expert (from, e.g., an institution of higher learning, a unit of the Polish Academy of Sciences, or an R&D institute) testifying that the technology is new, and must cover at least 25% of the total investment costs herself.

product; the exemptions are now available regardless of the outcome of the research. Among other things, the law also introduced a 22% VAT on R&D services, which were previously VAT exempt (the exemption actually hurt providers of such services by forcing them to pay VAT for their inputs but making it impossible to pass the burden on to their customers).

3.1. Work of government bodies which are active in the area of KBE

The Polish government bodies most directly involved with KBE are the Polish Agency for Enterprise Development (Polish acronym: PARP), which is responsible for programs in the areas of SME development, regional development, and support of innovation and technology transfer, and Innovation Center FIRE, founded about three years ago by the Industrial Development Agency, on the initiative of the Ministry of Economy, designed to help start-ups with high technological content develop their business. The budget information presented concerning these organizations can be taken as an indication of the Polish government's low prioritization of issues related to innovation and KBE.

3.1.1. PARP⁷

PARP is a governmental agency under the Ministry of Economy established in 2000 as a result of a merger of three governmental foundations that had been operating since the mid-1990s in the areas of SME support, regional development, and technology transfer. PARP's priority is to manage state and UE funds intended for supporting entrepreneurship and human resources, focusing on SME needs in particular. PARP is also one of the institutions responsible for the implementation of activities financed from the Structural Funds.

To realize its statutory goals of SME support and support for regional development and innovation, PARP uses the following instruments:

- grants to SMEs, SME support institutions, training institutions and labor market institutions (entrepreneurs may receive partial financing of activities for company development, export development, quality systems implementation, application of new technologies, etc.),
- advisory services,
- facilitation of SMEs' access to relevant information, studies and analyses,

⁷ Except where indicated otherwise, the information in this section is taken from the PARP web site: <http://www.parp.gov.pl>

- educational and promotional activities (each year the agency publishes a report on SMEs in Poland as well as a number of other publications and manuals, some of which can be read online; additionally, PARP organizes a yearly contest called “Polish Product of the Future,” the aim of which is to promote innovations and assist in marketing innovative products).

Some KBE-related institutional initiatives of PARP are:

- the “Innovative Entrepreneurs Club,” a forum for collaboration and exchange of information among entrepreneurs using innovative technologies and representatives of the S&T sector,
- the Bank of Technology and Products, which provides information about innovative products and technologies and matches business partners,
- Information and Consulting Points act as “first point of contact” institutions for SMEs. There were 180 such Points in 2004. SMEs may use free-of-charge consulting services covering issues related to commercial activity and enterprise management. The main aim of the Points is to provide information on all available support programs and assist entrepreneurs in the application process. The system of Information and Consultation Points includes the State Innovation Network, which provides SMEs with consulting services related to the commercialization of new technologies (including technology transfer). In 2002 the Information and Consulting Points spent 169,057 hours and 2.9 million euros (95.7% of the funds budgeted for them for that year) providing their services to 42,123 clients.

The 2005 law on support of innovative activity expanded PARP’s role in supporting innovation. Moreover, with respect to KBE-relevant Structural Fund activity, PARP is involved in implementation of the Sectoral Operational Programs mentioned above.

PARP’s expenditures on direct assistance for SMEs (investment and advisory assistance, loans) amounted to 419 million zł in 2004 (in excess of 90 million euros) and 210 million zł in 2005 (over 50 million euros), and spending on indirect assistance for SMEs (promotion of innovation, support of institutions realizing innovation-related projects, etc.) amounted to 14 million zł (approximately 3 million euros) in 2004 and 156 million zł (approximately 39 million euros) in 2005 (Source: email from Paulina Czerniecka, PARP PR, dated 24 April, 2006).

3.1.2. Innovation Center FIRE⁸

The FIRE Foundation was set up in 2002 by the Agency for Industrial Development in cooperation with the Ministry of Economy and Labor. Its major goal is to stimulate both market and financial development of start-up firms operating in the new technology sector and offering products with high commercial potential. The Foundation attempts to bring together representatives of the S&T sector, R&D-intensive enterprises lacking the funds and expertise needed to bring new technologies to the market, and creative employees from different types of enterprises willing to start their own technology-oriented business. For investors (business angels, seed capital and venture capital funds, etc.), FIRE is a partner helping them to find start-up companies that are innovative on a global scale, especially from sectors like biotechnology, nanotechnology, medical equipment, scientific equipment and software.

FIRE has a 3-step support program for start-ups. The first step focuses on identifying innovative ideas and selecting the best ones. During that step, the Foundation provides the entrepreneurs identified as having promising ideas with services such as training, financial aid, market analyses, financial forecasts, and assistance in the preparation of grant applications and offers to potential strategic investors, as well as advisory and consulting services in areas such as organization, law (particularly intellectual property issues), and technological issues.

In the second step, in which the new company is started, a business plan is prepared, and FIRE usually finds a business coach to help the new company with issues of a managerial nature. This coach sometimes becomes a shareholder in the new firm (as does FIRE itself). The final step consists in a 2-year program of coaching, advisory and financial support to put the new company into business networks which will assure its market success.

One of FIRE's start-up successes is Kucharczyk Electrophoresis Technologies. The company develops and produces equipment and chemicals for protein DNA/RNA analysis. One of the firm's innovations is a tool for genotyping and protein analysis – the DNA Pointer System – used for effective genetic diversity analysis. This system is an open platform for the use of several genotyping methods, although it is particularly recommended for a new genotyping technology – the Multitemperature Single Strand Conformation Polymorphism. The DNA Pointer System was created with major financial support from a US biomedical firm

⁸ Except where indicated otherwise, the information in this section is taken from the FIRE web site (<http://www.innowacje.org.pl>) and an interview conducted by Patryk Koc.

identified by FIRE. FIRE also found a Polish business angel from the IT sector who was searching for an investment opportunity. Together the US firm and the Polish business angel made an equity investment of approximately 125,000 euro in February 2005.

It is clear that the resources at the disposal of FIRE are not sufficient to realize its goals. In the years 2002-2005, FIRE had a budget of ca. 400,000 euro and employed 8 persons. In 2004-2005 one new firm was set up with the help of FIRE. For this reason, the Foundation has been forced to focus more on assistance for already existing firms than start-ups. FIRE representatives also mentioned difficulties in cooperation with Polish academics.

3. KBE case studies

The group of companies studied here includes examples of recent start-ups, academic entrepreneurship (i.e., companies created by university personnel to sell products developed in the course of their research), and corporate entrepreneurship (i.e., medium to large incumbent companies in high technology areas which demonstrate dynamic and innovative approaches). In the first sub-section we briefly introduce the firms, providing information about their products and markets (while maintaining their anonymity) and – most importantly – the entrepreneur(s) responsible for their creation and development. In subsequent sections we present comparative information about the firms thematically, beginning with strategies, then continuing with resources (especially knowledge), key business relationships (with special attention given to the roles of customers and other partners), the role of the public sector (including the S&T sector), and competition.

In selecting the companies for these case studies, we were guided primarily by two criteria: industry and entrepreneurship type. With respect to industry, we wanted to achieve a balance whereby not only ICT would be represented; having identified Polish strengths in the life sciences and optoelectronics, we believed it important to represent those industries in our sample of firms (F and A respectively). Even more important was the need to include examples of academic entrepreneurship (A, and perhaps also F) and corporate entrepreneurship (B). It was also important to include at least one company which had benefited from venture capital or private equity investment (E, in our sample), in order to deepen our understanding of how this form of finance affects knowledge-based entrepreneurial ventures in Poland. Additionally, D attracted our attention because of articles

in the business press on start-ups in the Polish aviation industry, indicating that some embryonic clusters might be forming, one of them being in the southern city in which D is located. Companies were identified by reading about them in the business press and in available literature on high-tech industries in Poland.

Information were gathered primarily through semi-structured interviews using questionnaires prepared beforehand; the interview partners were able to familiarize themselves with these questionnaires in advance. All interviews were conducted with persons from the top management of the firms whom we had identified as entrepreneurs. In two cases (C and F) we were able to conduct interviews with a number of persons; in the case of C, with a number of current and former members of the management team, in the case of F, with the president and a number of staff members. Additional information was gathered from the business press.

4.1. The companies and the entrepreneurs

4.1.1. Firm A (Optoelectronics; interviewed June 2005)

This company is a case of *academic entrepreneurship (spin-off)*. The invention on which the company's commercial activity was based (a type of infrared detector) was first announced at a conference in the United States in 1980. Production was set up at one of Warsaw's physics institutes thanks to access to American markets, made possible by a US company first contacted at the aforementioned 1980 conference and which acted as a distributor for the Poles in the USA. A business was set up in 1987 with three shareholders: the inventor (a professor at a technical university in Warsaw), the current vice president (who had done his doctoral research under the inventor), and a third person who left in the early 1990s but who is described by colleagues as the very entrepreneurial creator of the business (it was his idea to create the company). In 1993, the company was converted into limited liability; in 2002, it became a joint-stock company. At this point it gained an investor – an American corporation working on wireless data transmission technologies which made an agreement to purchase a 20% stake in A for almost \$2 million (Domaszewicz, 2003).

The roles of the founders have evolved over time. Currently there are three people with dominant shares: the vice president, the inventor, and the president (with 2/3 of the shares), who joined the firm around 1991. When the company was smaller, the vice president was involved in technology, but in recent years he has concentrated exclusively on managerial responsibilities. Organizationally, the firm has three divisions: two technical and one trade

(there was another technical division earlier, but it was shifted to a sister company because A's American shareholder wasn't interested in financing the technology it dealt with).

A's main product is an uncooled infrared detector with a very short response time. The comparative advantage of the product derives, in medicine, from the infrared detector's being uncooled, making it useful due to the difficulty in using cooled detectors, especially in provincial areas where liquid nitrogen is difficult to come by; in industry its portability makes it useful. Its high speed also makes it useful for scientific research (e.g. in laser technology and nuclear fusion research).

The USA is the company's biggest market, and scientists are the largest customer group. The share of export in sales fluctuates widely from year to year, but on average our interview partner put it at 60-70%, mostly to the US and Japan, as well as Western Europe. A has 16 distributors worldwide. Most domestic sales are to the Polish military. Outside of Poland, A has no important customers in the post-Communist countries of Europe. It is difficult to sell to foreign militaries, as military industries are generally domestic, but the French military has expressed some interest. Our interview partner said the market continues to grow but had been growing faster earlier; however, he added that growth in Europe has been proceeding at a rapid pace and Poland's accession to the EU now allows A to market itself as a European company. The company had turnover of approximately \$2 million in 2004, and our interview partner predicted that it would be 10-15% higher in 2005.

4.1.2. Firm B (Navigation systems; interviewed June 2005)

B is a case of *corporate entrepreneurship*. In summer 2005 B was a wholly owned subsidiary of the oldest company on the Polish market for cartographic publications. B was subsequently acquired by one of the world's leading geographic content providers, a West European firm which was B's biggest customer when the company was still Polish-owned. B provides technological solutions in cartography and has recently been moving in the direction of specialization in digital mapping for navigation systems. For this reason, an R&D unit was established which later evolved into B, devoted to developing and using advanced process technologies in their products. The company produces high quality printed publications of city atlases, city maps, wall maps, bird's-eye photographs and orthophoto maps, and digital cartographic publications based on the latest technologies (using Geographic Information Systems – GIS – and Global Positioning Systems – GPS). The innovative aspect of the navigation systems being developed by the firm is that instead of using aerial photography

like the competition, B uses cameras mounted in cars and original, proprietary software to translate the film made in those cars into navigation systems.

In this company we observe two kinds of entrepreneurs. One is the kind who creates and leaves the company, and the other is the kind of entrepreneur who takes over and develops the company to further success. We see the first type in the previous president of the Polish mother company, established B in 1999. He was responsible for establishing the aforementioned R&D unit, composed of creative young minds, for new process and product development.

The representative of the second kind of entrepreneur in this case is a native Pole who emigrated more than two decades ago and has extensive experience at large multinational enterprises, which are often more bureaucratic than entrepreneurial. He is an entrepreneur by choice, who entered by buying shares in the mother company of B when that company ran out of cash and saw the value of its shares (it is a publicly trade company) drop drastically. A new group of investors acquired the firm, and the cousin of the current CEO of B became chairman of the supervisory board and invited B's current CEO to join by buying shares in the mother company and becoming CEO of B. B's CEO's previous experience has helped in developing the customer base with large foreign corporations, which work with Polish firms only when they are able to establish trust and find a "common language." It was also this ability to establish a rapport with Western partners which led to the recent acquisition.

Fundamental strategic mistakes by the previous mother company president led to the takeover of that company and the subsequent entry of B's current president. Under the former mother company president, for three years priority was given to spending for establishing the foundations of the company, and sales were so neglected that the cash flow of the company was gravely threatened. Although the decision for separating cartography from technological solutions within the company was a good idea in itself, the R&D cycle for software development was miscalculated, according to the current president, and the R&D project was not finished on time. Lack of cash required the company to sell shares to private investors to the extent that major shareholders have changed.

According to B's CEO, roughly 30% of sales are to public sector customers (mostly Polish), and 70% are in foreign markets.

4.1.3. Firm C (Sales Force Automation solutions; interviewed June 2005)

C was founded by three entrepreneurs in 1997; a fourth joined them in 1998. Two of them, an American settled in Poland and a Pole, were the brains of the company and the source of its technological innovations at the beginning but have, to a large extent, withdrawn from involvement with the company; the other two were a father-and-son team of American business angels who provided the initial idea and an initial customer database which later gave rise to the company's technological innovations.⁹

The American "techie," who was the firm's first CEO, had a degree in computer science and mathematics and an MBA and, having worked in the US as a software developer, had moved to Poland in the mid-1990s to work with a USAID program helping Polish companies develop with the assistance of US MBAs. Under this project, he worked with a small software company in northern Poland. He met the younger business angel through a mutual friend who was also working for the USAID program. The two business angels had made a fortune pioneering medical publishing in Poland and Hungary at the beginning of the 1990s and had a large database of doctors due to that business. The two Americans began to talk about database technology and the uses to which the database of doctors could be put. The business angel was interested in using the database as a tool for pharmaceutical companies' direct marketing to doctors, and the "techie" had been involved in developing direct marketing systems in the USA. Thus the idea for a direct marketing firm was born. From the time of its registration until 2001, it was almost literally a garage company, with a location in barracks on the grounds of an R&D institute (the choice of the institute had nothing to do with technology clustering of any sort but was purely price driven).

The Polish "techie" who joined the team of entrepreneurs was finishing a degree in computer science and econometrics at the time he joined the company. He had been a "hacker" in his early teens, importing software and breaking code (which was not illegal in Poland at that time). Later, he started developing software protection systems, and he met C's president through a colleague working at his first employer. At that point, the CEO had noticed that the competition – two Polish companies which had doctor databases and were using them to provide direct marketing services, mostly to pharmaceutical companies – had sales representatives using laptops. At the same time, pharmaceutical companies had the problem that they were unable to observe the effectiveness of sales reps for months at a time when all records were on paper. The CEO had also met someone with a palmtop computer who

was praising it, and had begun to reflect on the possibility of using this portable technology to enable pharmaceuticals sales reps to feed real-time information to their companies regarding sales and orders. He called the manufacturer of the palm device he had seen and got a free device from a local distributor for testing. At this point (in early 1998) the two “techies” went to a country house for the weekend and wrote the first version of the software. An integrated Sales Force Automation (SFA) system was developed which included palmtop computers used by sales reps, the servers through which they contacted their companies to download and upload information, and the software that ran the entire system.

The first customer, a company the business angels knew, came half a year later and paid a monthly fee to use the system. It took a year before the system was fully developed to meet the demands of pharmaceutical MNCs. The latter were reluctant to use an outsourcing solution under which the servers would remain in C’s hands. But C did not want to turn the system over to the customers’ IT directors, because it was still evolving so rapidly. C had a hard time selling the companies on this, as they were apprehensive about security. But in the end the model was successfully marketed, though it remained a loss leader for several years. In 2001, sales from the SFA system were still lagging behind those from direct marketing.

As the new SFA system matured, the company entered a period of internal conflict due to troubled financial performance. The business angels were convinced that it was necessary to hire a new, non-technical, sales-orientated CEO who would more aggressively expand the customer base beyond pharmaceuticals to include Fast-Moving Consumer Goods (FMCG) producers, and hired a consultant to look for one. However, the CEO saw the consulting assignment as the preparation of a new business plan. After the appointment of the new president (a Polish-Canadian who had been marketing director for the Polish affiliate of a major food and beverages MNC), the former CEO was made responsible for closing a deal with a big multinational FMCG producer and developing other international business. At this time the company moved to a much more attractive office located in the old town. Investments in office remodeling and a new logo were financed from shareholder loans from the business angels. However, a year after the appointment of the new CEO, disappointment set in because product development had been neglected and sales were not developing rapidly enough (the new CEO closed only one deal which was his own work), and he left.

⁹ At the time the company was founded, there were two additional Polish partners (from an advertising agency) who withdrew after half a year in disappointment with the rate of growth, which was lower than had typically been the case in Poland in the heady days of the early and mid-1990s.

The turning point for C's SFA system came with the arrival of the aforementioned large FMCG customer, who is responsible for 30% of sales of the system. By the end of 2004, direct marketing accounted for only one fifth of total sales, while the SFA system's share had climbed to 80%.

The third CEO was an American living in Poland for approximately ten years and working in technology leasing. He was a personal friend of the first CEO and at some point began to talk with him about the situation at C. Eager to leave the leasing business and take a managerial position, he expressed his interest to the former CEO. The third CEO took over at the beginning of 2004 and began signing new contracts. At this point the first CEO decided to leave C to become CEO of an unrelated business.

At the time of the interview, the business angels continued to be majority shareholders; the first CEO remained a shareholder but was no longer a board member, and the third CEO had become a shareholder. The Polish partner was still a shareholder and board member, but left in May 2005 to go to Dubai; however, in the summer he was still working on a study on a new technology C has developed (looking at market needs, products with which they need compatibility and interoperability, and setting some preliminary development guidelines).

This technology represents a completely different business model for C. It is something to sell off-the-shelf (as opposed to an outsourcing service, like the SFM system). Technologically, the new product is a system for managing transmissions of very long streams of data. The clientele will be very different and the business model much less service-intensive (as the Polish partner said, they will often be application developers – “techies, who won't ask us for help”).

4.1.4. Firm D (Aviation; interviewed June 2004 and March 2006)

This firm is the most typical example of entrepreneurship in our group, in that it is the one firm among those studied in which we can identify a single person as the entrepreneur (in all the other cases, with the exception of the research institute, the entrepreneurial function has been shared among a number of people, either simultaneously or over time). However, the firm and its products are still in a very early stage of development, not having yet brought its products to market successfully.

The founder of D (we will call him M) began operating independently in the aviation industry in 1986 in a southern Polish city. The company is an example of what its owner describes as

the entrepreneurial spirit that motivated the industry's pioneers in 1920s, whom he describes as having been more aficionados than businessmen. This same spirit has led to the foundation of 13 small aviation firms in the same city since the early 1990s, without any exits; M's was the first. The key factor behind the rebirth of the aviation industry in the city in the 1990s is not related to economic factors but to entrepreneurship – almost a kind of hobby activity – without any financial base to stimulate development. These firms have created the Federation of Aviation Firms in the city.

M had worked earlier at Warsaw Technical University and later in a major Polish aviation industry producer, where he gained practical knowledge and experience. He later worked in his current city of residence in a number of firms, most importantly as a technical director in the glider factory, which provided him with the background necessary to start independent activity in servicing and maintenance of gliders. His entrepreneurship is captured in his words: "People often say: 'I would if I could' and not 'I will do this, now let's think how to do it'."

When he started his own firm in 1986, D was building and servicing gliders. The opportunity to develop creative ideas and to grow came as a result of contacts with acrobatic glider performers. This led to building two completely new and successful glider prototypes for the world championship in 1989-1990 under the aegis and motivation of a Polish-Swiss firm. This helped D's recognition in glider design and production. In the following championship in 1992, the firm was sponsored by a Polish firm and developed a new glider model. The production volume was rather small, 37 for the first model and 40 for the second model.

With the decline of gliding sport, the firm has become interested in innovative design and production of a new generation of jet training aircraft for the army. An aircraft for training is normally heavy (10 tons) and expensive (20 million USD), so D's contribution has been in reducing the weight of the aircraft by eliminating many real elements and replacing them with simulation, which makes it a third of the cost of the training aircraft currently in use. Indeed, in what M describes as a shockingly simple way, D produces a highly effective and maneuverable flying simulator through which all the weapon systems are simulated by a computer, thus making the jets cheap and effective. The crucial point is to find a shareholder to get engaged in production of the aircraft with M. Since M thinks that the project can only be profitable if it finds other customers in addition to the Polish military, he is trying to attract other potential financial investors.

The other current project is a model which M describes as something within their reach. This is a two-seater light plane that, according to M, is based on an invention that solves a basic problem in aviation: although the center of gravity had to be on the nose of the plane for the stabilization of the plane, recent plane constructions have become unstable due to the shift of this weight towards the back of the plane, requiring the use of computers to manage this instability. M says he has invented a solution which moves the weight from the front to the back while maintaining the stability of the plane. While his competitors – Piper and Cessna – are renewing their old models, M wanted to build a user-friendly plane that everybody can use. The goal was to easily board and get off the plane, like a car, without having to walk along the wing. They wanted the plane to be for business people, not for pilots only. They built a prototype and have all the certificates needed for the “special-use” category. It has fulfilled their expectations. The next stage is preparing the model for serial production, and then the certification procedures. As of March 2006, M expected to gain the necessary certification by the end of the year.

4.1.5. Firm E (IT consulting; interviewed June 2004 and June 2005)

E is a provider of internet applications. Our interview partner stressed that it is not an R&D firm, but a service firm, adding that their technologies are usually not developed in-house. However, the way they use those technologies is innovative, he said, adding that ideas they had at the beginning of the decade about on-line customer service are only now becoming the industry standard.

E was formed from the merger of two companies. The first, which provided assistance to clients interested in presenting information about their firms and products on the internet, was founded by two people who had studied marketing and management and a third who was working at a multimedia firm. The second firm was a spin-off created by people who left a multinational company. When one of the firms sought investment from a private equity fund, the latter brought the two firms together and proposed the structure of the merger. The fund had identified synergies that could arise as a result of a merger, based on the complementarities of the capabilities in the two firms: the first firm had graphic skills, skills in communication with customers, and an interesting customer base, while the second firm had sales, project management, and IT consulting, and also had an interesting customer base. The investment occurred in 2000, the merger a year later.

The fund brought ideas about the organizational structure and management; according to our interview partner, not all of those ideas proved to be good, but they helped the firm to

mature. As in the case of C, the fund also brought new management, and again as in the case of C, it is gone now, and the firm is once again managed by its founders. According to our interview partner, the president and financial director the fund had brought made some positive contributions, and there were no conflicts, but when the time came, there was also no trouble in convincing the fund of the need for change.

4.1.6. Research Institute F (interviewed June 2004 and June 2005)

F is an unusual case. Because it is a state-owned industrial research institute, it is in a way close to academic entrepreneurship, but not quite the same. In fact, it doesn't fit into any of the three categories of entrepreneurship. But its business success, due to the entrepreneurial spirit of its director, clearly makes it an example of Knowledge-Based Entrepreneurship.

F was founded in 1930 in a part of eastern Poland which was incorporated into the Soviet Union following the Second World War. Following the war, it was moved to a city in western Poland. The current director of the institute assumed his post in 1987, having been in the institute since 1976 as the research and science director. His professional area is applied chemistry. The institute conducts research on many characteristics of various forms of fibers, including flax, hemp, wool and silk. What is remarkable about the institute is its success in commercializing many of its patents, especially in such areas as clothing and food supplements, but also in many other areas. Like many other Polish R&D institutes, it also realizes significant revenue streams from provision of services (in F's case, they include flammability testing, furniture and construction materials testing, training of fire brigades, students of polytechnics, etc.).

In the communist era, the Institute was actively inventing products for a variety of industries. For instance, linen socks with good absorption capacity were invented 30 years ago. However, at that time these products were not commercialized. F had to wait until ten years ago to become innovative in the market. With the transition, the institute began to sell products that were invented by the staff and as a result, by 2004, 60% of the institute's budget came from other sources than the state.

In the early 1990s, F started to market its socks, as the first product in the market with the transition. The transformation was a 'must' to survive under changing conditions. F has established a new division that deals with marketing and distribution of the products in four shops in four cities (apart from its own shop at the institute's main office); this distribution

network involves cooperation with two clothing producers. Today around 300 products that are more or less 50-50% own production and licensed production have been marketed.

In contrast to many research institutes in the transition period, F's scientific research has not halted with this transformation, but rather gained momentum in related areas. For example, they conduct research on clothing as a health factor (they have proven that polyester clothing increases the level of histamines in blood, while linen clothing reduces it), as well as on food and cosmetic products made from natural fibers. One of their food products is linseed oil, and they also make polymethane from linseed oil (it is worth noting that after an initial decline in flax production at the beginning of the transformation, more and more of F's linseed input is domestic). In cosmetics, a well-known Polish cosmetics company uses F's linseed oil for its products.

4.2. Strategies

For all the companies studied here, innovation is central to their strategy: constant reinvention of their products and services is seen as crucial to staying ahead of competition, or indeed to keeping competitors from emerging – most of them regard themselves as (and seek to continue to be) operating in niche markets without any competitors, a point to which we will return in section 4.6. For the five commercial firms studied, a thread we find running through the interviews (and reflected in ensuing sections) was the importance of foreign markets and customers; Polish customers are of relatively little importance (or when they are important, they are very often subsidiaries of multinationals). This reflects on the poor level of demand within Poland for knowledge-intensive products and services. Many of these organizations are hungry for investment capital and eager to find a strategic investor; indeed, one of them did so during the study period. Several noted, however, that they would not be looking for a Polish strategic investor. For the research institute, this issue is complicated by the fact that it remains state-owned and the state has thus far failed to develop a coherent strategy on the ownership transformation of R&D institutes in Poland.

A's strategy is to move ahead as fast as possible, to stay ahead of potential competition. Our interview partner said described a market situation characterized by network externalities which have not been realized yet: he said that the market needs to grow in order for investor interest to grow to appreciable levels. Many potential investors have shown interest in A, but A is interested only in strategic investors from the industry – investors who have ideas and markets, not just money. Money alone is insufficient to create a market, our interview partner said, adding that A is unable to guarantee a return sufficient to satisfy a financial investor. He

said that in Poland it is difficult to find big companies interested in absorbing small companies that can bring them competitive advantages (e.g., flexibility and new ideas). He said in Poland big companies are interested in buying products, but fail to see the advantages advantage they could gain from helping small companies to develop.

By closely monitoring the developments in the sector and by looking at their customers, who are the biggest three companies in the sector, B knows exactly where it stands in the world market. For the time being, the low costs in Poland make it possible for B to compete with big European firms in software systems; however, the current CEO is aware of the fact that there is no future for them to stay in the software business among the big players. Instead, his plan is to become a leader in 'mobile mapping systems', the new technological solution pioneered by B to develop detailed and comprehensive road maps for car navigation systems.

The development of new technologies has been one of the main strategies of B. Mobile mapping has emerged as a result of this strategy. Under the previous president of B's mother company, B was part of a process of changing the perspective of the mother company – a capital group active in all areas of cartography and cartographic publishing – to search for new ways of gathering and processing geographical resources, moving from traditional ways to digital ones (digital maps and geographical databases). It has achieved this transformation by development of new technologies for collecting, processing and rendering accessible digital geographic data. With the current CEO, the technological activities of the company have been re-shaped and focused, and the company expanded its activity into international markets.

The current CEO's vision for the technology is to aim for complete automation of the translation of film (shot by cameras mounted in cars) into computerized navigation systems. At that point, he says, the company's work will consist almost entirely in the gathering and updating of the information input into those navigation systems, using its fleet of cars.

C plans to continue diversifying its customer base, acquiring more customers from the FMCG sector. The SFA system will remain its core business. There are also thoughts about expanding internationally, both within the EU and in the CIS (though the latter is seen as very risky, and therefore necessitating "serious backing"). Tools like the new technology discussed at the end of 4.1.2 could be made available on licensing basis even to competitors (e.g., for monthly user fees). The company needs to diversify from the current palmtop system, as C has lost a number of deals with companies whose standard hand-held was a

competing model. And there are ideas for the development of entirely new technologies, serving entirely new markets, as well.

M believes in his ability to combine the capability to invent with organizational skills to turn inventions into innovation, i.e. to commercialize them as new products. So the motivation for D as a firm is to create a platform for realizing innovations, rather than innovations creating a platform for the successful growth of a firm. Strategically, the ideology behind the motivation of the founder of the firm was not to make a profit, but to realize design ideas, thus combining technological capabilities with organizational capabilities. He is aware of the fact that there is a lot of risk involved in innovative ideas, and that one must have very strong will to complete the project. He emphasized that the ability to lead – to bring people under one banner – is crucial to success, not just the idea itself.

E originally modelled itself on a major US firm. Knowing that it can never operate in the way big multinational companies do, it has looked for a niche for itself and found it. Today it exploits the first-mover advantages in its sector as a growing medium-sized company. Since its foundation, each new project has enhanced the firm's innovativeness capabilities. E has positioned itself as a quality subcontractor in projects with big multinational companies: it plays with the big players in the market by adding value to their business projects at complementary levels rather than competing with them. The more it is involved in such projects, the more knowledge it extracts from those networks. Having proved its absorptive capacity, E is able to make each network become a tool for improving its innovative capabilities.

As everywhere else in the economy, the transition forced F to undergo transformation from soft-budget to hard-budget management in the early 1990s. The difference between F and many poorly performing government R&D institutes in the 1990s was F's ability to go beyond inventing and patenting new ideas to the next step of commercialization, something at which F has been very successful, in many ways becoming a firm in its own right. With the transition, the well-established tradition of scientific research within the institute has been reinforced through development of marketing capabilities for the innovations of the Institute, which further stimulated its innovative activities, and through improving research links / collaboration with foreign organizations within the EU that not only provide finance but also generate knowledge to be shared, acquired and disseminated internationally. In the future, F's director wants to further develop academic exchanges with other European countries and the US, as well as developing its research network and project portfolio through involvement in EU-funded projects. However, F's status as a state-owned institute make many strategic

decisions complicated or impossible (e.g., the possible privatization and/or restructuring of the institute).

4.3. Resources

As mentioned in the previous section, all the institutions studied have expressed a shortage of financial resources. As we are dealing with knowledge-based entrepreneurship, the most important knowledge resources are contained within each of the organizations. However, intellectual resources need to be constantly renewed, and this is usually done by hiring fresh university graduates (and/or graduate students). Knowledge is also obtained through standard academic channels, such as literature and participation in conferences. A variety of attitudes was found on intellectual property issues. In the cases most directly related to IT (but also in the aviation firm), patenting did not seem to be an issue; at most, copyrighting was used. Some firms expressed little worry about any codified knowledge being “leaked” outside the firm, indicating that they see their human resources as being crucial; however, some other firms were very concerned about the possibility of their intellectual property being appropriated. Interestingly, in one case, the greatest fear concerned the possibility of their largest customer somehow acquiring their technology without paying for it, and a few months later they were acquired by that customer – an indication that practically the entire value of the company rested in that (codified) technology. Polish patents tend to be seen as relatively unattractive, though US and European ones are seen as very expensive.

A

In the beginning A had no money for development. They rented equipment from the physics institute in which they worked and in which they had high prestige because their production was a source of hard currency (from rent).

A has approximately 50 employees. The inventor is still the scientific leader at A, and young employees work under his supervision. Our interview partner said that one of the company's risks is excessive dependency on single asset in the form of this person. Indeed, the three leaders of the company are all past their mid-50s, and our interview partner said finding replacements for generational change is a problem the company needs to deal with (the inventor's son, who works in a lab at A, is one person being groomed for this succession). Many young people come to A from the Warsaw polytechnic institute. A recruits 3rd year students there, suggesting to the faculty that they can provide their good students with good job opportunities as well as opportunities to do research which they can use for their final year projects. When such students go on to work for A after graduation, they are encouraged to get PhDs. A makes an effort not to divide people into scientific and production tasks;

everyone should be multitasked and conception and execution integrated. This, said our interview partner, is necessary for flexibility and continuous product improvement.

It is not difficult, he said, to find people who want to work, but it is difficult to find people who are not only qualified but are driven to continually upgrade their qualifications. Moreover, people who have spent a lot of time in academia have intellectual habits which are not useful (we will return to this point in the discussion of the role of the S&T sector in section 4.5).

Knowledge is the firm's most important resource. For internal knowledge sharing and transfer, a short meeting is held every morning to discuss current problems (led by the inventor). The company intranet also has files that are accessible to everyone in the technology divisions, allowing them to write and read about problems, solutions, future problems to solve, new client expectations, etc. Keeping knowledge in the company: is not considered to be a problem, for two reasons. First, the inventor knows everything going on in the technology area; all others are specialized more narrowly. Second, if anyone but the inventor left, the threat would be minimal because the company does not rest on its laurels but continually advances its technology, so attempts to imitate would be shooting at a moving target. As our interview partner said, knowledge doesn't necessarily accumulate – people at A both learn and forget.

With respect to acquisition of knowledge from outside, there has been no work with consulting companies, but the vice president received a postgraduate degree in marketing and management in the early 1990s. They have not learned anything about technology from their distributors, which have given A markets rather than knowledge. Knowledge is acquired primarily from literature, conferences (the inventor is sometimes invited to foreign universities and has contacts with scientists all over the world), and the new graduates whom the firm hires, but also from scientific customers, including institutes in the USA, Japan, Germany, Switzerland, and Australia.

B

In-house R&D appears to be the most important knowledge resource for the company. Linkages with foreign customers and technology suppliers are also important channels for acquiring advice, information, knowledge, technology, and other resources. Technology suppliers organize regular scientific conferences to introduce their products that are helpful for development of new ideas for process and products in B's area of activity.

With the purpose of developing new digital systems for mapping, the previous mother company president founded the R&D laboratory in a provincial city with young and brilliant minds – graduates of the IT department of the local university, whose sole motivation seems to be their passion for taking on the problem-solving challenges associated with development of the proprietary software. It is these people who came up with the idea for B's mobile mapping technology (using cameras mounted in cars). They gather information through the internet, reading related materials and journals. They personally know each other and cooperate amongst themselves if needed. In 2004, 10 new young people were hired for the lab; so as of June 2005 there were 25 employees in this lab. Growth in employment there depends on the firm's ability to win bids for new projects, the new CEO said; however, he does not worry that these people could be lured away, even though their physical working conditions are not very good, as long as he is able to guarantee them a steady flow of challenges which give them opportunities for personal development. There is no shortage of Polish talent, the CEO said; there is a shortage of Polish customers.

In the headquarters, another 25 people work in the production segment of B. The cartography department, however, consists of 50 people.

Patenting their products does not appear to be profitable in this sector. Patenting, they feel, would do more to disclose than to protect their technologies (as the CEO said, his biggest risk was that his biggest client would acquire his technology; of course, that is what happened a few months after the interview, but that client acquired the firm along with the technology, thus fulfilling the CEO's aspirations). They do, however, have a patent lawyer working for them as a consultant. If they were to apply for a patent, it would be in the US or in the European Patent Office, not in Warsaw.

The pre-existing personal contacts and networks of the new CEO, and especially the knowledge he has acquired about how to establish and maintain such contacts, have been highly significant in establishing new relationships of the company. The recent opening up in international markets is a result of his *savoir-faire*, which allows him to establish trust with business partners. Trust is the main barrier for Polish firms; a vicious circle resulting from their outsider position makes it difficult to enter in international markets without establishing trust of the partners but no foreign company is willing to work with Polish companies as it does not trust them.

On the financial side, the current CEO said during the interview in June 2005 that the company needs West European venture capital investment or a Western strategic investor

interested in marketing and technology. There is insufficient interest from Polish venture funds for reasons discussed in section 2.3, and also due to the fact that such funds would have particularly great difficulty with an exit strategy based on a Polish strategic investor, as strategic investors are usually customers and B has no significant domestic customers. This finance gap could be closed by funding support from the public authorities, but this support never comes either. The company has even tried to work with a consultancy to be able to get money from PARP, but at the time of the interview this attempt had not yet been successful. In the end, as mentioned, the company's quest for a Western strategic investor was successful.

C

In the early stages of development of C's SFA system its competitive advantages consisted in its mobility and simplicity (the competitors were using laptops, though they have since moved to hand-held devices). Direct marketing also served as a "cash cow" during the period of the SFA system's development (C would have gone bankrupt if not for the revenue stream from managing hosting).

At the beginning, the company had access to skilled human capital and finance for the entrepreneurial activity. But sometime later, the need for professional sales and marketing of the products appeared. This led to the conflict situation among the original entrepreneurs described above.

The number of employees has increased from 3 in 1997, to 12 in 2000-2001, to 19 today (9 are software developers, 2 are in sales, 5 in customer support, plus the president and secretary). There are two factors that keep their number of employees relatively low. One is purely legislative: staying under 20 is important to avoid various mandatory social costs (like vacation funds). The other is the level of sales (the number of customers). They hire more people every time they get a new corporate customer. As the current CEO said, the market is there, and customers are there, but their personnel (IT) capacity holds them back. If they could hire the people *before* getting new clients, they could grow faster, but they cannot afford to do that. Demand is not the problem; rather, they need more capital in order to be able to invest: in IT capacity, in technology upgrades, in web site upgrades. At the time of the interview, the firm was looking for an investor and talking with a potentially interested investment fund.

Their IT personnel are recruited from among university students. This is a sort of *perpetuum mobile* – employees bring employees. Although there are universal skills in programming

provided in every IT student's education, all software developers at C have a 6-8 week training period. According to the Polish partner, himself a "techie," programmers are artists and have their own culture; they are often rather uncommunicative, assuming that their colleagues understand their coded and implicit messages, and situations tend to be explosive if there is a misunderstanding. Fortunately, at C there is now an IT manager in charge who coordinates this unwieldy group.

A Rapid Application Development (RAD) tool was used at the very beginning for creating "quick and dirty" versions. The product was based on software generated in this manner for quite a while. This became impossible when a new version of the palmtop computer appeared that was no longer compatible with the old programs. At this point the programming platform was switched; C invested a couple hundred dollars in a compiler, got a software development kit from the internet and rewrote everything from scratch. This was a challenging time but also allowed for many improvements to be made.

C's logos and trademarks are registered, and its software is copyrighted. Protection of IP is not an issue.

D

The firm's work force consists of 35 persons, including 6 engineers – designers (3-4 of them have been working 1-2 years). The others have secondary or vocational school education. M says it is beginning to be a problem to find qualified workers, and adds that the costs of developing employees are also high: someone with a master's degree in engineering becomes a real engineer only after 5 years of work in a firm like this, he says. Updating the knowledge of the work force (e.g., by training) costs too much. Two people are getting postgraduate degrees, M says, but they do this on the weekend.

M says the main motivation of the workers, in addition to their pay, is the opportunity for self-realization. People at D work in teams: there are no "individual geniuses," M says.

According to M, an important source of knowledge for him has been learning from the mistakes of others. For example, D has some design solutions taken from the last plane designed and built exclusively for the Polish military in the late 1970s and early 1980s. However, that model had some design flaws and thus was unsuccessful, and D has eliminated those flaws. Another example: Diesel motors for airplanes were fashionable at one point, and D considered this at one point for the two-seater plane, but when they

observed the problems with diesel motors in other airplanes, they decided not to adopt this solution.

Finance has been a source of huge problems for M. Aviation requires a lot of money, (e.g., in the case of a jet, to draw up plans, create prototype and test it costs \$100 million). Banks aren't interested in risky ventures, M says, especially given problems in the Polish aviation industry in the 1990s. Public sources have also been of little help (we will discuss this in section 4.5). As of March 2006, he says that some firms from Western Europe are trying to help D find finance and a partner for technology development

Having inventions, D has submitted patent applications in the past. The rather slow procedures (time concern) and expensive US patents (money concern) were discouraging, and M no longer believes that having patents will be profitable for his firm. An idea has to be brought to a very advanced state of development before there is something to protect. Making a prototype ready for mass production takes years, not like working faster with gliders, where small changes were made between one model and the next (as in the case of big car manufacturers). For designers, compromise is key; rather than forging into new territory, they improve already existing ideas.

E

The two constituent firms began with nothing – no capital, no employees, and no customers – and built themselves up from scratch.

When three people in different occupations started the business as an internet marketing company, the number of employees was only 12. By the end of 2003, this number had increased to 90, with three businesses within E: first, IT consulting, with 35 employees, as their primary field of activity; second, the technology team, composed of 45 employees dealing with multimedia projects, web-sites and e-commerce applications, and third, a user experience team of 10 employees who are responsible for user experience, ergonomics, and digital marketing. E recruits its employees through market methods (advertising, etc.) and tries to recruit experienced people who can immediately get into projects without extra training. Only when consultants are hired does the company use networking activities to find experienced and reliable people with good track records.

Teamwork is the basis for E's work; extraordinarily skilled technical people who try to dominate the other team members are not welcome. Communicative computer scientists, our interview partner said, become the bosses of those who are not communicative; generally

there are no problems with communication, and everyone has his/her place in the firm. But that place is not a rigidly fixed one. According to our interview partner, there is a lot of internal rotation at E – employees are expected to develop multiple skills and become familiar with many technologies, which allows the firm to realize economies of scope. E claims to have an international culture, meaning that it is flexible to work and build trust with any domestic and international organization without any difficulty. They have worked with major domestically and foreign-owned customers. Within their organization, they had employed international people for some time in the early years (they helped establishing research and consulting divisions). Also, it is company policy to hire people who have experience in multinational companies.

The accumulation of knowledge at E is project-based. Knowledge is shared within the firm through the company intranet (knowledge management tools) as well as through annual internal conferences where IT teams make presentations and have a platform to discuss their projects. Conferences organized by vendors also serve as training for the employees. Moreover, each project starts and finishes with a workshop. Training is also done on a project-by-project basis, depending on the needs of a given project. Being a knowledge-intensive firm, E tries to minimize turnover and prefers to reallocate people within the company rather than see them leave; moreover, before people are reallocated, there are programs for upgrading knowledge (supplementary training). But the company has a policy of keeping good relations with people who do leave the company and have potential to bring E new business.

E produces innovative software based on copyrighted normal code, which is prepared in open code then compiled and delivered to final customer, sometimes in source code. However, E is not an open source company, as they keep the copyrights of all the software they create for their clients, to whom they license the software. They sometimes apply some restrictions, such as no re-sale of the software to third parties. Only in case of use of ready software from companies like Oracle does E transfer the rights to the modifications done to the original software to the client. Of course, copyrights for third-party software used in developing E's software remain with the third party, and this is sublicensed to the final client as part of E's package. According to our interview partner, there is no problem with copyright protection – they have never had to go to court.

F

F owns a web of laboratories throughout Poland (with a total of 2200 hectares), including biotechnology and molecular biology labs. These labs are working on methods for treatment

of plant diseases, development of substances which help prevent rejection of transplanted organs, testing of the effects of clothing on the human organism, development of dyes from natural sources (vegetation) and development of products which are fire-resistant and heat-resistant (can serve as insulation).

A promotion system is available within the institute to encourage the staff for inventions. There are bonuses for patents, publications, and conference presentations, as well as coverage of patent costs by the institute (patents are also an evaluation criterion for Ministry of Education and Science); also, since the institute owns all the patents of its employees, it pays the latter shares in the royalties received from licensing. However, E's fund for patents is enough for only one new European patent per year (European patents are very expensive, the director said). Moreover, the director believes that the main motivation of researchers is intellectual stimulation.

Lots of staff members come from local universities, as well as from a polytechnic institute in another city. Each day some job applications come, according to the director. It is also able to access university students for some of its work, giving them opportunities to complete their final year projects; for example, in clothing design they are able to benefit from the work of students at the local art school. Contacts with the Labor Office also allow them to have unpaid interns, some of whom come from secondary schools.

As mentioned in section 4.1.6, the institute owns a shop at its headquarters in which its clothing and other products are sold.

4.4. Relationships

Relationships of various types, ranging from the personal to business partnerships, appear to be of particular importance in distribution, in finding customers and markets. We have observed a relatively minor role of horizontal relationships in the cases studied here. Two interesting exceptions can be observed in the important role of American expatriate networks in C and the aviation federation in which D is involved, although neither of these is an example of a network serving knowledge transfer purposes. The one case in which we do observe the importance of horizontal relationships for development of capabilities is the case of E, which has a shifting constellation of strategic partnerships in its various projects. Scientific partnerships supported by the European Union's Framework Programmes have been important for F.

In a sub-section on relationships with customers, we find these partners contributing importantly to innovation processes in the firms studied. Equity partners (including a venture capital fund) have in two cases had significant impacts in organizational matters, changing the management team, for example. While the role of venture funds in bringing in new management is fairly well known, it is interesting that in both of these cases, the management changes were later reversed (in one case, the original management resumed control, and in another, a new CEO brought in by the first CEO replaced the second CEO, who had been brought in by consultants hired by the partners providing the financial capital).

As noted in 4.1.1, the beginning of A's business was made possible by its relationship with a US firm, contacted at a 1980 conference, which has acted as the company's distributor in the USA. This firm's (and other distributors') ability to give good technical support to purchasers of A's products is crucial, as Poland is not perceived in places like the USA and Japan as a high tech producer. However, the US firm gives A suggestions about new customers and markets but not about technology.

Relationships have been important in developing investment projects; however, these projects have tended to encounter significant difficulties. In the case of an attempt by the local technical university for which the inventor originally worked to develop a science park on the outskirts of Warsaw, A was interested in moving to the park, but administrative obstacles and problems with financing killed the idea.

Another case is that of a very modern lab which was opened in 2003. The cost was too much for A, and Polish banks were unwilling to give them a loan, as the only collateral they are willing to accept is equipment and no one in Poland would buy A's equipment in the event of bankruptcy (according to our interview partner, Polish banks do not know how to assess value of intellectual property). Thanks to participation in PARP's "Polish Product of the Future" competition, A got a loan from a governmental source for approximately a quarter of the cost of the investment and began to look for a partner who could make up the difference. At this point, the infrared technology group at the aforementioned technical university got involved in project. The university had a promise from the State Committee for Scientific Research (KBN; see section 3) that they would be able to get a grant for this lab. A's vice president worked hard with university management to convince them to sign an agreement to build the lab jointly, as neither of them separately could use it at full capacity. Talks lasted about 1.5 years, and it was not until the KBN threatened to withdraw its promise of grant funding that the university signed the agreement and the project got underway. Since the lab was opened, cooperation between A and the university in use of the lab has gone smoothly.

A is planning a move to a technology park to be created in a town outside of Warsaw, and our interview partner said there were a few companies there (including an electronics company) that could be partners in the future. However, he added that because A's technology is very unique, it could not be direct cooperation, but would rather be based, for example, on outsourcing of some electronics work (circuit plates assembly, etc.).

In the case of B, horizontal cooperative relationships are absent, not because B has not tried to create them, but because of problems with public sector institutions which will be discussed in the section devoted to that question.

The role of personal networks of US expatriates has been crucial in C's development – these networks have been the source of practically all the company's capital and most of its management resources.

In product development, the role of the external world is limited. The only need is for a software development kit, which can be obtained from the internet. As shown in section 4.3, the firm has needed close relationships with hardware suppliers, sometimes requiring help from them in developing peripheral devices like printers, but also being strongly affected by the introduction of new hardware products, which can radically affect software needs. However, as the Polish partner said, "techies" don't like to get help, but prefer to solve problems themselves, and they are too impatient to wait for technical assistance. In those cases when a problem cannot be solved in-house, "internet forums" are a "community" from which help is sometimes accessed.

D's components come from all over the world. Only a few of the components required for the construction of the jets are from Poland, although D's staff consider the Polish materials better than the foreign ones they purchase (the problem is that the Polish suppliers' potential customer base in the aviation industry is too small to make it worth their while to obtain the necessary aviation certificates and attestations). This sheer fact leads D to procure its inputs mainly from German firms that help D to meet the quality requirements that JAR-21 quality standards for aviation make compulsory. D was certified 6 years ago by Polish aviation control, which certifies production and design, gives 2-year certificates (sometimes 5-year certificates), when they produced components for other firms. Although not doing so today, D might soon be making parts for a larger Polish aviation industry producer, as a new activity.

As mentioned in 4.1.4, M's city has an aviation tradition – its glider factory was Poland's

'calling card' in the world aviation industry in the past. There are 13 aviation firms in the city which have formed a Federation of Aviation Firms because, as M says, they consider it easier to discuss business as a group of firms, since "power is in numbers". The group is named in the Regional Development Strategy for Silesia.

As a federation D and the other firms went to an air show and fair in Friedrichshafen, Germany, in 2003. One of the member firms is active in Germany, where it gets its supplies; it also brings supplies for other members of the federation. As well as shifting members of the work force from one firm to another, some contracts or links might be passed between members with complementary and specialized capabilities. They share market information (indeed, M says the purpose of the creation of the network was information exchange and mutual marketing). There is cooperation between members to share a project if it is too big for one of them to handle. They also attract foreign-owned firms by developing supply chain for them. D no longer takes servicing (repair and maintenance) jobs, though other firms in the local aviation federation do. About one third of aviation firms in the city have worked for M at one time, and he continues to cooperate with them and maintain good, friendly relationships (of which the federation is an example). Poles are developing the ability to cooperate, M says. Thus, it appears that an aviation industry cluster is developing in the city. However, M says there have been no attempts thus far to cooperate in knowledge creation, though this could come in the future; the network is in an early stage of development, he says and what is important now is achieving economies of scale by pooling resources.

This initiative is related to another one in southeast Poland – the "Aviation Valley," grouping large aviation firms and some of their more important suppliers. D is a participant in this initiative, though geographically distant from the core participants and much smaller in size. Transfer of knowledge in the western way (from big firms to their smaller suppliers) is one of the Aviation Valley roles, M says: the biggest firms transfer the knowledge to smaller subcontractors within the production value added chain. This works around Rzeszow, but not yet in M's city, where the development of the industry is still in an early phase. D is also involved in another Aviation Valley initiative, the Polish Aviation Technology Platform (Polska Platforma Technologiczna Lotnictwa), which was created in 2005.

A distinctive characteristic of E is its recognition of need for strategic partnership at the project level. They do not aim at doing everything on their own but cooperate with other firms, using their specialization as an advantage. This sometimes leads E to participate in a project as subcontractor and sometimes to coordinate a project, using subcontractors. The former is what they call 'tactical partnership' and happens when they do not win the bid but

manage to get involved in the project of a consortium of international companies (as subcontractor). The latter is to integrate the knowledge of other firms (as their subcontractors) with their existing internal system. Also, there are occasions when a big company, instead of bidding on a project itself, asks E to lead a project.

As a policy, E always appoints a project manager to lead its team in the projects it is involved in. It is also critical for them to get involved in a defined part of the project. The most active cooperation and learning effects appear in their inter-personal relations during the projects when they send their team to the contractor and to the final consumer.

E has an important business partner who provides information on the IT business; indeed, our interview partner said that the firm has numerous strategic partnerships with the producers of various software systems which they use. Such partnerships are based on mutual benefits; E offers markets and implementation to producers of technology.

In June 2004, our interview partner described the most important and biggest project E had implemented to date; we present this description as a characterization of the role of E's strategic alliances in its innovative activities.

Historically, E and its partner in the project, the Polish division of a major multinational, had been competitors in bids on projects, which E won several times against the other company. For this particular project, in which the customer was a major Polish bank the two companies joined their forces and created synergy instead of rivalry. This marked the beginning of long-term cooperation with the partner company.

In this project, with its partner, E developed and implemented an online service system for corporate clients of the customer. Members of both companies created interactive platforms allowing for flexible customer service. These were tested by regular clients of the customer, one of them being E itself, before becoming available to all other clients. This pilot implementation got an award from a Polish business newspaper. From bid to pilot installation, the project lasted two years.

For the project management, the partner company appointed two of the three project managers (the business manager and the overall project manager). The third project manager, responsible for technical matters, was from E. During the implementation of the project, there was enormous interaction between the partners and with the customer.

The main benefit of E from this project in terms of business was to learn how to cooperate in big projects as a subcontractor with big and recognized companies. Technologically, they learned how to create and organize large, complicated projects, code management, and how to manage inaccuracies in bringing a system into operation. E proved to its partner that when given a chance, a subcontractor might bring its own innovative high-quality solutions to a strategic alliance. E is now recognized by the partner as one of its best subcontractors in terms of product quality.

According to our interview partner, the company has generated only one identifiable spin-off. This was a company created in 2000 (before the entry of the investment fund) which still exists. Our interview partner said it is a very small firm, not comparable with E. He described it as economically neither a partner nor a competitor, though he said social relationships still exist between the two firm

F's biggest deficiency appears to result from its lack of trust in industrial firms (based upon a bad experience with a dishonest partner who, the director says, stole the institute's intellectual property), hindering both spin-offs from the institute and cooperation with industrial firms for specific innovation projects. In spite of this, the institute has had two spin-offs, according to the director, and they cooperated with them but one business failed, no one ever became competition. However, the director believes that this negative environment may be changing for the better; Polish industrialists, he said, are beginning to understand that they need to cooperate in order to survive competition with China.

In marketing, F works with advertising agencies (TV, radio ads, leaflets, press conferences). Presentations of results at conferences are opportunities to learn about potential customer interests; the institute also organizes fashion shows (sometimes even at scientific conferences).

In clothing, the institute cooperates with famous Polish designers (it had employed them in the 1990s, but this proved to be too expensive). F also sometimes collaborates with Poznan-based medium sized producer in clothing production when they have especially large orders.

International programs provide the institute with many important contacts and opportunities for collaboration. The institute coordinates a European research network under the auspices of the UN's Food and Agriculture Organization (FAO) in Rome. The Institute has also been involved in several EU 5th and 6th Framework Program projects. Employees usually develop ideas for projects, but in the case of EU projects, ideas come from partners, and are not F's

initiative. According to the director, the benefits of European projects include experience, knowledge, recognition and networking.

Participation in Framework Program projects has given F access to equipment and technologies not previously available in Poland, but knowledge flows are mutual. Western scientific partners come to F inviting the institute to join consortia because, the director says, Western Europe completely neglected natural fibers for 20-30 years and the knowledge is gone. The Framework Programs are also valuable because of the industrial contacts they create. Because the projects require cooperation with SMEs, the institute gets new Polish SME customers as a result, but it also helps those Polish SMEs to develop their linkages. The projects also give the institute access to new industrial customers in Western Europe.

Conferences are, of course, a major source of academic contacts. F is often an organizer of international conferences, and at the time of the 2005 interview was co-organizing one in South Africa with a government research center. The institute also hosts 2-3 invited lecturers per year, as well as PhD students and post-docs from various countries (e.g. Egypt). The fruits these contacts can bear are demonstrated by the institute's physiology lab for testing the effects of clothing on the organism, which was developed under the supervision of two Japanese professors.

Cooperation with customers

Our interview partner said that A's policy is to work in directions which are suggested by customers. Customer input is also crucial in determining with which complementary devices A's products have to be compatible and in solving problems in this area. However, A does not directly cooperate with producers of complementary accessories (our interview partner said this has not been necessary, as members of A's electronics group are able to design those complementary devices themselves if necessary).

As noted above, for B, customers are a significant external source of knowledge.

The most strategically critical relations for B are inter-organizational relations with *foreign* organizations companies, institutes, public institutions, etc. The same kind of relationships in the domestic environment have failed, not because the company was unwilling to cooperate, but because the domestic partners are not appreciative of the contribution they could make to innovativeness and competitiveness. B's CEO believes that demand-side barriers to innovation in Poland are mostly related to the "risk averse" attitude of business people. Not to

take any risk, they avoid innovation, preferring to try to consolidate their current positions in the market with their existing products. They do not make innovative purchases, but rather “stay safe” and “get by” doing the minimum necessary to maintain their markets.

Foreign downstream links appear to be more significant in the history of relationships of the company, and trust is a very important factor in the company’s success in engaging in relationships with its foreign partners.

For C, the main source of information in product development proved to be customers who provide feedback; one of our interview partners stated that “customers always steered our development.” On the other hand, not all of customers’ ideas are good, and it requires a great deal of experience, discretion, and tact to recognize which ideas are not worth pursuing and convince the company that this is the case. Because customers do not understand the technology, some of their ideas are not feasible, others are not sufficiently user friendly. C tells its new customers that they will listen to their ideas then return to them with a solution, but asks them not to tell C how to design the database. As the current CEO says, “sales people want to talk about tech, and techies want to talk about sales, so you have to be able to steer the conversation to people’s competencies.”

M says demand in Poland is incidental. D concentrates on institutional customers from Western Europe, but M says that in order to develop this market, D needs certification from EASA, the European Aviation Safety Agency. He would also like to enter the US market, which accounts for 70% of the world aviation market, and says he is thinking seriously about Asia and is beginning to see interest from China and India in small planes. But despite the rapid rate of growth in Asia and the fact that the market is much easier to enter than the American or European, he says the aviation market in Asia is in its infancy.

According to M, the internet is the most important means of establishing contacts with potential customers, and D’s web site is updated regularly. Such customers cooperate in designing the airplane by expressing their goals and needs (now, for example, as a result of customer suggestions, they are experimenting with installing radar in one of the airplanes).

Without being an exporter of services, E is definitely operating in a global context; 95% of its customers are located in Poland, but they are very often affiliates of MNCs. Polish firms generally don’t feel a need for E’s services, according to our interview partner, he says they don’t see a return to the very high costs, usually having a different kind of customer than the MNCs that make up E’s customer base.

In the project described above, the first step was the interaction between E and the customer to define the research problem carefully since the customer knew what functionality it needed. With the help of the customer's expert in customer relations, E was informed in detail about the system requirements. After a series of workshops, E staff and the customer's staff developed a new application with functionality (a value added in its own right) that could be scalable according to the customer needs. For instance, the inflexibility of the former application for changes in tax levels was eliminated. A completely new user interface was built by E, as they could not find something that met the complexity and flexibility the customer was looking for at the same time. Such a user interface was crucial to meet the demands and use of different types of users (e.g., customer with very different volumes of business).

As stated in section 4.1.6, F does a good deal of testing for manufacturers (including foreign customers). The firms sometimes signs agreements for testing of fabrics, yarns, fibers for periods of up to three years. Much of the testing is of imported products (the customers want to test the composition to see if they got what they paid for).

According to the director, the institute learns a lot from industrial customers by talking with engineers about product development (they go to customers with a raw idea and refine it as a result of such discussions). Companies also tell them which of various materials can be economically viable for a given product.

Theoretically, the purpose of the institute, like all other R&D institutes in Poland, is technology transfer. However, licensing is a sore point for the institute. Under communism licensing was more or less forbidden; there were so-called "implementation agreements" (*umowa wdrożeniowa*). The fee was a profit share, but profits were manipulated by managers to the detriment of institutes. The institute now sells licenses, but the director says these are still not lucrative; he says they are "almost charity," and while he agrees that, given the institute's mission, it should help industry on not completely market principles (because it gets financing from the government and Polish SMEs are poor), he hopes that licensing will be more profitable in the future. Another problem he mentioned is that if the management at a company which has a licensing agreement with F changes, the new management does not always honor its agreements and may go on producing without paying licensing fees.

Other partners

A's American shareholder was venture capital financed, but has closed down operations (the company is practically bankrupt) and become a passive shareholder, which has contact with A not more often than once a year. At the time of the interview in the summer of 2005, they had a share of approximately 6%. The company did help a great deal in creating the new lab. The American distributor is negotiating to buy the shareholder's shares.

Our interview partner said that A has no partner in Poland, and technological cooperation with foreign partners is very risky. They do it, but have to be very careful to protect their intellectual property; because of their lack of strong financial backing, Western partners could easily abuse their access to A's intellectual property.

According to B's CEO, there are no links among Polish firms in the sector. However, big foreign partners have become important sources of information. B's most important technology partner (with which it exchanges and/or generates knowledge) was its largest customer – the company by which it was subsequently acquired. The mobile mapping technology was, to some extent, co-developed by B and that company

However, it is not easy to access knowledge directly from the customer. Rather, B tries to gain information from the customers of these customers. These customers would never directly reveal to B their technology needs, treating this information as a trade secret. Yet, to be competitive and competent enough to remain a supplier of these foreign companies, B has to find ways to anticipate its customers' needs and requirements, as well as the developments in the IT sector with its applications to geographic mapping, and does so by seeking knowledge by understanding the needs of their customers.

At the time of the interview in June 2005, B had responded to a request for proposals issued by the US public authorities and was expecting to win the contract. This large project would sow the seeds of a promising relationship for knowledge transfer in the long term.

Apart from its customer base and its most important hardware suppliers, C lacks partners of an institutional nature. However, the company's evolution has been driven by the personal networks of US expatriates in Poland.

D has initiated its two current projects with the help of a strong equity relationship with another businessman from the same city, a man who has known M since 1980s. M's

partner's firm owns over 50% of the shares in D. The financial backing from this business angel has allowed M to initiate his projects, although it is too little to finance the move to production. The personal relationship underlying the equity relationship is strongly motivated by an interest in innovation, as M's partner is also special by his inventions of personal hygiene goods, artificial marble, etc. He is now concentrating on super-sulfated cement, a technology which is well developed in the US but much less well-known in Europe (where it has good development prospects).

D is currently pursuing an agreement with another firm, with which it would build a production facility for composites and a laboratory.

F's most important partners include West European institutes and industrial partners. The latter sometimes have equipment which is of interest to F. One tests F's fibers, and the president said that in return, the institute may later work on improving that partner's testing equipment.

Distribution relationships are important for the institute; as mentioned in section 4.1.6, a number of Polish producers of products similar to the institute's sell the products of the institute and other producers in their stores.

The institute's memberships in two industrial associations give it access to SMEs in the associations' member databases when it is looking for industrial partners for EU research projects. F has also done some development projects for another industry association on processing and equipment, and is assisting breeders in an area of pathology (a doctoral student at the institute is working on biological defenses against certain plant diseases).

When asked to compare foreign and Polish partners, the director said that the main problem with the former is their prejudices against Poles, and the main problem with the latter their language difficulties.

4.5. The role of the public sector

Our respondents express differing views on the EU's Framework Programmes. While they are important for F, others complain about bureaucracy and/or irrelevance to needs of the Polish S&T community. We heard no good words, however, for the Polish authorities, either on the central level or on the local or regional level. Corruption and lack of

understanding of technology and the benefits to be gained from it are among the problems cited in discussions of the role of Polish public authorities.

With respect to the public sector in Poland, most of A's domestic sales are to the Polish military, so much depends on the annual budget process. As a result, the lack of multiannual budgeting in Poland is a problem for A. (The problems with the Polish S&T sector are in a class by themselves and are dealt with separately.) On the positive side, PARP's "Polish Product of the Future" competition served A well.

With respect to the European Commission, our interview partner complained that the Brussels bureaucracy is worse than that in Warsaw. He also argued that programs developed by the rich EU-15 were often of little benefit for the much poorer new member states: as a result of the EU's Lisbon Strategy to catch up with the USA in productivity growth, the EU finances research framework programs which are good for needs of developed rich countries, but which could rarely yield results of practical application value for the new member states. If, for example, Poles were to cooperate with a rich country in developing a satellite, he asked whose industry will benefit from the application? Obviously not Poland's.

According to B's CEO, the role of Polish public authorities has been a hindrance to innovative efforts. Given the unconstructive role of the public sector and the lack of links among Polish firms, B's CEO sees little room for the development of clustering, technology parks, science parks, etc.

Public institutions in Poland do not understand the potential uses of B's technologies and fail to collaborate with B in undertaking projects. The new CEO's list of failed attempts to initiate common projects with regional and national public institutions included a proposal to a major city to help improve street lighting by developing a system for identifying poorly lit areas.

Corruption in post-socialist countries is another reason why entrepreneurial activity has been evolving slowly. While B's CEO has observed a decline in corruption in recent years, the downside is that officials' fear of such allegations leads to paralysis in decision-making.

The new CEO said that if the government would just leave C alone, it would be good, although he added that it would be good if there were better incentives for employment. Like many businesspeople in Poland, he complained about the frequency with which the law changes, and said in a country where regulations change as often as they do in Poland,

accounting has to be outsourced so that one has the benefit of the agency's knowledge of the labor code, tax code, etc.

He was critical of programs run by PARP, saying that they are very bureaucratic (e.g., the company had to write a huge letter just to be placed on PARP's website). He also noted that support for implementation of the ISO-1779 information security system was unavailable under PARP's ISO-9000 support program.

M says that in general Polish officials (e.g., from the Ministry of Science, now the Ministry of Education and Science) are bureaucratic and not helpful (they look for excuses not to give money). He said the conditions for applying for the Technology Credit (see section 3) are senseless (for example, with respect to the maximum number of years a technology can be in existence, he says that in aviation, older technologies can still be cutting-edge technologies, which are absent in Poland). M also believes that many policies based on models from other countries are being adopted in Poland without being adapted to local conditions. Nevertheless, he said, the public sector is no longer a barrier, though it had been in the past.

State aviation regulations (e.g., conditions for obtaining certification) have affected the firm, leading to changes in its organizational structure (e.g., procedures for processing documents), quality systems, etc.

The public sector *could* profit greatly from E's services, but doesn't, our interview partner said. Although E got its start by winning a contract to service a big city, generally public procurements are considered a disaster in the firm. Our interview partner said the selection criteria are often incomprehensible and rarely transparent: sometimes price is the only criterion, and sometimes public bids are obviously organized with a particular contractor in mind. As a result, they have very seldom participated in bidding on public contracts, and especially recently stay away from them.

Our interview partner feels that the role of politics should be lessened in the area of entrepreneurship and technology. Polish bureaucracy is restrictive and oppressive, not civic-minded, and while for a firm with 100 employees this may not be a big problem, it is for small businesses (questions related to social insurance contributions and taxes unnecessarily lead to conflicts between the state on one hand and the citizen and entrepreneur on the other). On the positive side, our interview partner said in June 2005, there had been a better tax environment in the past 2-3 years, and greater accountability of the tax authorities. However,

he had not noticed any public support for technology or innovation, he said, adding that the firm does not qualify for SME aid programs because it has outside equity investment of over 25%.

F has good relationships with officials in the voivodeship and the city, which help to promote the institute and its products with displays in fairs and local festivals, etc. The voivodeship also has partnerships with Berlin, Hesse, and Brandenburg in Germany, which also creates opportunities for promotion and development of contacts. Polish embassy in China helped them develop contact with organizer of fairs in Beijing (2002 – Polish Week in China). Public sector customers also include courts, for which F conducts analysis of narcotic content. The institute also does some training of high school students.

The Polish S&T sector

Difficulties in the area of linkages between industry and the S&T sector in Poland have been frequently noted in the press and academic literature since the 1990s, and our respondents felt strongly about this issue as well. The fault seems to lie on the side of the S&T sector and is due largely to a lack of awareness on the part of scientists about industry needs. This lack of interest in industry needs is due to the incentives in the system for financing research projects as well as academic promotion criteria, which are based largely on publication and ignore patenting and commercialization of inventions and technologies developed by scientists. While cooperation with universities and R&D institutes does occur, it is often limited to fairly routine subcontracting of materials and quality testing or the use of lab equipment for such testing. Perhaps the Polish academic community's most important contribution to knowledge-based entrepreneurship consists in the university education and training of new staff.

Commenting on the much discussed gap between science and industry in Poland, our interview partner at A said that academic habits unfortunately often lead to an ivory tower approach not conducive to commercialization of research results. For example, A has agreed to help the technical university with which it cooperates to commercialize its results wherever possible, but such a case (of commercializable results) has not yet occurred; A tries to tell the university people what research topics would be interesting from a commercial point of view, but there is a lack of incentives in the system to do research with commercial applications (academic careers are based on publications and not commercialization). In sophisticated technologies, said our interview partner, it is impossible to develop technology in an academic setting and then transfer it in codified form, on paper; rather, inventors have

to actively participate in the application process and work on continuous improvement, something which industry engineers cannot do by themselves. But, he added, scientists in Poland rarely understand this.

Most Polish scientific researchers, he said, are concerned only with being among the world leaders in their discipline, being in the forefront of the newest basic research; only a few of them have any knowledge of industry needs, as the majority have practically no contact with industry. For example, he said, the Polish electronics industry collapsed 15 years ago, but about 20 electronics institutes continue to operate.

The method of financing of science in Poland is the problem, he argued. In theory, under the existing financing schemes for cooperation between industry and the S&T sector, if a firm needs any particular research, it finds a research institution that can be a partner for the project, the Ministry of Science (now the Ministry of Education and Science) finances 50%, and the firm finances the other half. But in practice, he said, the universities and R&D institutes go to firms with offers that are usually not very attractive. They find a firm that does not really make a financial contribution to the research, but simply finds a way to make it appear on paper as if it had, and then writes in the report at the end of the project that the application failed because, for example, the market turned out to be too small.

B's list of failed attempts to initiate common projects with some regional and national public institutions includes a proposal to one R&D institute to develop technology for identifying cracks in roads and a proposal to a university to develop a special infrared sensor that could be used for making various kinds of maps identifying street lighting needs, pollution, road surface heat and resistance, etc., as well as proposals to some other R&D institutes. The CEO said that the project originally intended for the university would most likely be conducted with the National Geographic Institute in France, using EU funding.

D's relations with scientific research institutes and universities are restricted to subcontracting activities for some design activities and for analyses and stress tests that could not be undertaken in D and are done by two universities; additionally, the Aviation Institute in Warsaw does aerodynamic calculations. Additionally, M says, super fast cameras are necessary for testing airplanes, and there are only two such cameras in all of Poland; D borrows one from a technical institute when it is needed.

Apart from the fact that one of E's co-founders is a visiting professor in new media techniques in a film school, the contacts with IT professors at universities and polytechnics

consist in the recruitment of successful graduates and exchanging ideas (mainly from E to the professors) that help to shape the curriculum with business examples and applications. This kind of relationship has an indirect influence on E's future employees, via their training.

Barriers which affect F in its status as an S&T institution are the lack of state funding (low budgets) and the lack of a state policy (or, perhaps more accurately, a constantly changing policy) on industrial R&D institutes (the president said that constant discussions never lead to decisions, and this makes him unable to make long-term plans). As a result of problems with the Polish state budget, the institute is shifting its funding strategy to the EU, becoming less interested in projects funded from Polish sources and more interested in projects funded by the EU's Framework Programs.

The institute has partnerships with polytechnic institutes in five major Polish cities. It cooperates with one in the organization of a conference as well as the production of a polyurethane foam, and with another on flammability (due to that partner's possession of certain equipment. Its cooperation with two polytechnic institutes is based on their certificates to produce for the shipping industry. Another polytechnic has testing equipment similar to F's, which gives F an opportunity to compare results. But its closest partner in the world of Polish higher education is the local agricultural academy, whose PhD students working on their doctoral research there and are later employed there. F also sometimes cooperates with other R&D institutes.

4.6. Competition

As noted above in section 4.2, most of the respondents regard their companies as operating in niche markets without any competitors (at least not in Poland); when they do see competition, it tends to be in world markets rather than Polish markets.

According to our interview partner, A has no competition. The few high-tech companies that exist in Poland, he said, are generally scattered across various disciplines and not concentrated in any given one. The managers of A know the management at other Polish optoelectronic companies (but they are not competitors).

As in the case of A, B sees no competition in the Polish market. Such competition as there is in world markets is based on a completely different technology which gives results of lower precision.

C's SFA system was, to some extent, the result of observation of what two Polish competitors were doing (sales reps using laptops). After the competitors followed C's lead and switched to palmtop devices, their products remained slow, with small memory. Finally, the two competitors were acquired by an investor and their technologies were closed down (the buyers only wanted their networks).

Until recently, M says, D's was a niche market, though it is becoming less so (M mentioned Austrian-Canadian producer Diamond Aircraft Industries GmbH, which has been producing an airplane similar to D's two-seater). But there is still no real competition in Poland, and D still makes the best small airplanes in Poland, which are shown at the most important world aviation fairs.

E is a company whose profile is unique in Poland; it does not have a particular competitor yet in the area in which it is specialized. Of course, there is competition on a project-by-project basis, but those competitors in one project may be partners in another.

5. Conclusions

Poland as a location for knowledge-based entrepreneurship

A common thread we see running through these cases is a negative assessment of Poland as a location for knowledge-based entrepreneurship: demand in the Polish market for knowledge-intensive products and services is weak, Polish public administration is unhelpful at best and possibly even harmful, Polish patents are much less interesting than US or European ones, Polish partners have little to offer (in particular, the Polish S&T sector has little to offer to industry), Polish competition is weak or non-existent, and potential Polish investors are either non-existent or unattractive. Foreign partners, investors, competitors, and markets are generally much more important for this group of firms (even the most important Polish customers tend to be subsidiaries of multinationals).

Entrepreneurs and the entrepreneurship function

We observe the following differences among the six cases with respect to the entrepreneurship function:

- There is one case of a classic entrepreneur (D) - an individual with ideas starting a private business. There is also a dominant individual entrepreneur in F, but in his case entrepreneurship is not linked to ownership.
- In the other cases, the entrepreneurship function is either divided among a number of founder-partners (three cases) or is of a corporate nature (one case).
- In two cases (A and F) we observed the danger of excessive dependency on a single individual who is the “guru.”

Distinction between the entrepreneurship function and the management function

The two cases in which management was changed from outside are the two IT firms. In the one doing sales force automation, the change was made based on the advice of an outside consultant, in the other it was the choice of the venture fund. This is a typical problem with innovative start-ups – good product ideas but weakness in sales and management skills. What is interesting is that the management brought in externally failed to meet expectations and was replaced in both cases – in one case by the original team of founding members (and the venture fund agreed to this without objection).

Resources and relationships: Networks and finance

A common element is the difficulty with financial resources. Only the firm with venture capital did not complain of a shortage of finance. With respect to the role networks play in accessing financial resources, we observe business angel finance in two cases.

Other interesting instances of the important role of networks of various types include the expatriate networks in the case of C, family connections in the case of B, and one local cluster (D). In contrast, the institute examined here (F) has developed commercial activity (products including clothing and food supplements) in order to reduce dependency on state funding but also to *avoid* engagement in commercial relationships like licensing or joint ventures because of bad past experience (this is due to the insecurity of IPRs in transition-era Poland, a point to which we will return in a moment). In the one case of academic entrepreneurship (A), links to the university from which the company was spun off are rather weak (basically limited to gaining access to equipment), which tends to confirm what has been written about the difficulties with spin-offs in the Polish academic world.

Knowledge resources are largely in-house; these organizations tend to rely very little on networks for the development of capabilities or acquisition of knowledge (instead, networks

tend to be useful primarily in the area of distribution and finding new markets and customers). The main exception is the research institute (F), which networks strongly with other research institutions and universities, both in Poland and abroad, for purposes related to knowledge transfer and capability building. It is worth noting, however, that the role of customers in the innovation process was stressed, though this role is not so much one of providing knowledge of a technological or scientific character, but rather knowledge about customer needs and requirements. The important role of conferences as a method of making new contacts and sharing new knowledge in the academic environment is also worth noting.

There seem to be large differences in the extent of the need for protection of intellectual property. Some of the respondents expressed serious concerns regarding the need to protect it, either by patenting or (with more deleterious effects for the development of cooperative relationships) by exercising caution in entering into any cooperative relationships as well as in the way they manage such relationships. However, other firms showed little interest in patenting and little fear of their intellectual property being leaked or “poached.”

Strategies

Innovation is the keystone of the strategies of the companies studied here. This means that they are constantly reinventing their products and services, which often leads to the necessity for reinvention of the firm itself (B is a particularly good example of this, and the development of commercial activity by F may also be seen as a radical redefinition of its own identity). Constant innovation is also necessary to keep competitors from emerging; maintaining their product differentiation and/or niche market position is very important for all of the companies studied.

The role of the public sector on the demand side

The role of state and local governments is very important in generating demand for high-tech products. In this respect, representatives of the companies studied had several complaints about the public sector, saying that it is unable to create demand for high-tech products and services to an extent comparable to Western countries, due to a number of factors:

- budget difficulties which make public finance uncertain from year to year (lack of multiannual budgeting),
- excessive caution in public procurements (fears of accusation of corruption due to the large number of corruption scandals in recent years),

- lack of transparency in public procurements (probably indicating the presence of corruption),
- lack of understanding of technology and the benefits it could give to the public sector.

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