Wziątek-Kubiak, Anna; Balcerowicz, Ewa; Pęczkowski, Marek

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Differentiation of innovation behavior of manufacturing firms in the new member states: Cluster analysis on firm-level data

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Differentiation of Innovation Behavior of Manufacturing Firms in the New Member States. Cluster Analysis on Firm-Level Data

Anna Wziątek-Kubiak
Ewa Balcerowicz
Marek Pęczkowski

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CASE-Center for Social and Economic Research on behalf of CASE Network
12 Sienkiewicza, 00-010 Warsaw, Poland
tel.: (48 22) 622 66 27, 828 61 33, fax: (48 22) 828 60 69
e-mail: case@case-research.eu
http://www.case-research.eu

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Contents

Ewa Balcerowicz *is a co-founder and the Chairwoman of the Supervisory Council of CASE – Center for Social and Economic Research; from 1 July 2004 to 30 June 2008 she served as President of the CASE Management Board. She has a PhD (1988) and Master's degree (1977) from the Warsaw School of Economics. Her research and publications focus on: the SME sector, the environment for the development of the private sector, the banking sector and insolvency systems, barriers of entry and exit in the transition economies of CEEC, and, most recently, innovation economics.*

Marek Pęczkowski *is a lecturer at the Faculty of Economic Sciences at the University of Warsaw. He specializes in business process modelling, multivariate data analysis, data mining and econometrics. He has worked in numerous international research projects involving statistical databases and statistical computing.*

Anna Wziątek – Kubiak *is a professor of economics and head of the Department of Macroeconomics and Economic Policy at the Institute of Economics in the Polish Academy of Sciences, a lecturer at the Dąbrowa Górnicza Business School and a scholar at CASE – Center of Social and Economic Research. She has participated in and coordinated numerous research projects focusing on international economics, including international trade and competitiveness and innovations. She has authored and co-authored numerous articles and books published by Springer, Palgrave and Edward Edgar.*

Abstract

This paper investigates the differences in innovation behaviour, i.e. differences in innovation sources and innovation effects, among manufacturing firms in three 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 (innovation outputs and international competitiveness of firms' products and technology) in the three countries. After employing cluster analysis, five types of innovation patterns were detected. The paper characterises and compares these innovation patterns, highlighting differences and similarities. The paper shows that external knowledge plays an important role in innovation activities in NMS firms. The ability to explore cooperation with business partners and the benefits of using external knowledge are determined by in-house innovation activities, notably R&D intensity.

1. Introduction

One of the main issues of economic growth and competitiveness in the New Member States of the EU (NMS) is their innovativeness. As widely proved by economic research, innovations stimulate the economic growth of countries and thus enable the NMS to catch up with developed market economies. The NMS inherited an anti-innovation bias from the command economy system. However, in response to the introduction of market institutions and market rules in the 1990s, firms active in these countries faced increased competition and had to modify their innovation behaviour.

In terms of innovations and economic performance, firms in the NMS are heterogeneous. This raises the issue of differences in innovation patterns[1] among firms, i.e. differences in innovation sources and innovation effects. These countries were isolated from the world economy for many years. During the transition period, new economic networks among firms developed rapidly. Thus, the question emerges of whether or not enterprises also benefited from cooperation with business partners in this period. In other words, we would like to know if they gained the ability to absorb domestic and international knowledge spillovers. This leads to a question about the role of external sources of innovation versus internal ones. Last but not least, the relationship between innovation patterns and international competitiveness is also of interest.

This paper aims to answer the questions listed above. Its purpose is twofold. Firstly, to examine differences in the innovation activities of firms in the three NMS: the Czech Republic, Hungary and Poland, as well as their sources and effects. Secondly, it aims to detect and characterize the innovation patterns of manufacturing sector firms in the three countries and their relationship with economic performance.

The paper is divided into two parts. In the first part the background for our study and specifics of the NMS are presented. First, the main theoretical approaches in explaining the process of differentiation of sources and modes of innovation among firms are presented (Section 2). We summarize the results of research on the role of external versus internal factors of innovations. Next, in Section 3 specifics of the NMS compared to developing and developed market economies is shown. The second part of the paper presents the results of our own research on innovation activities run by manufacturing firms in the NMS. To our

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

knowledge, no analyses on differences in the innovation activities of firms have been undertaken for the NMS so far. This part begins with a brief presentation of 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 aggregate factors that turned out to matter in clustering of enterprises by innovation indicators. The last section presents and discusses innovation patterns of the NMS firms. It focuses on similarities and differences between innovation patterns of firms and their relationship with economic performance. Conclusions convene the paper.

2. Background

For many years, most empirical studies on the diversity of innovation activities focused on inter-industry variations. The studies neglected the heterogeneity of firms within industries and intra-industry differences among firms in terms of innovation behaviour and strategy. At the same time, the theoretical literature does provide some guidance in identifying sources of inter-firm variation in innovation activities. It points out that the unevenness of the availability of information, the various means used to innovate, the differences in expectations about the return to R&D investment and other factors may lead to differences in innovation behaviour and performance.

In theory, the differentiation of innovations within an industry is analysed from various points of view. Two approaches play a crucial role[2] in explaining the process of differentiating sources and modes of innovation among firms: evolutionary theory and the theory of endogenous growth. The former focuses on analyzing ways in which firms develop their innovation process. The specific nature of the process of technological change of a firm and the fact that innovation activities depend on the firm's past history are at the heart of this approach (Nelson and Winter 1982; Verspagen 2000). Heterogeneity in knowledge stocks across firms plays a crucial role in the variation in enterprises' innovation patterns. As a result, firms differ significantly in terms of innovation capabilities: innovation inputs, activities, scope, forms and partners of external cooperation, and innovation output. This also implies

[2] There are many other approaches and theories which refer to the heterogeneity of firms' innovation activities within an industry. For example, the life cycle theory shows that at a given point in time, firms within a given industry can be at different stages of development and innovativeness. This suggests the heterogeneity of their innovation patterns. The strategic management literature shows that firms may intentionally seek to find different innovation strategies from their competitors.

that for firms which did not accumulate knowledge in the past, the potential for creating innovation and using it as a market-expansion factor is rather limited.

The excessive focus in evolutionary theory on the importance of internal resources as a dominant factor of innovation created a tendency to neglect the contribution made by external factors (i.e. knowledge linkages) and their role. The development of the theory of endogenous growth and the endogenization of technological change into economic growth resulted in the introduction of knowledge spillovers to the analysis on innovation (Grossman and Helpman 1991, Rivera-Batis and Romer 1991). The non-rival character of knowledge implies that firms may learn from other firms' innovations. These are known as technological (knowledge) externalities or spillovers. So a firm's innovation capabilities depend on the pool of knowledge it accumulated through internal efforts, on the pool of general knowledge it has access to and its ability to use it. This means that apart from in-house capabilities accumulated in the past, firms rely on external (both domestic and foreign) sources of innovation when developing and introducing innovations. This approach also results in the emergence of the notion of knowledge capital as a function of both the firm's own R&D investment and spillovers (Ornaghi 2006).

If knowledge is cumulative (in the sense that only leaders, that is creators of innovation, can conduct innovative activities), then, as the theory of endogenous growth proves, an outsider can also learn from the previously accumulated technology and acquire or imitate it. For example, firms can enhance the quality of their product by learning from an innovation introduced by competitors and by imitating it. In this way, firms can benefit from a positive externality (a spillover). Outsiders can introduce a new product or simply upgrade the quality of the existing one. However, they have to invest in this improvement as imitation also requires some knowledge. So imitative activity is a type of learning activity, but the learning of new knowledge is costly. This suggests that "in order to recognize, evaluate, negotiate and finally adapt the technology potentially available from others," (Dosi 1988, p. 1132) firms require some in-house innovation capacity. A precondition for the endogenization of knowledge spillovers is some accumulation of knowledge by the firm. The dual role of in-house R&D activities as creator as well as adopter of innovations that spill over from external actors has been recognised.

The discussion on sources of innovation inevitably leads to various taxonomies of firms in terms of innovation capabilities, strategies, ways of creating innovation and modes of innovation (Clausen and Verspagen, 2008; Srholec and Verspagen, 2008). Most of them are based on two types of sources of innovation: internal and external, although in reality they coexist. In many respects, the division of firms into cumulative and non-cumulative (Llerena, Oltra 2002) overlaps with the division of firms into those generating innovation and those adopting innovation (Damanpour and Wischnevsky, 2006). Yet another criterion of classification is by pioneering R&D and by imitating R&D that generates incremental innovation. Other examples are taxonomies on STI (Science, Technology and Innovation) and DUI (Doing, Using and Interacting) firms (Jensen et al. 2007). Although these classifications differ in many respects, they have a dichotomous character as they distinguish between two types of firms: leaders (creators of innovation) and outsiders. They reflect the distinction between innovation and imitation and between innovators and imitators. The last category is diversified. It covers incremental innovators, followers[3] and traditionals[4] (Avermaete et al., 2004).

The discussion on innovation sources, patterns of innovation, and their effects is very relevant for the NMS. Both their heritage as centrally planned economies and the progress they have made during the transition period, meaning the speed at which firms have adapted and integrated into a highly competitive global economy, means that research on the variation of 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 the countries of the Central Europe in their transition to a market economy (i.e. in the entire decade of the 1990s) and the years preceding their EU membership. Firstly, although under socialism, science and technology were very high on the list of government and communist party priorities (Gomulka 1990, Chapter 7), the focus of research was on the areas of science which did not require market validation.[5] Secondly, for systemic reasons, enterprises did not create demand for research from the universities, while the latter did not deliver research results that served the market expansion of firms. There was no demand for and no supply of research results that could have enabled producers to innovate. Numerous

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

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

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

factors that formed the 'constructional logic' of the command economic system were in fact anti-innovation (Balcerowicz 1995, Chapter 6). Nearly all research was government-sponsored and was mostly theoretical in nature with hardly any market implications. The prolonged isolation of these countries from the world economy and the structure of incentives discouraged not only innovation but also imitation (Winiecki 2002, p. 14). "The enterprise managers avoided innovation as much as possible if new technology and associated organization arrangements affected the existing productive capacity (...) and they preferred investment in new capacities, using the same (often already obsolete) technology, to technological modernization" (Winiecki 2002, p. 13). The closed economies blocked international linkages that impact on innovation, including knowledge spillovers. The 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 in-house innovation activities or international knowledge spillovers. The anti-innovation bias of managers and employees and the resistance to privatisation in some industries at the start and early years of transition made the enhancement of innovation quite difficult. However, in terms of human capital, enterprises had a much greater potential to innovate[6] than most firms in developing countries.

During the transition period, the three countries that are of interest to this paper were characterised 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;
- 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 (so called "adverse shock to network activity", see Woodward and Wójcik, 2007) as a result of privatisation and bankruptcy of many firms;

In the early 1990s, defensive restructuring was taking place in the enterprise sector and it was based on shedding labour, reducing costs and scaling down or closing unprofitable

[6] Since the Marxian theory of economic development stressed the key role of economic efficiency, the innovation rate and ultimately productivity levels in the competition of centrally managed economies with capitalistic ones, the countries of the Soviet bloc placed an extraordinary emphasis on technical education (for evidence see Gomulka 1990, p. 94).

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 firms and created 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) countries' domestic firms to absorb knowledge spillovers from external sources, both domestic and international. Absorption is not less important than generating new knowledge, including creating radical innovation. The term 'ability to absorb' covers not only the implementation of external knowledge. It also contains improvements in the knowledge which 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[7].

Research on the NMS underlines 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 a conclusion that 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) basing on analysis of 21 OECD countries in a long run shows that for the G7 group foreign knowledge has a negative impact on competitiveness, while for less advanced ones countries it has a strong positive impact. This impact is stronger the higher the degree of openness to FDI. However, research results are varied depending on the period of analysis, the country, the model introduced, and the types of spillovers. Empirical research on the period up till 1998 (Konings 2001; Zukowska-Gagelmann 2001) showed negative spillovers effects of FDI for domestic firms, although Damijan et al. (2003) did not confirm it. However, research results covering period since 1999 and long term analyses do not confirm earlier research results They did find more positive effects of vertical knowledge spillovers for domestic firms rather than horizontal spillovers was found (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

[7] In 1992-1997, in opposition to Ireland and Spain, FDI in Greece did not generate positive knowledge linkages externalities.

spillovers. Hagemejer and Kolasa (2008) show that differences in ability to absorb foreign knowledge through spillovers varies among types of firms in terms of internalization. Last but not least the issue of indirect knowledge spillovers as a result of R&D conducted abroad was raised. It turns out that the impact of foreign R&D on productivity of the Central and East European countries was greater than that of domestic R&D (Chinkov 2006; Tomaszewicz & Swieczewska, 2008 and 2007). This is in opposition to what has been detected in the EU-15 (Leon-Ledesma 2005).

Summing up, the potential for radical innovations in the NMS is limited. Both the accumulation of knowledge and R&D intensity are low although differentiated among these countries[8]. The number of enterprises in theses countries engaged in innovation activities (as a share of all firms) also remains low[9].

4. Data source and enterprise sample

The data used in this paper was collected through a firm survey 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".[10] The survey was aimed at investigating the networking of firms in the three accession countries (the Czech Republic, Hungary and Poland) and Spain, and its effect on competitiveness[11]. Fortunately we have found a substantial number of questions included in the survey questionnaire as relevant to the analysis of innovation processes. Altogether 41 innovation indicators were selected. We grouped them into four sets by 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. As many academics argue that in the catching up economies diffusion can be the most important part of innovation, we decided to include not only the linkages but also their effects. We also chose four performance

[8] 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 the accumulation of knowledge of firms.
[9] For Poland and Hungary, it was two times lower than the EU-27 average. Only in the case of the Czech Republic was this indicator close to the EU-27 average.
[10] 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. CASE-Center for Social and Economic Research, Warsaw led the research consortium.
[11] 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 on the domestic and on the international markets.

All respondents surveyed were managers responsible for day to day business processes. 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, which happened on May 1st, 2004. Obviously both processes influenced the behaviour of the real sector, i.e. firms, entrepreneurs and investors.

Data was collected for 490 companies. After carefully examining the answers received to questions relevant for researching the innovation patterns, we had to delete 132 firms from the data base, due to missing individual data. As a result the sample shrunk by ¼ to 358 firms. The composition of the sample is presented in Table 1.

Table 1. Enterprise sample composition

	No of firms	**% of the sample**
Countries		
1. Czech Republic	70	20
2. Hungary	111	31
3. Poland	177	49
Ownership		
1. Domestic	244	68.2
2. Foreign	108	30.2
Industry		
1. Food and beverages	160	45
2. Automotive	65	18
3. Electronic	109	30
4. Pharmaceutical	24	7
Total	358	100

Polish firms dominated the sample: they accounted for close to half of the enterprise population surveyed. The majority (ca 70%) of firms was domestically owned; and domestic ownership prevailed in each individual country, though to different extents (Poland was on one extreme with an 81% share of domestic capital, while Hungary was on 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.1 – da15); (2) Pharmaceuticals (NACE Rev.1 – dg244); (3) Electronics (NACE Rev. 1 – dl30); and (4) Automotive Industry (NACE Rev.1 – dm34). Food and beverages firms were the most numerous (45% of the sample), while pharmaceutical firms appeared the least (only 7%).

5. Methodology employed to explore innovation patterns

In order to figure out 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 synthesize the information contained in the original variables. Factors are standardised 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 indicators which refer to the same issue are likely to be strongly correlated and factors that are obtained are uncorrelated. PCA helps prevent including 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, non-hierarchical cluster analysis was performed in order to group firms into a number of clusters by innovation variables as homogenous as possible (small within cluster variance) and at the same time as different as possible from each other (large between clusters variance).

In the Appendix, there is a table which shows the results of factor analysis for 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 factor analysis led to statistically satisfactory results. Eleven factors jointly explaining, in the case of the three countries firms, 54.5% of the total variance were selected. 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 results for the range of K min ≤ K ≤ 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. 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 have been further aggregated and as a result we have received eight so called aggregate factors. These are:

- In-house inputs and activities (aggregate factor 1),
- two types of cooperation in R&D: backward (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 ones,
- innovation outputs (8).

The 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 expenditures as a portion of firm's sales revenues), human resources (share of R&D, IT staff, engineers and technicians in total employment), human capital upgrading through training, R&D unit in a firm, and R&D activities in 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 organization- foreign and 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.

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

Two types of innovation activities: product and process ones constitute factor 7.

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

7. Innovation patterns of firms in the NMS

After detecting the clusters, we analyzed their features. The first step was to study the values of the innovation indicators that were chosen in the course of the cluster analysis. The data is presented in Table A1 in the Appendix. The second step was to compare the value of each factor (i.e. composite variables) between the clusters. We used the following scores: from 'lowest', through 'low', 'moderate', 'high' to 'highest'. The third and last step was to analyze all the scores for each cluster and invent a name for each one based on its distinguishing features.

This procedure has brought us to the finding that the following innovation patterns emerged in NMS firms during the EU accession preparatory period: (1) low profile, (2) hunting for product innovation in the market, (3) spillover absorbers in process innovation, (4) on the science-based innovation path and (5) externally sourced firms (see Table 2).

The detected innovation patterns represent the different innovation behaviours of firms as well as different innovation outputs. 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. Differences in the branch structure of these firms are much greater.

Low profile pattern

Very low in-house innovation resources and activities as well as little external cooperation in R&D distinguish 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 portion of firms benefit from cooperation in the production process suggests that the diffusion of external knowledge, notably to the production process of these firms, plays an important role in innovations. It serves for the accumulation of knowledge, which is very low.

The low innovation potential and the limited innovation activities of this group accompany the worst - among the five subsets of firms (grouped by types of innovation behaviour) - innovation outputs and international competitiveness. The moderate competitiveness of their products and production technology on the domestic market allows them to operate in the niche of this market, possibly in its lower quality segment. The use of external knowledge in the production process indicates that they are conscious of their low competitive position and to improve or maintain it, they focus on the absorption of external 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. Most of the firms (ca 64%) following this pattern are in the food industry, 22% in electronics, 11% in the automotive industry and only 3% 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).

Hunting for product innovation in the market

This cluster encompasses firms that focus on the adaptation of innovations by acquiring them mostly from research organizations. Their R&D intensity is the lowest among innovation patterns. This is accompanied by an extremely high (60%) share of R&D and IT staff in total employment and the dispersion of R&D activities among many fields. Most of the firms have R&D and design units. This suggests that in-house R&D activities focus on searching for new product innovations on the market and better R&D subcontractors. Most of the firms 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 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 in most of these firms. This innovation pattern was the least frequently undertaken: only 7 firms were adopting it. Interestingly, all of them were from the same branch: electronics. The ownership composition of the cluster is not specific; it is similar as in the case of other clusters.

Firms on the science-based innovation path

Firms pursuing a science-based innovation path rank high in the R&D factor (R&D intensity and share of firms that have an R&D department). They also rank highly in cooperation in R&D with different types of partners, notably with research organizations (including foreign ones and independent scientists) as well as with suppliers of raw materials and machinery. Their ease in cooperating with many types of partners reflects their ability to absorb not only tacit but also codified knowledge, as well as their ability to accumulate external knowledge. The fact that they score highly on the R&D factor and on external R&D collaboration suggests the complementary role of two types of sources of innovation rather than the “make or buy decision” (Veugelers, 1997; Veugelers and Cassiman, 1999) model. They score highly on organizational changes as an effect of cooperation. However, the share of firms that recognize cooperation in innovation activities as beneficial is average. This either reflects their consciousness of their knowledge distance from main competitors (they expect that they can gain more from the 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 and international competitiveness. Although they come close to the STI/DUI mode of learning and innovation (Jensen et al., 2007), the international competitiveness of their products remains moderate.

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

Externally sourced firms

This innovation pattern shares some features with the one that relies on hunting for product innovation. The common feature of the two is their low R&D intensity and high share of R&D and ICT staff, which accompany a relatively high use of outsourcing of innovation results. However, in opposition to 'hunters', firms pursuing supplier orientation in innovation behaviour cooperate in R&D with many partners, including both research organizations and suppliers of raw materials and machinery. Their product rather than process innovation orientation is confirmed by a high innovation output and widespread number of firms that benefited from product-oriented cooperation. However their ability to collaborate with different partners does not translate into a very high innovation output or the strong international competitiveness of their products. A considerable portion of firm managers recognized their products and technology as weakly competitive, while the share of firms that recognized their product and technology as strongly competitive was average in comparison with the entire population of firms.

The firms using this innovation pattern differ from others in respect to branch structure. The share of foodstuffs and automotive firms accounted for 27%, while electronics accounted for 33%.

Spillover absorbers in process innovation

In this cluster, we have firms that are in the process of developing R&D potential and learning and this serves the absorption of external knowledge. The surprisingly high growth of R&D spending and R&D intensity did not translate into cooperation with research organizations. This explains why a considerable number of firms use the outsourcing of 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 in a large number of firms) leads them to cooperate strongly in R&D with suppliers of machinery and equipment. They benefit from this cooperation quite considerably. On the other hand, they are also conscious of the role of product differentiation in competition, as 72% of firms introduced new products and, for 50% firms, this product was new to the market. International product competitiveness was moderate for as much as nearly 2/3 of firms but was weak for only 8%.

The branch structure of this subset of firms is differentiated. Out of the total number of firms, 43% were foodstuffs producers, 32% were electronic manufacturers, and 19% were automotive producers.

Table 2. The three NMS: Firms' innovation pattern characteristics

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

P-product, T- technology

Conclusions

Although most firms in the NMS are imitators, non-cumulative (using the Llerena and Oltra definition (2002, p. 185) and follow Jensen et al. (2007)'s DUI rather than STI mode of learning and innovating, they differ in terms of partners and forms of cooperation in innovation activities and in their internal capacities to innovate. The differences in innovation behaviour as well as differences in innovation output and economic performance gave us a base from which we could detect five types of innovation patterns.

On the one hand, a considerable number of sample firms (29%) are low profile that is they are typical imitators. Their low innovation inputs, outputs and cooperation in innovation means their products suffer from the lowest competitiveness on the international market and only modest competitiveness on the domestic market. Their domestic orientation, their ability to operate in market niches and in lower quality segments of the market allow them to survive.

On the other hand, there are three groups of firms which make extensive use of external sources of innovation, cooperate in innovation with many partners and are therefore beneficiaries of this cooperation. Despite these similarities, they represent three different innovation patterns. They differ in innovation strategy in terms of their in-house innovation capacities, its forms (human capital versus R&D intensity), their strategies for using external sources of innovation (the partners and forms of cooperation they focus on), areas of spillover absorption and economic performance.

The first group of firms, labelled 'hunting for product innovation in the market,' represent a type of outsourcing-oriented group of firms which were not detected in incumbent EU countries. Their high share of R&D and ICT staff results in high ability to explore the outsourcing of R&D and surprisingly they have the highest international product competitiveness out of the entire population of analysed firms. However, their low R&D intensity suggests a limited understanding of the role of accumulation of knowledge in 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 potential. They have varied R&D intensities, different shares of R&D and ICT staff in employment and they focus on a different type of innovation (product versus process).

The high share of R&D and ICT staff in 'the externally sourced' firms allows them for cooperation in R&D activities with different partners. Their low R&D intensity is to some degree substituted by beneficiary cooperation with research organizations. On the other hand, although the high R&D intensity of the firms within the next innovation pattern, 'spillover absorbers in process innovation,' supports collaboration in R&D with different partners, in opposition to the previous firms, their absorption of knowledge spillovers is high mainly in process innovation.

A specific group of firms termed as being on the science-based path has been also detected. They represent Jensen et al.'s DUI/STI mode of learning and innovation. 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 transfer into high international competitiveness. Rather, it remains moderate for most of these firms.

Analyses show that it was 'the hunting for product innovation in the market' innovation pattern that was branch and ownership specific. The other four innovation patterns were employed by firms in different manufacturing branches and of different ownership.

To improve international competitiveness, various firms in the NMS introduce different innovation strategies. In innovation activities of most (but Low profile) detected groups of firms, cooperation plays an important role. Differences in the partners and in the form of cooperation differentiate the patterns of innovation of these firms. On the other hand, 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 innovation patterns of NMS firms raises the question of the reasons for the moderate international competitiveness of firms that have high R&D intensity and extensive use of cooperation with different partners in innovation activities. Is it because R&D activities require a critical mass before being capable of generating new technology and yielding economic results and firms' budgets in the NMS are too tight to meet it? Or should high R&D intensity also be accompanied by a high share of R&D staff? Is it also possible that they operate in the countries that have specific characteristics that may influence their capacity to transform R&D investment into economic performance? The scope of analysis in this paper does not allow us to answer these 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) Hunting for product innovation in the market	(3) Spillovers absorbers in process innovation	(4) Science-based innovation path	(5) Externally sourced firms	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 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
Independentt 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

Innovation patterns Innovation factors and indicators	(1) Low profile	(2) Hunting for product innovation in the market	(3) Spillovers absorbers in process innovation	(4) Science-based innovation path	(5) Externally sourced firms	All firms
Design	4.8	14.3	34.7	20.6	50.8	25.7
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 revenues						
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

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	0ur 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

Table A3. The Three NMS: Results of Factor Analysis

Variables	Factors										
	1	2	3	4	5	6	7	8	9	10	11
Beneficial Cooperation (BC) with business partners in i 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						0.72					

Variables	Factors										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
subcontracted											
Design subcontracted						0.62					
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