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DIFFERENTIATION OF INNOVATION STRATEGIES OF MANUFACTURING FIRMS IN THE NEW MEMBER STATES: CLUSTER ANALYSIS ON FIRM LEVEL DATA

This paper investigates the differences in innovation behaviour among manufacturing firms in three New Member States (NMS): the Czech Republic, Hungary and Poland. It is based on a survey of firms operating in four manufacturing industries: food and beverages, automotive, pharmaceuticals and electronics. The paper takes into account: innovation inputs in enterprises, cooperation among firms in R&D activities, the benefits of cooperation with business partners and innovation effects. Five types of innovation patterns that firms in the NMS introduce to improve competitive advantage were detected using a cluster analysis. They differ in terms of in-house innovation capabilities, their forms, the use of external sources of innovation, spillover absorption and economic performance. Interestingly, most of them are similar to the innovation patterns of firms in the incumbent EU member states. This seems to confirm Shorec and Verspagen's (2008) claim that, in the heterogeneity in firms' innovation behaviour, countries matter only to a certain extent. The paper shows that in the NMS the role of the two types of innovation sources – R&D and cooperation – are complementary rather than consist of the 'make-or-buy decision' (Veugelers, 1997) model. Although external knowledge is important in innovation activities, the benefits of using it are determined by in-house innovation capacities.

Keywords: innovation modes, differentiation of innovative firms, strategy of innovation

1. INTRODUCTION

One of the main issues of economic growth and competitiveness in the New Member States (NMS) of the EU is their innovativeness. The isolation of these countries from the world economy for many years and the logic of the planned economy system resulted not only in low competitiveness and technological obsolescence, but most of all in anti-innovation bias. However,

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in response to the introduction of market institutions and market rules in the early 1990s, firms active in these countries faced increased competition, which according to evolutionary views produces innovation, and they had to modify their innovation behaviour.

As compared to the incumbent EU countries, a relatively small proportion of NMS firms accumulate knowledge capacity, which results in the introduction of innovation. The degree of cumulativeness of knowledge by individual firms and the opportunity conditions that reflect the ease of innovating are low. However, during the transition period, many NMS firms accumulated new knowledge, competence and capacity. New economic networks with domestic and foreign firms developed rapidly and created conditions for the absorption of domestic and international knowledge spillovers. This raises two questions. First, in what way did these firms accumulate knowledge, or what activities aimed at generating and acquiring new knowledge are reflected in the differences in innovation patterns[1] among firms? Second, what are the differences in innovation patterns between the NMS during their EU accession preparatory period and the old EU member states?

Building upon the knowledge-based theory of firms, this study focuses on firms in three NMS – the Czech Republic, Hungary and Poland – and develops three themes. First, we analyse the heterogeneity in the innovation behaviour of the NMS firms that reflects how these firms acquire and extend knowledge, as well as the kinds of complementary resources they use and create, which are crucial to gain a comparative advantage. Second, the paper refers to the relationship between innovation patterns, reflecting differences in their knowledge capacity and international competitiveness – showing their comparative advantage. In conducting a multivariate (factor and cluster) analysis of firm-level data for manufacturing companies in the three countries, we intend to establish a taxonomy (Peneder, 2003) of innovating firms rather than innovating industries. Third, based on existing research, we refer to innovation patterns selected in the incumbent EU member states.

The paper is divided into two parts. In the first part, the background for our study and specificities of the NMS are presented. First, we present an evolutionary view of firms' behaviour and other modern theories of firms that share affinities with the evolutionary approach in explaining firms' heterogeneity with respect to innovation (Section 2). Next, in Section 3, the specificities of the NMS compared to developing and developed market

[1] Or innovation modes – we use these two terms interchangeably.

economies are shown. The second part of the paper presents the results of our own research on innovation activities run by manufacturing firms in the three NMS. This part begins with a brief presentation of the data source and an enterprise sample (Section 4). In Section 5 we discuss the methodology employed to detect firms' innovation patterns in the NMS. Section 6 presents the aggregate factors that proved to matter in the clustering of enterprises by innovation indicators. The last section (Section 7) presents and discusses the innovation patterns of NMS firms. It focuses on the similarities and differences between firms' innovation patterns and their relationship with economic performance. The conclusions summarize the paper.

2. BACKGROUND

2.1. The firm as a repository of knowledge that is historically structured

The evolutionary paradigm, i.e. various kinds of evolutionary theories (Hodgson, 1993, pp. 39-51), and its modern extension, are the framework of our analysis. The common premise and characteristics that they share, especially the role of history, resources and cooperation, seem adequate for the analysis of the heterogeneity of innovation behaviour of NMS firms.

In the modern interpretation of the evolutionary approach (research-based theory, resource-advantage theory, relational-based view and knowledge-based view), 'organizational routine' (Nelson and Winter, 1982), 'competence' (Foss, 1993) and 'capabilities' are the kinds of resources that are crucial for any firm. Resources are "assets, capabilities, organizational process, firm attributes, information, knowledge, etc., controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness" (Barney, 1991, p. 101). Intra-organisational trust needs to be added to this list, as it is the foundation for cooperation between co-workers, as well as a condition for building a pro-innovation culture within a firm, since innovation is the result of a collaborative effort of teams of people (Lewicka, 2012; Costa, 2003).

As tangible and intangible entities, resources are seen as the heritable units of evolutionary selection. They enable firms to produce efficiently and have an impact on their ability to compete. Some of them (like standard equipment, unskilled labour) are mobile or tradable (in the terminology of Dierickx and Cool, 1989), while others (like R&D, capability, reputation for quality) are immobile (non-tradable). Being mobile, tradable resources are available and can be acquired or imitated quickly and easily by other firms. In opposition to them, non-tradable resources, being immobile, must be created, developed and accumulated and are maintained through time. They can be neither imitated nor substituted by rivals in a short time. First, as immobile resources, they are a part of the process of knowledge accumulation, and the time required to develop them cannot be easily shortened. Second, the development of these resources also depends on having complementary resources. This makes non-tradable resources rare and unique. Although they provide the basis for the sustainability of competitive advantage (Barney, 1991; Wernerfelt 1984, Hunt 2000), a firm must create "tomorrow's competitive advantage faster than competitors mimic the one the firm possesses today" (Hamel and Prahalad, 1989, p.69). A firm must continuously improve the existing skills and learn new ones, i.e. invest in these competences.

Resources can be both a strength and a weakness for a firm (Wernerfelt, 1984, p. 172). Rare, immobile resources constitute a barrier to rivals' attempts at resource acquisition, substitution or imitation, and they generate a competitive advantage. They must be discovered and/or created by a firm and are particular to it. Other resources are easy to substitute or imitate and can be acquired by rivals. This results in the improvement of imitators' innovativeness and competitive advantage. Therefore, "firms need to find those resources which can sustain a resource position barrier" (Wernerfeld, 1984, p. 175).

In the modern evolutionary approach, firms are seen as 'combiners' of different resources that are accumulated. They are also seen as a collection of routines, capabilities and competences historically constructed, i.e. as a repository of knowledge which is a crucial competitive resource (Kogut and Zander, 1992; Grant, 1996; Spender, 1996; Nonaka 1994; Nonaka and Takeuchi, 1995). Organizational capabilities are the outcome of knowledge integration (Grant, 1996a). In the knowledge-based theory of firms, the organisation is seen as storing knowledge (Loasby, 2002, p. 1235) and as an institution for the application of knowledge (Grant 1996, p. 113). Because knowledge is embedded in organizational routines and individual skills, part of which are tacit, the organization is partly unaware of the existence of knowledge (Garrouste and Saussier, 2005). As long as a firm is unaware of the importance of knowledge, it does not invest in it intentionally.

Knowledge is the result of learning, which encodes inferences from history into routines that guide behaviour. As there are different forms of learning and experience, different firms accumulate different elements of knowledge. Knowledge characteristics, such as transferability, capacity for aggregation, appropriateness, specialization and requirements of production, are "pertinent to the utilization of knowledge within the firm to create value" (Grant, 1996, p. 110).

As some resources, including knowledge, are mobile, the generation and acquisition of knowledge can take place not only within the firm. They may also originate from external sources and partners (e.g. Grant, 1996; Malerba, 1992; Coriat and Dosi, 2003; Teece 2003).The non-rival and cumulative character of knowledge implies that firms may learn from other firms' knowledge that was previously accumulated so outsiders can recognize and imitate other firms' knowledge. For example, firms can enhance the quality of their products by learning from an innovation introduced by competitors and by imitating it. In this way, firms can benefit from a positive externality (a spillover). Relying on external knowledge enables firms to decrease new product development time, thereby leading to faster market entry and limiting competitors' first-mover advantages. So a firm's capabilities depend on the pool of general knowledge it has access to (explicit knowledge), its ability to use it (tacit knowledge) and on the pool of knowledge it accumulated through internal efforts. This means that, apart from in-house capabilities accumulated in the past, firms rely on external (both domestic and foreign) sources of knowledge when developing and introducing innovations.

However, the receipt of knowledge, including imitation, also requires the prior accumulation of some knowledge by the recipient, i.e. knowledge absorption (Cohen and Levinthal, 1989). Possession of 'common knowledge' (Grant 1996, p. 115) allows firms to communicate professionally with providers of knowledge. It allows them to "recognize, evaluate, negotiate and finally adapt the technology potentially available from others" (Dosi, 1988, p. 1132). When a firm lacks absorption capacity in related areas, it may not benefit from knowledge transfer (Girma, 2005; Kessler et al., 2000). So a precondition for the endogenization of knowledge spillovers by the firm is the prior accumulation of some knowledge. On the one hand, knowledge receipt and imitative activity is a type of learning activity. On the other hand, learning new knowledge is costly and positively related to knowledge stock (Griliches, 1979). Thus, learning from external sources may contribute less to knowledge accumulation for firms with limited prior knowledge. The success in the imitation and receipt of knowledge depends upon the recipient's ability to add new knowledge to existing knowledge (Grant, 1996, p. 111).

There are many channels through which a firm can acquire outside knowledge. The fact that it is hard to imitate tacit knowledge by market procurement (Nonaka, 1994) increases the role of interpersonal contact, for example via collaboration or cooperation. Cooperation enables firms to internalize incoming knowledge spillovers and allows them to increase knowledge transfers voluntarily among the cooperating partners (Katsoulakos and Ulph, 1998; Cassiman and Veugeleurs, 2002; Belderbos et al., 2004). Different collaborators (i.e. suppliers, customers, and competitors) are sources of different knowledge. For instance, cooperation with suppliers that have a better knowledge of components allows a firm to create new products and identify potential technical problems. Collaboration with research institutions allows firms to acquire new scientific knowledge and helps them broaden their technological knowledge (Spencer, 2003).

Not only the kinds of resources and elements of knowledge, but also the connections between them, matter for a firm's performance and its differentiation (Potts, 2000; Loasby, 2001). While firms in the same industry may need to accumulate a similar set of resources or competencies, they may use such competencies in different ways (D'Este, 2005). So in terms of resources, not only immobile, but also mobile, firms are heterogeneous. Despite operating in a similar environment, firms may adopt widely different innovation strategies.

In the evolutionary approach, history plays an important role in the actual development and performance of firms. Companies and resources are heritable, durable units of evolutionary selection. Competition for high quality and rare resources constitutes the basis for the selection process. In this approach, firms are viewed as entities that are historically situated in space and time and their economic variables move throughout time (Dosi and Nelson 1994). Both the internal structure and external relationship of firms change over time. Changes and novelties introduced by a firm are conditioned by pre-existing structures and by the history of past adoptions (Potts, 2000). The evolution of firm's knowledge over time is cumulative and incremental, although it differs across firms. As they start from different resource bases, they vary in their patterns of knowledge, that is in the structure and network of connections between elements. The accumulation of knowledge is a precondition for the creation of new knowledge, its utilization results in innovation.

2.2. Empirical studies on the heterogeneity in firms' innovation strategies at micro level

For many years, most empirical studies on the diversity of innovation activities focused on inter-industry variations. Pavitt's (1984) taxonomy of sectors in terms of their innovation strategies has been developed and later extended in many empirical studies (de Jong et al., 2006; Leiponen and Drejer, 2007; Castellaci, 2008; Peneder, 2003). However, some research shows (Clausen and Verspagen, 2008; Srholec and Verspagen, 2008) that most of the variance in innovation behaviour is explained by the heterogeneity among firms within sectors and countries and that sectors and countries matter only to a certain extent. This suggests that there is asimilarity in the innovation patterns of firms from different European countries.

In the empirical literature, there are two main approaches that report on the heterogeneity in the innovation strategies of firms. Both are an extension of the evolutionary approaches. The first one focuses on internal and external sources of innovation. The second one uses cluster analysis to select different innovation strategies.

Drawing on Malerba's (1992, p. 848) taxonomy of learning – divided into internal and external learning – Llerena and Oltra (2002) introduced a typology of firms, divided into 'cumulative' and 'non-cumulative'. Cumulative firms generate innovation internally and invest in R&D in order to accumulate knowledge. Non-cumulative firms learn from public research and intra-industry spillovers. In many respects, this taxonomy overlaps with Damanpour and Wischnevsky's (2006) division of firms into those generating innovation and those adopting innovation. Yet another criterion of classification is by pioneering R&D and by imitating R&D that generates incremental innovation. Other examples are taxonomies that formulate different 'modes of innovation': 'the Science, Technology and Innovation mode' and 'the Doing, Using and Interacting mode' (Jensen et al., 2007). Although these classifications differ in many respects, they all have a dichotomous character, as they distinguish between two types of firms: leaders (real innovators) and outsiders (imitators). They reflect the distinction between innovation and imitation and between innovators and imitators. The last category is diversified. It covers, for example, incremental innovators, followers[2] and traditionals[3] (Avermaete et al.., 2004) and lead innovators, technology modifiers and technology adopters (Arundel et al., 2007).

The second approach introduced different methodological tools, i.e. cluster analysis, e.g. Arundel et al., 2007; Tiri, Peeters and Swinnen, 2006; Leiponen and Dreijer, 2007; Hollenstein, 2003; Srholec and Verspagen, 2008; Peneder 2010; Som et al., 2010; for an overview of some studies on innovation modes, see Frentz and Lambert, 2010. Most of them are based on data from the Community Innovation Survey (CIS) and some use other European surveys (Arundel et al., 2007). This pool of research differs with respect to the period of analysis, countries, activities (manufacturing and/or services) and variables used. This impacts on the differences in the innovation patterns selected. In research on the EU countries, three common innovation patterns have been detected and described:

- **low profile** (Srholec and Verspagen, 2008). They share features of ‘low-profile innovators with hardly any external links’ (Hollenstein, 2003) or ‘low learning firms’ (Jensen et al., 2007), ‘non-innovative, production intensive manufacturers’ (Som et al., 2010);
- **high profile** (Srholec and Verspagen, 2008; Tiri, Peeters and Swinnen, 2006). This is described as being employed by ‘science-based high-tech firms with full network integration’ *(*Hollenstein, 2003), ‘strategic innovators’ (Arundel and Hollander, 2005), or ‘knowledge intensive product developers’ (Som et al, 2010); and
- **externally sourced** (Srholec and Verspagen, 2008), which is utilized by firms that intensively use both external and internal knowledge, notably R&D. Such companies are termed ‘intermittent innovators’ *(*Arundel and Hollander, 2005*)*, ‘IT-oriented network-integrated developers’ (Hollenstein, 2003) or ‘medium profile’ (Tiri, Peeters and Swinnen, 2006). However, this pattern was also detected in Turkey.

Other patterns of innovation have also been observed. Some of them, like ‘customer-driven, technical process specialists’ (Som et al., 2010), ‘cost-oriented process innovators with strong external links along the value chain’ (Hollenstein, 2003) and ‘technology adopters’ (Arundel and Hollander, 2005), are different versions of Srholec and Verspagen’s (2008) externally sourced model. They source innovation knowledge from external organisations. However, the role of internal inputs is small. In opposition to

[2] They spend up to 1% of their annual sales on R&D.

[3] They do not perform R&D activities themselves; however, they introduce new or substantially modified products or processes.

them, in the case of ‘intermittent innovators’ (Arundel and Hollander, 2005) and ‘occasional product developers’ (Som et al., 2010), knowledge relevant for innovation comes mainly from the inside (i.e. their own employees, in-house R&D). There are also innovation patterns that do not share the characteristics of the above-mentioned patterns. For example, the ‘technology modifier’ modifies its existing products or processes through non-R&D based activities(Arundel and Hollander, 2005), and the ’volume flexible, specialised suppliers’ focus on non-technical process innovation (Som et al., 2010). It is worth mentioning that some of these patterns were distinguished not only in the old EU member states and the NMS, but also in non-EU member states, like Turkey (Yurtseven and Tandoğan, 2011) and Taiwan (Tsai and Wang, 2009).

The discussion on innovation sources, patterns of innovation, and their effects on firms’ performance is very relevant for the companies in the NMS. Both the NMS’ heritage of centrally planned economies and the progress they have made during the transition period, i.e. the speed at which privatized and green-field firms have adapted and integrated into a highly competitive global economy, mean that research on variations in innovation behaviour among firms in these countries provides an excellent test-case of the sources of innovation and economic growth. This relates to the role of different factors in innovation patterns and their results. It also shows the different faces of innovation activities.

3. THE HERITAGE OF A COMMAND ECONOMY

It seems reasonable to refer briefly to the command economy heritage for the innovativeness of Central European countries in their transition to a market economy (i.e. in the entire 1990s) and the years preceding their EU accession. Although under socialism, science and technology were very high on the government and Communist Party’s list of priorities, the focus of centrally managed research was on those areas of science that did not require ‘market validation’.[4] The constructional logic of the command economic system (Balcerowicz, 1995, Chapter 6), the structure of incentives and the prolonged isolation of these countries from the world economy discouraged not only innovation but also imitation (Winiecki, 2002, p. 14). The closed economies blocked international linkages that have an impact on innovation,

[4] The term used by Arogyaswamy and Koziol (2005), p. 456.

including knowledge spillovers. For systemic reasons, enterprises did not create demand for research from domestic universities, while the latter did not deliver research results to serve the market expansion of firms. Incentives characteristic of the command economic system resulted not only in low competitiveness and technological obsolescence, but most of all in an anti-innovation bias (Winiecki, 2002). These countries and their firms did not accumulate innovation resources due to their low in-house innovation activities or very limited international knowledge spillovers. Although in terms of human capital, enterprises had a much greater potential to innovate[5] than most firms in developing countries, the anti-innovation bias of employees made the enhancement of innovation quite difficult.

During the transition period, the three countries that are of interest in this paper were characterizsed by:

- A peripheral position with respect to global technology-intensive manufacturing production; the structure of production was not conducive to innovation activities and the quality of goods was very low;
- Low share of R&D and low share of business R&D spending in GNP; and
- Low level of knowledge linkages between R&D organizations and firms, as well as among firms; inherited poor innovation capabilities of domestic firms accompanied by radical changes in cooperation among firms (the so-called 'adverse shock to network activity', see Woodward and Wójcik, 2007) as a result of the privatization and bankruptcy of many firms.

Luckily, all three countries under investigation avoided unfair privatization (to oligarchs, which was the case in Russia and some other former Soviet Union countries), and the newly-privatised and private companies that emerged were subject to fair competition. In the early 1990s, defensive restructuring was taking place in the state and post-state enterprise sector and was based on shedding labour, reducing costs and scaling down or closing unprofitable plants. In later years, strategic restructuring based on investment and innovation was increasingly common (Konings, 2003).

The opening up of the transition economies resulted in an increase in the competitive pressure of foreign products and firms on domestic products and

[5] Since the Marxist theory of economic development stresses that economic efficiency, the innovation rate and ultimately productivity levels play a key role in the competition of centrally-managed economies with capitalistic ones, the countries of the Soviet bloc placed an extraordinary emphasis on technical education.

firms, and created the potential for international knowledge spillovers. Their main channels were foreign trade and foreign direct investment.

Here we come across the problem of the ability of the transition NMS's domestic firms to absorb knowledge spillovers from external sources, both domestic (Truskolaski, 2012) and international. The term 'ability to absorb' covers not only the implementation of external knowledge, it also contains improvements in the knowledge that is imported (copied), i.e. its upgrading.

First of all, as the NMS are knowledge absorbers, learners rather than creators, the role of international knowledge spillovers in their innovation activities should be greater than in the case of the old EU member states. However, the effects of international knowledge spillovers depend on many factors and these effects may be positive or negative.[6]

Research on the NMS underlines the crucial role of international spillovers for their accumulation of knowledge and growth. Analysing 17 OECD countries including CEECs (Central and Eastern European countries), Bitzer et al. (2008) came to the conclusion that the productivity effect of spillovers through vertical backward linkages between multinationals and domestic firms in CEECs is much higher than for other OECD countries. Leon-Ledesma (2005), analysing 21 OECD countries over the long term, shows that for the G7 group, foreign knowledge has a negative impact on competitiveness, while for less advanced countries it has a strong positive impact. The higher the degree of openness to FDI, the stronger this impact. However, research results vary depending on the period of analysis, the country, the model introduced, and the types of spillovers. Empirical research on the period up to 1998 (Konings, 2001; Zukowska-Gagelmann, 2001) showed negative spillover effects of FDI for domestic firms, while Damijan et al. (2003) did not confirm it. However, research results covering the period since 1999, as well as long-term analyses, do not confirm the earlier research results. They did find more positive effects of vertical knowledge spillovers for domestic firms than of horizontal spillovers (Terlak, 2004; Gersl et al., 2007; Hagemajer and Kolasa, 2008; Kolasa, 2007; Bijsterbosch and Kolasa, 2009; Gorodnichenko et al., 2007). Some research referred to the role of foreign trade as a source of international knowledge spillovers. Hagemejer and Kolasa (2008) showed that differences in the ability to absorb foreign knowledge through spillovers varies among types of firms in terms of internalization. Last but not least, the issue of

[6] For instance, in 1992-1997, as opposed to Ireland and Spain, FDI in Greece did not generate positive knowledge linkages externalities.

indirect knowledge spillovers as a result of R&D conducted abroad was raised. It turns out that the impact of foreign R&D on the productivity of the CEECs was greater than that of domestic R&D (Chinkov, 2006; Tomaszewicz and Świeczewska, 2008 and 2007). This is contrary to what has been detected in the EU-15 (Leon-Ledesma, 2005).

Summing up, both the accumulation of knowledge and R&D intensity are low, although differentiated among the three countries.[7] The number of enterprises engaged in innovation activities (calculated as a share of all firms) also remains low.[8]

4. DATA SOURCE AND ENTERPRISE SAMPLE

The data used in this paper was collected through a survey of firms performed by an international research team led by Richard Woodward (of CASE – Center for Social and Economic Research) and within the European research project entitled ‘Changes in Industrial Competitiveness as a Factor of Integration: Identifying the Challenges of the Enlarged Single European Market’.[9] The survey was aimed at investigating the networking of firms in three accession countries (the Czech Republic, Hungary and Poland) and Spain and its influence on competitiveness.[10] Fortunately, a substantial number of questions included in the survey questionnaire were relevant to the analysis of innovation processes. Altogether, 41 innovation indicators were selected. We grouped them into four sets, according to the dimensions of innovation activities: (1) innovation inputs, (2) innovation linkages, (3) effects of cooperation with business partners reflecting that diffusion of external knowledge is taking place, and (4) innovation outputs. Since many academics argue that in the developing economies diffusion can be the most important part of innovation, we decided to include not only the linkages but also their effects. As far as performance is concerned, we chose four

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[7] For example, in Poland, the share of R&D in GNP is almost three times lower than in the Czech Republic and two times lower than in Hungary. Although R&D intensity in the Czech Republic is close to the average for the EU-27, it is still not high enough to catch up in terms of firms’ accumulation of knowledge.

[8] For Poland and Hungary, it was two times lower than the EU-27 average. This indicator was close to the EU-27 average only in the case of the Czech Republic.

[9] It was funded by the 5th Framework Programme of the European Community (Ref. HPSE-CT-2002-00148). The project was led by Anna Wziątek-Kubiak, and the Warsaw-based CASE (Center for Social and Economic Research) led the research consortium.

[10] For the results of this specific analysis, see Woodward and Wójcik (2007).

indicators, these are self-assessments of the competitiveness of a company's products and technology separately in the domestic and international markets.

The interviews were conducted in 2004 in Hungary and Poland, and in early 2005 in the Czech Republic. The data collected refers to 2003 and, in some cases, to the five-year period 1998-2003. This was an interesting and important period in the three former 'socialist' countries – they were undertaking market reforms, shifting from defensive to strategic restructuring, covering innovation activities and advancing preparations for formal accession to the EU. Obviously, these processes influenced the behaviour of the real sector, i.e. firms, entrepreneurs and investors.

All the respondents surveyed were managers responsible for day-to-day business processes. Data was collected from 490 companies. After careful examination of the answers received to the questions relevant for researching innovation patterns, we had to delete 132 firms from the database due to individual missing data. As a result, the sample shrunk by one-quarter to 358 firms.

Polish firms dominated the sample, they accounted for nearly half of the enterprise population surveyed. Hungarian firms amounted to 31% of the sample. The majority (ca. 70%) of firms were domestically-owned, and domestic ownership prevailed in each individual country, though to different extents (Poland was at one extreme, with an 81% share of domestic capital, while Hungary was at the other extreme, with only a 54.1% share of domestic companies). All size classes of firms were investigated, but medium-sized firms dominated the sample.

Four industries were studied in the survey: (1) food and beverages (NACE Rev. 2, class 10); (2) pharmaceuticals (NACE Rev. 2, class 21.1; 21.2: 32.5); (3) electronics (NACE Rev. 2, class 26.11; 26.2; 28.23; 33.2; 62.09); and (4) automotive industry (NACE Rev. 2, class 28.11; 28.92, 29.1; 29;2; 29.32; 30.91; 33.11; 33.2). Food and beverages firms were the most numerous (45% of the sample), while pharmaceutical firms appeared the least (7%).

5. METHODOLOGY EMPLOYED TO EXPLORE INNOVATION PATTERNS

In order to detect the innovation patterns of firms, a cluster analysis was adopted. Given the relatively large number of innovation indicators (41), we decided to use principal component analysis (PCA) to measure the sources of innovation in firms. PCA allows us to reduce a large number of indicators to a small number of composite variables (called ‘factors’) that synthesise the information contained in the original variables. Factors are standardized variables containing the information common to the original variables. In this way, we were able to consider as much available information as possible. PCA is based on the idea that the indicators that refer to the same issue are likely to be strongly correlated and factors that are obtained are uncorrelated. PCA helps prevent the inclusion of irrelevant variables and reduces the risk that any single indicator dominates the outcome of the cluster analysis.

We assumed that if the correlation between factors and original variables is lower than 0.48, the analysis is inappropriate.

In the next step, a non-hierarchical cluster analysis was performed in order to group firms by innovation variables into a number of clusters that are as homogenous as possible (small variance within a cluster) and, at the same time, as different as possible from each other (large variance between clusters).

The Appendix contains a table showing the results of the factor analysis for firms in the three NMS (Table A3). It includes the loadings of the variables on selected factors after the so-called rotation. The loadings of the various indicators on the retained factors are correlation coefficients between the indicators (the rows) and factors (columns) and provide the basis for interpreting the different factors. These loadings are adjusted through rotation to maximize the difference between them. We use varimax Kaizer’s normalized rotation that assumes that the underlying factors are uncorrelated.

The first step of the factor analysis led to statistically satisfactory results. We selected eleven factors jointly explaining, in the case of the three countries’ firms, 54.5% of the total variance. In the second step, we conducted a non-hierarchical cluster analysis based on the eleven composite variables extracted in the factor analysis of the first step. Introducing hierarchical agglomeration methods for a subset of objects and comparing the results for the range of $K_{min} \leq K \leq K_{max}$ (where K is between 2 and 7), we chose the optimal number of clusters. Using hierarchical analysis and

Ward's minimal variance method, we chose five clusters that group the enterprises into five categories in terms of innovation indicators. Based on the distance from the centroids, we compared the variance within clusters and between clusters. The centroids of clusters obtained in the hierarchical method were used as the initial centroids for the K-means algorithm.

6. AGGREGATE FACTORS DESCRIPTION

The factors yielded in the cluster analysis were further aggregated and, as a result, we obtained eight so-called aggregate factors. These are:

- in-house inputs and activities (aggregate factor 1),
- two types of cooperation in R&D: backward (aggregate factor 2) and with research organizations (3), as well as subcontracting of R&D activities (4),
- beneficial cooperation with business partners: in product (5) and process (6) innovation,
- type of innovation (7): either product or process, or both, and
- innovation outputs (8).

Aggregate factor 1, which is called 'in-house inputs and activities', groups a multitude of internal innovation (research) inputs and activities of firms that may contribute to their absorptive capacity and the creation of innovation (Cohen and Levinthal, 1989). It includes the following variables: R&D intensity (R&D expenditure as a proportion of firms' sales revenue), human resources (share of R&D, IT staff, engineers and technicians in full employment), human capital upgrading through training, R&D unit in a firm, and R&D activities with respect to product and process development and others.

Three aggregate factors encompass various collaborative networks in R&D. They cover backward linkages (aggregate factor 2) that focus on cooperation in R&D with raw material suppliers and machinery and equipment suppliers, as well as cooperation with research organizations: foreign, domestic and independent scientists (factor 3). The subcontracting of R&D activities aimed at product and process development and improvements (aggregate factor 4) is also considered.

In the late 1990s and early 2000s, cooperation in the R&D activities of firms in the NMS was still a new phenomenon (see Section 2). Gaining experience in how to effectively profit from others in knowledge extraction took time. This was most likely the reason why cooperation was less common and less effective than in developed market economies at that stage. Therefore, two types of aggregate factors were selected: beneficial cooperation with business partners in product innovation and in process innovation. They constitute factors 5 and 6.

Two types of innovation activities – product- and process-based – constitute factor 7.

The last aggregate factor considers the output of a firm's innovation activities in terms of new products and production technology. However, while this factor was not retained for the Czech Republic alone, it was retained for the other two states and the three countries together.

7. INNOVATION PATTERNS OF FIRMS IN THE NMS. SOME COMPARISONS WITH FIRMS IN THE INCUMBENT EU COUNTRIES

Throughout this procedure we have found the following innovation patterns in NMS firms during the EU accession preparatory period: (1) low profile pattern firms, (2) virtual firms, (3) spillover absorbers in process innovation, (4) firms on the science-based innovation path, and (5) firms pursuing supplier orientation (see Table 1). These patterns represent the different innovation behaviour of firms and different innovation outputs. As in the incumbent EU countries' innovation patterns, they "tend to rely on different mixes of external actors and […] some differences exist across countries" (Freitas et al., 2011, p.113). The economic performance of sets of firms employing individual innovation patterns varies as well. Surprisingly, the ownership structure of firms realising these patterns does not differ considerably, the differences in the sectoral structure of these groups are much greater.

Low profile pattern

It is worth underlining that low profile firms are found not only in the NMS, but also in the incumbent EU countries and non-EU countries, for example Turkey. They have low scores in all innovation ingredients. They "perform most weakly with respect to the majority of variables used to characterize modes of innovation" (Hollenstein, 2003). Very low in-house innovation resources and activities, as well as limited external cooperation in R&D, distinguishes this innovation pattern from the others. These features, together with the focus on process (rather than product) innovation and the fact that a relatively large proportion of firms benefits from cooperation in the production process, suggest that the diffusion of external knowledge, notably to the production process, plays an important role in innovation. This enables the accumulation of knowledge, which is nevertheless very low.

The low innovation capabilities and the limited innovation activities of this group accompany the worst – from among the five subsets of firms – innovation outputs and international competitiveness. The moderate competitiveness of their products and production technology in the domestic market allows them to operate in a niche of this market, possibly in its lower quality segment. The use of external knowledge in the production process indicates that these firms are conscious of their low competitive position, and to improve or maintain it, they focus on the absorption of external knowledge, which is the major source of innovation.

From a general perspective, it is very telling that the low profile pattern firms in the NMS accounted for 29% of the entire population surveyed. However – to put this figure in a comparative perspective – in the Swiss services sector, this type of firm accounts for 22.5% of enterprises (Hollenstein, 2003). Coming back to our firms' sample – most of the firms (ca. 64%) following this pattern are in the food industry, 22% are in electronics, 11% are in the automotive industry, and only 3% are in the pharmaceutical industry. Surprisingly, the ownership structure of this subset of firms is similar to that in other clusters (specifically, foreign owned firms accounted for 28% of the total number of low profile firms).

Firms on the science-based innovation path

Contrary to the low profile group, there are firms pursuing a science-based innovation path. They rank highly in all the main ingredients of the innovation process except for 'subcontract'. Since they rank highly in the R&D factors and in R&D cooperation with different types of partners, notably with research organizations (including foreign ones and independent scientists), as well as with suppliers of materials and machinery, they come close to some firms from the incumbent EU countries. The latter are called by other researchers the 'high profile group' (Srholec and Verspagen, 2008), 'science-based high-tech firms with full network integration' (Hollenstein, 2003), 'science-based' (Leiponen and Drejer, 2007), 'new-to-market innovating' (Frenz and Lambert, 2009), 'strategic innovators' (Arundel and Hollander, 2005), 'knowledge intensive product developers' (Som et al.,

2010) or firms performing the ‘Science, Technology, Innovation mode of learning and innovation’ (Jensen et al., 2007). However, the science-based innovation path group of NMS’ firms is, in our opinion, closer to the STI/DUI mode of learning and innovation than the STI mode. So, even though the NMS firms pursue a science-based innovation path, in some respects they differ from the developed countries’ science-based pattern of innovation.

The ease with which this group of NMS firms cooperates with many types of partners reflects their ability to absorb and accumulate external knowledge. The fact that they score highly on the R&D factor and on external R&D collaboration with various partners, suggests that there is a complementary role for these two types of innovation sources. They combine internal and external sources of innovation rather than restrict their innovation strategy to the ‘make’ or ‘buy’ strategy (Veugelers and Cassiman, 1999). They score highly in organizational changes as an effect of cooperation. However, it is worth mentioning that the share of firms that recognize cooperation in innovation activities as beneficial is average. This either reflects their consciousness of their knowledge distance from their main competitors (they expect that they can gain more from cooperation) or that they are in the process of searching for partners that can better serve their innovation activities.

A high number of in-house innovation activities and cooperation in R&D does not translate into high innovation output, which remains moderate. Surprisingly, although the international competitiveness of their products is high, the competitiveness of their products in the domestic market remains low. Perhaps they produce high quality products for which domestic demand is low.

This innovation pattern is followed by foodstuff and electronic firms (75% of the cluster population); the ownership structure of firms in this cluster does not differ significantly from the other clusters.

The next three innovation patterns of the NMS are based on different external sources of innovation and the use of different internal inputs. There are some differences between these three groups of externally-sourced patterns of innovation, as they are between externally-sourced patterns of developed countries. In the latter group of countries, many versions of the externally-sourced pattern have been also selected. They are labelled in different ways, for example as ‘externally-sourced firms’ (Srholec and Verspagen, 2008), ‘intermittent innovators’ *(*Arundel and Hollander, 2005), 'IT-oriented network-integrated developers' (Hollenstein, 2003), and 'medium profile' firms (Tiri, Peeters and Swinnen, 2006).

Virtual firms

This innovation pattern is similar to Teece's (2003, p.155) 'virtual corporation' pattern, that is "business enterprises that subcontract anything and everything". These firms focus on the adaptation of innovations by acquiring them mostly from research organizations. They hunt for product innovation in the market. Their R&D intensity is the lowest among innovation patterns. This is accompanied by an extremely high share of R&D and IT staff in full employment and the dispersion of R&D activities among many fields. Most of the firms have R&D and design units. However, in-house R&D activities focus on searching for new product innovations in the market and better R&D subcontractors. Most of them gain benefits from linkages in different forms of product development. The widespread diffusion of innovation through subcontracting R&D is a crucial source of their innovation. The virtual pattern of innovation is not specific to the NMS: Teece (2003) has studied it in developed countries, and it is also popular in Taiwanese manufacturing (Tsai and Wang, 2009).

The market orientation of these firms is revealed through their high level of innovation output. The share of new products in sales and the share of sales attributed to new technology was one of the highest. Surprisingly, the internationally competitive position of products and production technology was strong. This innovation pattern was the least frequently followed: only seven firms adopted it. Interestingly, all of them were from the same sector, electronics. The ownership composition of the cluster is not specific – it is similar to the other clusters.

Firms pursuing supplier orientation

This innovation pattern shares some features with the pattern of virtual firms: low R&D intensity, a high proportion of R&D and ICT staff, and the relatively high use of outsourcing in innovation. Both groups of firms cooperate in R&D with many partners, including both research organizations and suppliers of inputs and machinery. However, there are some differences between these two patterns. Firms pursuing supplier orientation focus on human resources upgrading. However, as compared to the virtual firms, they cooperate less often with domestic research institutes, but much more frequently subcontract R&D results in both product and process development. Yet their ability to collaborate with different partners does not translate into a strong international competitiveness of their products, although their domestic competitiveness is quite strong.

They differ from other patterns with respect to sectoral structure – 27% of foodstuff and automotive firms, and 33% of electronics firms, followed this pattern.

Spillover absorbers in process innovation

This group includes firms that are in the process of developing R&D potential and learning, which enables the absorption of external knowledge. Their scores in the use and development of internal inputs are higher than those of firms pursuing supplier orientation, but their rate of human resources upgrading is lower. The surprisingly high growth of R&D spending and R&D intensity do not translate into cooperation with research organizations. This explains why a considerable number of firms outsource R&D results, which is a substitute for cooperation with research organizations. Their consciousness of the weaknesses of process innovations (confirmed by their weak international competitiveness in terms of technology) leads them to cooperate strongly in R&D with suppliers of machinery and equipment. They benefit considerably from this cooperation. Conversely, they are also conscious of the role of product differentiation in competition, as 72% of firms introduced new products and, for 50% of firms, these products were new to the market. International product competitiveness was moderate for most of the firms. Their focus on the development of internal capacity is oriented towards the improvement of the effects of cooperation on product innovation. The benefits of this cooperation remain low.

The sectoral structure of this subset of firms is differentiated. Out of the total number of firms, 43% were foodstuff producers, 32% were electronics manufacturers, and 19% were automotive producers.

Table 1

The three NMS: Firms' innovation pattern characteristics

Innovation patterns / Innovation factors	Low profile	Science-based innovation path	Externally-sourced firms		
			Virtual firms	Spillover absorbers in process innovation	Pursuing supplier orientation
In-house inputs and activities	Lowest	High	High R&D staff and innovation activities but low R&D intensity	High	Moderate
Backward linkages	Low	Highest	High (but supplier of materials)	Moderate	High
Cooperation with research organizations	Lowest	Highest	High	Low	High
Subcontracting	Lowest	Low	Highest	Moderate	High
Beneficial cooperation: product innovation	Lowest	Moderate	High	Low	Highest
Beneficial cooperation: process innovation	Moderate	High	Lowest	Highest	Low
Types of innovation	Process	Product	Product	Product/ process	Product
Innovation output	Lowest	Moderate	Highest	High	High
International competitiveness	P – lowest T – lowest	P – high T – high	P – highest T – highest	P – moderate T – moderate	P – moderate T – moderate
Domestic competitiveness	P – lowest T – lowest	P – low T – moderate	P – high T – moderate	P – highest T – highest	P – moderate T – high
Cluster composition	29% of the firm sample; Food-64%	18%; Food-38%	2%; Electronic-100%	35%; Food-43%	16%; Automotive -34%

P – product, T – technology

Source: own estimates based on questionnaire

SUMMARY AND CONCLUSIONS

Although most firms in the NMS are imitators, externally oriented, non-cumulative (using Llerena and Oltra's notion, 2002, p. 185) and follow Jensen et al.'s (2007) DUI/STI rather than STI mode of learning and innovating, they differ in terms of internal capacities to innovate, as well as partners and forms of cooperation in innovation activities. Most of the NMS innovation patterns are based on an extensive use of external knowledge. In this respect they share the characteristics of many of the innovation patterns of the incumbent EU countries.

A considerable number of sample firms (29%) are low profile (but in the Swiss services sector a similar proportion of firms were found to be low profile). Their low innovation inputs, outputs and cooperation in innovation mean that their products suffer from the lowest competitiveness in the international market and only modest competitiveness in the domestic market. Their domestic orientation and their ability to operate in market niches and in lower quality market segments allow them to survive. They are typical imitators, but such companies are also detected in the incumbent EU member states. The conclusion is that the low profile pattern of innovation is not typical for the NMS exclusively.

As opposed to the low profile pattern, a specific group of firms on the science-based innovation path has also been detected. These firms represent Jensen et al.'s DUI/STI rather than STI mode of learning and innovation, which was found in developed countries. However, their relatively high R&D intensity (but low share of R&D and IT staff) and broad cooperation in R&D with all types of partners, including foreign research organizations, does not translate into high international competitiveness. This can be a result of their relatively low benefits of cooperation, which may reflect specificities of national innovation systems in the NMS as compared to the incumbent EU countries. International competiveness remains moderate for most of these firms, although it is a bit higher than average for the entire sample. The case of firms on the science-based path seems to confirm the impact of national innovation systems on the innovation patterns of firms.

In the NMS firms that were analysed, there are three groups of firms that make extensive use of external sources of innovation, cooperate in innovation with many partners and benefit from this cooperation. Despite these similarities, they represent three different innovation patterns. They differ in innovation strategies in terms of their innovation capacities, its forms (human capital versus R&D intensity), strategies for developing them, the use of external sources of innovation, the areas of spillover absorption, and economic performance. It is worth mentioning that in the literature on innovation patterns of developed countries, many different externally-sourced firms, some of which are similar to the NMS groups, have been distinguished. This shows that the range of externally-sourced patterns of innovation in both the NMS and developed countries is very wide. Our research shows that some of them overlap.

The first group of firms, labelled 'virtual firms' by Teece, is an outsourcing-oriented group and has been detected in developed countries, including Taiwan. Their high share of R&D and IT staff results in a high ability to explore R&D outsourcing. Surprisingly, they have the highest international product competitiveness of the entire population of firms that were analysed. However, their low R&D intensity suggests a limited understanding of the role of knowledge accumulation in their future expansion.

The next two groups of firms share quite an extensive and beneficial use of external knowledge and have moderate international competitiveness. They differ in terms of the types of weaknesses of their production processes and innovation capabilities. They have varied R&D intensities and different ratio of R&D and IT staff in employment, and they focus on a different type of innovation (product versus process).

The high percentage of R&D and IT staff in firms pursuing supply orientation allows them to cooperate in R&D activities with different partners. Their low R&D intensity is to some degree substituted by beneficial cooperation with research organizations. Their competitiveness in the domestic market is quite strong, whereas in the international market it is moderate.

Although the high R&D intensity of the firms within the next innovation pattern, i.e. spillover absorbers in process innovation, supports collaboration in R&D with different partners, as opposed to the previous firms, their absorption of knowledge spillovers in process innovation is high. The development of R&D potential serves to improve the low benefits of cooperation in product innovation. As in the case of the previous group of firms, their product and technology competitiveness in the domestic market is quite strong, while it is moderate in the international market.

Analyses show that it was the virtual innovation pattern that was sector and ownership specific. The other four innovation patterns were employed by firms in different manufacturing sectors and by both private and state-owned companies. This confirms Srholec and Verspagen's hypothesis that in the heterogeneity of firms' innovation behaviour, countries matter only to a certain extent.

To improve international competitiveness, firms in the NMS introduce different innovation strategies. In the innovation activities of most (except low profile) of the detected groups of firms, cooperation plays an important role. Differences in the partners, the form of cooperation and its benefits differentiate the innovation patterns of these firms and their economic effects. Conversely, the competitiveness of firms whose R&D intensity is very low is much lower than those whose R&D intensity is higher (or at least moderate). However, a comparison of the innovation patterns of firms in the NMS raises the question of why firms that have high R&D intensity and extensively use cooperation with different partners in innovation activities only have moderate international competitiveness. Is it because R&D activities require a critical mass before being capable of generating new technology and yielding economic results, and the NMS firms' budgets are too tight to meet it? Is it also possible that the national innovation system influences the capacity of firms to transform high R&D intensity into economic performance? The scope of analysis in this paper does not allow us to answer these two interesting questions.

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APPENDIX

Table A1

Firms in the three NMS: Description of innovation patterns by types of innovation indicators (% of cluster's firms answering 'yes' except for factors where other measures apply)

Innovation patterns / Innovation factors and indicators	(1) Low profile	(2) Virtual firms	(3) Spillover absorbers in process innovation	(4) Science-based innovation path	(5) Pursuing supplier orientation	All firms
I. In-house innovation inputs and activities						
Innovation activities in-house						
R&D or design unit in house	8.6	57.1	51.6	58.7	62.7	42.2
Process development and improvement activities in house	35.7	71.4	91.9	74.6	71.2	65.6
Product development and improvement activities in-house	30.5	71.4	95.2	82.5	72.9	69.8
Gathering commercial and technical information in-house	11.4	57.1	69.4	54	54.2	45.9
HR upgrading						
Management training very important	36.2	28.6	37.9	61.9	59.3	45.0
Employees training very important	22.9	28.6	29.8	39.7	54.2	33.5
Human resources						
Employment share of technicians and engineers (%)	8.8	54.3	9.0	7.0	15.2	10.4
Employment share of R&D and IT staff (%)	3.0	40.0	3.0	1.0	4.3	3.2
R&D Intensity R&D to sales revenues, %	0.13	0.01	0.78	0.82	0.24	0.49
II. Innovation linkages						
Backward linkages and cooperation with R&D units and scientists. R&D department cooperates with:						
Suppliers of raw materials	10.5	42.9	46.8	93.7	49.2	44.7
Suppliers of machinery	2.9	85.7	41.1	85.7	42.4	38.8
Independent scientists	1.9	57.1	8.1	66.7	40.7	22.9
Domestic research institutes	19.0	85.7	44.4	95.2	49.2	47.5
Foreign research institutes	3.8	28.6	5.6	57.1	27.1	18.2
Subcontracting of R&D activities						
Process development / improvements	14.3	100	22.6	12.7	61.0	24.3
Product development /improvements	11.4	100	14.5	23.8	79.7	25.7
Design	4.8	14.3	34.7	20.6	50.8	25.7

Innovation patterns / Innovation factors and indicators	(1) Low profile	(2) Virtual firms	(3) Spillover absorbers in process innovation	(4) Science-based innovation path	(5) Pursuing supplier orientation	All firms
III. Benefits of cooperation with business partners influencing both product and process innovation						
In improved access to modern technology	39	14.3	54	46	28.8	43.3
In improvement in the production process	38.1	14.3	62.9	47.6	42.4	48.6
In modernization of equipment	44.8	42.9	68.5	46	27.1	50.3
In inventories and management	33.3	26.6	34.7	55.6	55.9	31.3
In product quality	61.9	71.4	71	73	93.2	72.3
In design	33.3	71.4	61.3	39.7	78	52.2
In R&D activities	24.8	85.7	53.2	38.1	69.5	45.5
IV. Innovation outputs						
Share of new products and new technology in a firm's sales revenue						
Sales revenue share of products less than two years old	22.4	55	32.9	32.2	47.6	32.6
Sales revenue share of production from manufacturing technology less than two years old	40.2	55.3	47.8	45.8	59.7	47.3
New products introduced in the last two years and						
New in a firm	55.2	71.4	72.6	68.8	64.4	65.6
Being new for domestic market	33.3	85.7	52.4	47.6	42.4	45.0

Source: own estimates based on questionnaire

Table A2

The Three NMS: Product and technology competitiveness of firms by innovation patterns (% of cluster's companies answering 'yes')

Innovation patterns		**1**	**2**	**3**	**4**	**5**	**All firms**
Competitiveness of company's products on the domestic market	Company's products are: strongly competitive	29.5	57.1	70.2	46	50.8	50
	moderately competitive	61	42.9	29.8	49.2	47.5	45.5
	weakly competitive	9.5	0.0	0.0	4.8	1.7	3.9
Competitiveness of company's products on the world market	Our products are: strongly competitive	27.6	57.1	29.8	31.7	30.5	30.2
	moderately competitive	50.5	28.6	62.1	55.6	54.2	55.6
	weakly competitive	21.9	14.3	8.1	12.7	15.3	14.2
Competitiveness of company's production technology on the domestic market	Company's technology is: strongly competitive	27.6	28.6	57.3	44.4	55.9	45.5
	moderately competitive	60.0	71.4	38.7	49.2	40.7	47.8
	weakly competitive	12.4	0.0	4.0	6.3	3.4	6.7
Competitiveness of company's production technology on the world market	Company's technology is: strongly competitive	24.8	42.9	26,6	36.5	23.7	27.7
	moderately competitive	47.6	42.9	52.4	47.6	54.2	50.3
	weakly competitive	27.6	14.3	21	15.9	22	22.1

Source: own estimates based on questionnaire

Table A3

The Three NMS: Results of Factor Analysis

	Factors										
Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Beneficial Cooperation (BC) with business partners in improved access to modern technologies	0.72										
BC in improving the production process	0.71										
BC in modernization of production equipment	0.91										
R&D or design unit in-house		0.53									
Process development in-house		0.79									
Product development in-house		0.75									
Applied Research in-house		0.49									
Design in-house		0.67									
Gathering commercial and technical info in-house		0.64									
R&D department cooperates with raw material suppliers			0.81								
R&D department cooperates with machinery and equipment suppliers			0.79								
R&D department cooperates with independent researchers			0.49								
R&D department cooperates with domestic institutes				0.50							
R&D department cooperates with foreign institutes				0.63							
BC in inventory management and improvement				.	0.70						
BC in product quality improvements					0.66						
BC in product specification and design					0.49						
BC in R&D activities					0.48						
Process development subcontracted						0.76					
Product development subcontracted						0.72					
Design subcontracted						0.62					

	Factors										
Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Managerial training very important							0.81				
Employees' training very important							0.82				
Employment share of technicians and engineers in 2003								0.82			
Employment share of R&D and IT staff in 2003								0.82			
Share of sales revenues from sales of new products in 2003									0.65		
Sales revenue share of production from manufacturing technology less than 2 years old in 2003									0.61		
ISO certificate received									0.51		
New products introduced in a firm										0.67	
New products sold and being new for domestic market										0.70	
R&D intensity in 2003											0.70

Source: own estimates based on questionnaire