Innovation Performance in the EU-25 – Methodology, Measurement, Effects[*]

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Abstract: The innovation performance effects are considered the key indicators of the success of innovation activity. Their quantification is however difficult and its results, especially when based on a traditional industry approach, call for careful interpretation in countries with an incomplete value chain and underdeveloped local knowledge base. In the paper, alternative approaches are presented, which consider the significance of qualitative characteristics of the innovation performance effects and allow a more sophisticated analysis of their components at a microeconomic level. Attention is given to four cross-sectional indicators which evaluate the sources of competitive advantage as quality-based as opposed to cost-based (in the combination of the completeness of the value chain and the sophistication of company operations), the level of cluster development (assessed in terms of the frequency and intensity of the links between participating entities), the level of technological readiness (according to dependence on external sources of technology knowledge and the quality of the specific research and skill inputs) and the knowledge-intensity of employment (according to the significance of quality-intensive occupations). By using the given indicators, firstly, the position of countries within the EU-25 is defined in a matrix of the innovation performance effects, and, secondly, their key characteristics in the new member countries of the EU are identified. Conclusions formulate the related challenges for the policy support focused to overcome the new EU entrants lagging behind in the transition to knowledge-based economy and achieving the Lisbon strategy targets.

Keywords: innovation performance, competitive advantage, technological readiness, cluster development

1. Introduction

Innovation performance has a key significance for long-term sustainable, i.e. quality-based economic performance. Evaluation of innovation performance at the same time requires a comprehensive interpretation, which will consider its partial aspects (inputs, outputs and effects) and structural specifics (CES 2005).[1] The range of indicators used in this field is otherwise relatively large but the partial aspects are not covered to the

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[1] The contribution presents selected methodology highlights from the comprehensive assessment of the Czech Republic competitive capacity within EU-25 (The Czech Republic Competitiveness Yearbook) based on four key pillars – growth performance, institutional quality, innovation performance, and human resource quality. The yearbook is annually published by the Centre for Economic Studies with the collaboration of National Observatory of Employment and Training – National Training Fund in Prague responsible for the human resource quality chapter (CES 2005).

same extent and depth. The problem lies particularly in data availability for some (mostly the new) member countries of the EU-25, especially in the long-term time rows (OECD 2004, EUROSTAT 2005a), and also in the fact that the most of inputs, outputs and effects of innovation activities are in their nature not directly measurable or quantifiable.

The presented paper concentrates on the evaluation of innovation performance and within its framework specifically on the effects of innovation performance.[2] The effects are a target indicator of innovation activities and a reflection of the effectiveness of innovation inputs (CES 2005). The data used for innovation performance evaluation are mostly derived from the World Economic Forum executive opinion surveys (WEF 2004, Porter 2003) to asses the microeconomic effects, and from employment statistics to assess the overall significance of knowledge-based activities. Consequently, a matrix is constructed of innovation effects, which allows an evaluation of the resulting qualitative position of the EU-25 countries.

2. The Innovation Performance Effects

Most often used to measure the innovation performance effects are data on the shares of knowledge-intensive activities in total value added, exports or employment (OECD 2003), and, consequently, on their contribution to the overall domestic macroeconomic performance (growth in GDP and productivity), see e.g. Ark, Mahony (2003). An alternative evaluation of the innovation performance effects places emphasis on their role in microeconomic competitiveness, whose precondition (and result) is the technology capacity and quality of input supply, completeness of value chain, sophistication of company operations, and level of cluster development (Porter 2003). Microeconomic competitiveness directly reflects the level of development of the local knowledge base. In the paper, the innovation performance effects are evaluated in terms of the following four indicators:

- knowledge-intensive activities – the share of workers in quality-intensive occupations as % of total employment (EUROSTAT 2005),

[2] Innovation performance is assessed in terms of innovation inputs (financial and human), specific innovation preconditions (supply of tailored financial instruments and skills and intensity of science-industry linkages), scientific and technology performance (bibliometric and patent statistics, number of innovation companies, nature of innovation activities), the presented innovation performance effects, and indicators on information society and economy.

- technological readiness – characteristics of technological readiness in WEF executive opinion survey (technology capacity, supply of qualitative factors, related government policy focus),
- competitive advantage – characteristics of competitive advantage in WEF survey (completeness of value chain, sophistication of company operations),
- cluster development – characteristics of cluster development in WEF survey (sophistication of input supply and demand, local availability of inputs, and quality of cluster development).

The problem of indicators on the innovation performance effects is either the greatly limited availability of (directly measurable) data for the purposes of temporal or cross-country comparisons, or their limited explanatory value. These deficiencies can be compensated only partially by using for example data from expert surveys on qualitative characteristics of competitiveness (i.e. soft data with a greatly limited temporal and cross-country comparability) or by more sophisticated analysis of (qualitative) structure of production or trade which goes beyond the traditional industry-based viewpoint (i.e. which takes into account especially the country position in the supranational value/production chain), see e.g. Kaderabkova (2005).[3]

2.1 Knowledge-intensive activities

The ability to create, utilise and transmits knowledge is reflected in the growing share of knowledge-intensive activities (i.e. intensive in R&D and in higher skills) in exports, value added and employment (OECD 2003, EUROSTAT 2004a), as reflected in a transition to a knowledge-based economy (EC 2004). Specifically, the export of high-tech products shows up the ability to exploit commercially the results of research and innovation activities in international markets. To become quality-competitive, the less developed countries must be able to absorb effectively the technology knowledge of developed countries (through imports, foreign direct investment, and learning by exporting) and adapt it to local needs Reciprocally, an effective technology transfer

[3] The more sophisticated analysis would require differentiation of production or trade data in terms of intra-firm transactions and/or quality intensity of inputs and their combinations. In principle, more attention should be given to the micro data qualitative analysis based on tailored (country specific) expert surveys and interviews with the individual agents of innovation processes. This analytical approach is particularly desirable in the countries with still poorly developed and less structured national innovation systems.

requires an adequately developed local knowledge base, i.e. with in-house R&D activities and high-skill supply.

The classification of knowledge-intensive industries reflects the share of their R&D expenditure in value added. In manufacturing, using OECD classification, industries (in NACE or ISIC codes) are differentiated according to their **technology intensity** from the highest to the lowest levels (OECD 2003).[4] Using the *Standard International Trade Classification* (SITC), a group of high technology products (OECD 1997) is defined. Different classifications (product or industry-based) are therefore used for high-tech activities. In addition to the OECD concept of technology intensity in manufacturing,[5] EUROSTAT defines **knowledge-intensive** services, and within them high technology-intensive services (for example, computing and related activities). Knowledge-intensive services are further specified as financial and non-financial market services (e.g. business services) and other knowledge-intensive services (e.g. education, health), see EUROSTAT (2005a).

The above-mentioned industry-based (and possibly product-based) classifications are used when evaluating the knowledge-intensity of trade, production and employment. It is, however, important to stress that the explanatory value of such data is mostly misleading in countries with an underdeveloped domestic knowledge base. These countries usually carry out the industries characterised as knowledge-intensive within the supranational value chains, i.e. they are undertaken in the affiliates of foreign investment enterprises and their R&D intensity (like their skill intensity) remains actually low. In the case of manufacturing, these industries usually contain mostly assembly operations or the production of simple parts and components. Therefore, in these countries, the use of industry or product based classifications according to technology intensity in comparison with developed countries is inadequate and mistaken (Kaderabkova 2005, CES 2005). An appropriate corrective viewpoint in this case is to consider the import intensity of the technology-intensive industries (or products) or their structure according to

[4] An example of industries with a high technology intensity is the production of pharmaceuticals or computers, medium-high technology intensity represents the production of automobiles, medium-low intensity the production of rubber and plastic, and low technology intensity that of food or textiles.
[5] The range of industry classifications used for manufacturing is actually much broader – industries are classified e.g. in terms of their skill intensity (according to the shares of white/blue collars with high/low skill levels), factor intensity (labour intensive, capital intensive, specialized suppliers, science-based), processing stages (resource inputs, intermediate inputs/outputs, final products) etc.

production/processing stages. The so-called technology-intensive exports in less-developed countries are usually also highly import-intensive, based on assembly of imported parts, and the range of traded products and trade partners is very narrow. Another example of a corrective viewpoint is the structuring of employment according to **occupation quality-intensity** using *International Standard Classification of Occupations* (ISCO), where the share in total employment of workers in ISCO1-3 occupations (legislators, senior officials and managers, professionals, technicians and associate professionals, so-called high-skilled white collars) is evaluated (Kaderabkova 2005).[6]

2.2 Technological readiness

Technological readiness shows up the conditions for the development of sophisticated products and company production processes in individual countries, i.e. for the development of quality/innovation-based competitive advantage (WEF 2004). This evaluation reflects a perception of the quality of business R&D and technology openness, supply of research services and research and technical skills, significance of technology transfer through foreign direct investment and the role of government in the support of business R&D.[7]

The **technological readiness** of a country itself is evaluated in an international context from a position of leading to one of strong lagging. Technological readiness expresses the availability of the latest technology for company operations (i.e. the level of development of technology base) and company in-house innovation activity. Partial characteristics of technological readiness are further evaluated in a more detailed structure.

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[6] The characteristics of the qualitative structure of employment in manufacturing can be further specified according to the *technology intensity* of industries. The specification is to show whether the differences in technology intensity are reflected in qualitative differences of employment structure. According to empirical analyses (Kaderabkova 2005), in the new (and/or less developed) EU members, the share of high-skilled workers in high-tech industries remain low, or are roughly comparable to those in the less technology intensive industries. On the contrary, in the more developed countries, the shares of high-skilled workers in high-tech industries are markedly higher than in the less technology intensive industries.

[7] In evaluating technological readiness the ten selected characteristics of subchapter 3 of the WEF survey of the year 2004 are used. Evaluations are based on the executive opinions, i.e. soft data. Evaluation moves in intervals from 7 (best result) to 1 (worst result). In the year 2004 104 countries were compared. An aggregate evaluation of technological readiness is expressed by an unweighted average for individual country partial characteristics.

Technological readiness evaluation starts with the company **technology capacity** which is determined by its expenditure on in-house R&D (in comparison with foreign competitors), absorption capacity towards new technology at a company level (in contrast with technology isolation), technology autonomy as opposed to dependence on external sources of knowledge (acquired only through licensing or imitating foreign technology). In sum, technology capacity expresses to what extent the utilised technology is the result of company internal innovative abilities as opposed to its mere adoption from external sources, in particular to what extent company is open to new technology knowledge.

The **supply of qualitative factors** influences the company technology capacity. Especially important are the availability of specific and high-skilled human resources (scientists and technicians), the quality of research institutions, the intensity of science-industry cooperation and the significance of foreign direct investment as a source of new technology (transfer). The quality of supply determines the development of company technology capacity according to availability of specific skills or services. Insufficient supply adversely influences development of technology capacity especially in smaller enterprises with limited access to external sources.

The environment for the development of company technology capacity is also influenced by **government policy** and its focus on the support of R&D activities and technology-intensive demand. Therefore, the extent of subsidized funding and tax allowances of company R&D activities is evaluated. Moreover, the criteria for government procurement are differentiated according to their emphasis on the technology advancement characteristics instead of solely the price. Other influential aspects of government policy include support of the supply of qualitative factors (initial and continuous education and training), of the technology transfer through foreign direct investment, of science-industry linkages etc.

2.3 Competitive advantage

Quality-based competitive advantage is a source of long-term sustainable growth and thus of economic prosperity. A condition for its emergence and development is an adequate supply of qualitative factors, e.g. technology and human resources, an adequate institutional environment, and a complexity and sophistication of company operations and strategies thanks to which these factors are utilised effectively and efficiently. In the global economy, the significance is growing of the country (or more precisely company) position in the supranational value chain (OECD 2005). This position is characterised by the completeness of the value chain, i.e. whether it contains quality-intensive segments (R&D, own marketing and distribution strategies, producing and selling under its own renowned brand) or just less quality- and technology-intensive activities (such as assembly operations of imported components and parts).

At first, two key **sources of competitive advantage** are differentiated, which are low costs and/or local natural resources (sensitive to price competitiveness) as against unique products and processes which are difficult to imitate. Further indicators specify in more detail the completeness of the value chain and the sophistication of production processes.[8] The completeness aspect differentiates between companies who only acquire and process resources (i.e. they undertake only primary basic productive activities) and companies who also perform more sophisticated strategy-based activities especially product design, marketing, logistics, and after-sales services. The richer and more complex the value chain, the higher the valuation of production inputs.

Specified in more detail is the significance of sales under an internationally renowned **own brand** in combination with a developed sales organisation as opposed to the sales limited to commodity markets (of homogeneous products) or to other companies (e.g. under foreign brands). A related question is whether **international distribution and marketing** are carried out via foreign companies or via companies who are owned and controlled locally (i.e. using their own marketing strategies). Finally, the extent of company activities in **foreign markets** is characterized. A larger range of trade partners usually points to the presence of a quality-intensive value chain and well-developed marketing and distribution activity.

Further is considered the **sophistication of production processes.** In this case, companies using labour-intensive methods or obsolete production technology are differentiated from those using advanced and efficient technology at a world-class level. The sophistication of production processes is directly influenced by in-house innovative

[8] The characteristics of competitive advantage are evaluated using parts of the indicators of subchapter 9 of the WEF investigation from 2004 (see previous indicator). An aggregate evaluation of competitive advantage for individual countries is expressed as an unweighted average of values of the partial indicators.

capabilities and quality of human resources and, in turn, is reflected in the developed marketing strategies.

Innovation capacity is evaluated according to whether a company acquires its technology primarily from licensing and imitating or by in-house research activities and by introducing new products and processes. A condition of the effective technology utilisation is a skilled workforce; therefore, the company approach to **human resources** is important, especially as reflected in the extent of investment in training and skill development (which simultaneously increase human resource adaptability in the labour market). **Quality of marketing** is evaluated according to the use of the most sophisticated instruments and procedures against only limited development and importance of marketing activities in company strategies.

2.4 Cluster development

The emergence of clusters is considered a characteristic of the sophistication of company strategies and operations.[9] Clusters are geographically close groups of companies, suppliers, service providers and related institutions in a certain industry, which are linked by common and complimentary characteristics. Clusters influence the company competitiveness in various ways. In contrast to isolated companies, they improve access to specialised suppliers, employees, information and training, which increases productivity. In addition, clusters make easier the utilisation of innovation opportunities thanks to better expertise of involved entities and to their better access to the specific skills, assets and capital which clusters attract. Finally, the supply of specific inputs facilitates the emergence of new enterprises, because it lowers entry barriers (Porter 2003). The emergence and development of clusters requires the accomplishment of a number of conditions and to a certain extent reflects the character of the company culture and the quality of the business environment. Especially it reflects the capability of cooperation in the acquisition and development of inputs and at the same time the preservation of competition upon the marketization of outputs. The functioning of a cluster likewise requires the communication capability across diverse interest groups

[9] The characteristics of clusters are evaluated using the indicators in subchapter 8 of the WEF investigation (see previous indicators). Aggregate value is expressed by unweighted averages.

(with different institutional backgrounds) in a given region, and thus their openness towards alternative value criteria and preferences.

The initial indicator evaluates the **state of cluster development** when their frequent occurrence and deeper structure (abundant and intensive linkages between involved entities) is preferred. Lower development stage is characterised by competition based on a cheap labour, local natural resources and a strong dependence of domestic producers on imported components, machinery and technology. Specialised local infrastructure and institutions are absent. In qualitatively higher stages, clusters develop and deepen. They include suppliers of specialised inputs, components, machinery and services. Specialised infrastructures and institutions likewise develop, which supply specialised education and training, and information and technical services. More developed clusters also include professional associations and other collective groupings of private entities, which support cluster members. Companies operating in the most developed clusters often establish or support clusters in other locations and thus partly disperse their activities to lessen risk, which improves availability of inputs and the provision of specific services. The qualitative advance of cluster development means a shift in their focus to more sophisticated and more prolific (innovation-intensive) activities.[10]

Partial questions on the subject of clusters are focussed on the sophistication of **supply of inputs and demand**. In the case of buyers, is considered their expertise and decision criteria (based on performance characteristics as opposed to low price). In the case of suppliers, is considered their quantity and quality. The quantity indicator takes into account also the local availability of key inputs (raw materials, parts, machinery and services). The quality indicator differentiates between internationally competitive suppliers capable to assist purchasers in the development of new products and processes and suppliers with low technology capabilities. A further group of indicators includes **local availability of inputs**, i.e. the availability of parts and machinery (in the required quality) from local suppliers as opposed to their availability only from imports. The

[10] Clusters of different specialisation and development levels can operate in different locations in a given economy. However, only a small number of clusters develop into real innovation centres, which usually specialise in specific market segments.

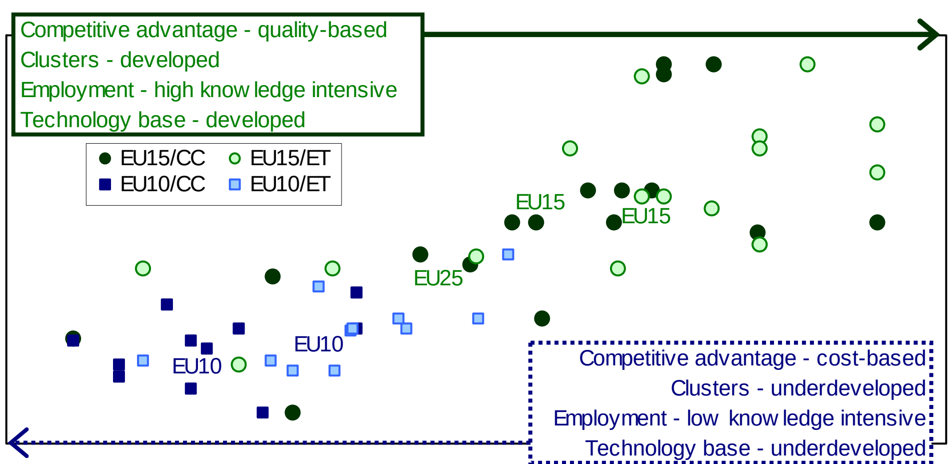
availability of specialised research and training services is evaluated according to whether they are provided at a local level at a world-class standard.

The last class of indicators evaluates related **qualitative characteristics** of cluster development. The strictness of regulatory standards is, as a demand factor, regarded a significant incentive for improving the technology level of products and processes. The decentralisation of company activities (as opposed to their high concentration) makes industry entry easier and stimulates competitive pressure in the market and, consequently, the innovativeness of involved agents. Frequency, diversity and intensity of linkages within clusters (i.e. between heterogeneous groups of participating agents) significantly contribute to their qualitative development.

3. Matrix of innovation performance effects

From the above-mentioned four indicators on the innovation performance effects (with 2004 data), a matrix has been created including EU-25 member countries and two country groups of new and old members (see figure).

Figure: Innovation performance effects matrix



Note: CC – competitive advantage, cluster development, ET – employment knowledge intensity, technology base development. Source: WEF (2004), EUROSTAT (2005), own calculations.

The country position is determined by values in the indicators of competitive advantage, cluster development, knowledge intensity of employment, and development of technology base. From the data presented, a clear difference can be seen in the positions of both groups of EU countries, i.e. the new members show more of a cost-based competitive advantage (with an incomplete value chain), a low level of cluster development, low knowledge intensity of employment and an insufficiently developed technology base, and consequently, an overdependence on external sources of technology knowledge.

It is possible to present aggregate quantification in the form of values of observed indicators which in the EU-25 are normalised in intervals from 7 (best result) to 1 (worst result). The difference between the values of EU-15 and EU-10 countries is substantial. The best position in the framework of EU-25 is held by the Scandinavian countries (Finland, Sweden and Denmark). The new member countries on the other hand occupy the last places together with Spain, Portugal and Greece (see table). Of the EU-10 the best positions are held by Slovenia, Cyprus and the Czech Republic. From the point of view of individual components of the innovation performance effects, the new member countries lag behind especially as to the qualitative sources of competitive advantage and completeness of the value chain and to a smaller extent also in the level of cluster development. Conversely, the position of the new member countries is on average the most favourable with regard to the knowledge-intensity of employment.

Table: Innovation performance matrix effects – average values

EU15	EU25	EU10	ES	SI	CY	CZ	PT	MT	EE	LT	PL	HU	SK	GR	LV
4,6	3,5	1,7	2,9	2,2	2,2	1,9	1,9	1,7	1,7	1,5	1,4	1,4	1,4	1,1	1,0

Note: Values in the interval from 7 (best result) to 1 (worst result) within EU-25. Source: WEF (2004), EUROSTAT (2005), own calculations.

4. Conclusions

Within the EU-25 countries, it is possible to observe considerable differences between the new and old members with regard to the innovation performance effects. The new members significantly lag behind especially in the sources of competitive advantage, which are predominantly cost-based (with sales under foreign brands), with an incomplete value chain and a low sophistication of company operations. The low level of cluster development shows itself in a low sophistication of network and cooperation links, weak quality of demand and technologically insufficient local supply of inputs. The low level of technological readiness is above all caused by persistent dependence on external technology knowledge and related low domestic intensity of expenditure on R&D. The limiting factor of the domestic technology base can be likewise ascribed to an insufficient supply of specific and quality-intensive inputs and also to insufficient government support in this area.

The question of the possibility of qualitative change of innovation performance effects in the new member countries is one of stronger use of technology transfer of foreign direct investment in the host countries, and of increased effectiveness of expenditure on innovative inputs (i.e. effectiveness of national innovation systems) particularly based on increasing economic benefits of R&D activities and the consequential development of the research and technology base (including adequate supply of high and specific skills). At the same time, the domestic structural specifics must be taken into account and the adaptation of transferred technology to local needs supported and made possible. Given the specific problems and needs of increasing the innovation performance effects in the new member (and generally in the less-developed) countries it is important that they are projected into the nationally-specific instruments of innovation policy, in particular the policy concerned with support of competitiveness and long-term sustainable growth performance.

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