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DEVELOPMENT OF HIGH TECHNOLOGIES AS AN INDICATOR OF MODERN INDUSTRY IN THE EU

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ABSTRACT. The article tries to classify the EU states in terms of the advancement of structural changes in their industries on the basis of the increase in the share of advanced technologies in total industrial production, labour, added value, and surplus. In the times of the knowledge-based economy the ability to produce high-tech goods, the demand for which is growing much faster than for traditional goods, indicates the level of modernity of industry.

The dynamic growth of the demand for knowledge-based high-tech goods results from the evolution of consumer habits, which are predominantly driven by educated and rich societies who demand that their sophisticated needs met. An important role in stimulating this demand is played by modern media as they instantly deliver information on the latest technical developments and are very efficient in transferring patterns of consumerism. The ability to adapt the structure of production to the needs of the market is crucial in defining a state's position in the international exchange of goods. This is due to the fact that the national technology is tightly interwoven with export abilities.

KEY WORDS: the European Union, industry, high-tech sector (high-technology industry), modernity.

INTRODUCTION

The first mention of high technology, also called high tech, appeared in the specialist literature in mid-1960s when the then modern industries developed rapidly (Wiśniewska, 2002). Generally, this category includes the industries which operate at the contact zone between science and industry by applying the results of scientific research in industry. In the European Union the delimitation of the

high-tech sector is presently based on the OECD's methodology elaborated in the years 1980–1995. In accordance with this classification, the high-tech branches include (Table 1):

Table 1. Manufacturing industries of high technology by NACE Rev 1.1

Codes	Manufacturing industries of high technology
24.4	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
30.	Manufacture of office machinery and computers
32.	Manufacture of radio, television and communication equipment and apparatus
33.	Manufacture of medical, precision and optical instruments, watches and clocks
35.3	Manufacture of aircraft and spacecraft

Source: NACE (Nomenclature statistique des Activités économiques dans la Communauté Européenne) Rev 1.1

MODERN INDUSTRY

In the circumstances of the knowledge-based economy formation, the restructuring processes in industry should be turned towards the development of branches and enterprises producing the up-to-date goods, which are much more in demand than some traditional industrial goods. The modernness of goods is connected with the involved inventions and technological processes. Today, to the group of 'modern' industrial branches are being included the high-tech industries, which show to be much more economically effective than the less technologically advanced branches. These industries are the main source of the high value added and the new and highly salaried jobs (Gierańczyk, Rachwał, 2010).

As the contemporary economic development promotes knowledge, the basic indicator of modernity in the structure of industry is the one which shows the share of high tech in total production (Karpiński, 1994). This is because production of these goods is one of the most dynamic elements of the world economy. Moreover, the changes evoked by the spectacular development of high-tech goods have been so large that they are treated as the element of empowering the reality (Bratnicki, Strużyna, 2001). The role of this factor, which was treated as a residual value, was first described by R. Solow in the 1950s. According to him, technological advancement, which is crucial for the productivity of other factors of production (productive inputs), increases by 80% of economic growth (Kelly, 2001). In modern times the ability of the economy to advance a higher technological level concordant with better economic, social, and ecological effects remains a key factor for the long-term economic growth (Fic, 2004).

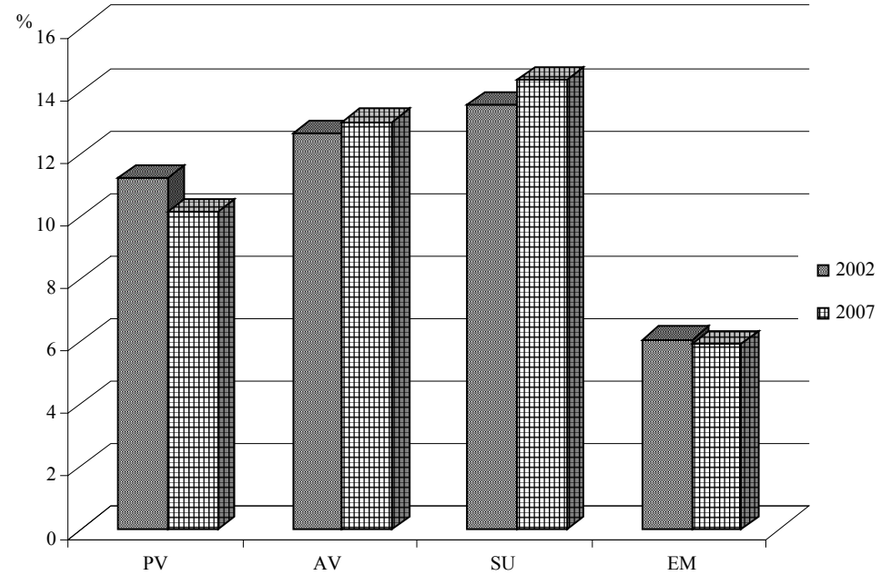

Fig. 1. The high-tech share in the structure of production value (PV), added value (AV), surplus (SU), and employment (EM) in the EU industry in 2002 and 2007

Source: Own compilation on the basis of Eurostat

In accordance with research results, the highest and constantly growing share of high-tech goods in the industrial production is recorded in the best developed countries of the world, such as USA (about 21%), South Korea (19%), and Japan (about 16%) (Turowski, 2005). In 2007 in the EU the high-tech goods constituted only 10% of the total industrial production, and this share ranged from 2.83% in Bulgaria to 32.71% in Ireland. High diversity in the abilities to produce goods of advanced technologies within the EU is proved by the V_s indicator, which in the study period increased from $V_s = 67.3\%$ in 2002 to $V_s = 71.2\%$ in 2007.

The increased diversity of the high-tech share in the total industrial production was mainly the effect of the changes in the production structure in the 'new' EU states. Although the growth rate of the high-tech production in the states of the 'old' EU was similar to this in total industry, the states of the 'new' EU showed an increased polarisation. In Slovakia and the Czech Republic the dynamics of the high-tech production was almost twice as high as in industry in total. At the same time, however, in Bulgaria and Lithuania, where the growth rate of the high-tech production was half of this in industry in total, the share of the high-tech

sector in the industrial production fell by almost 50%. This means that competing using the high-tech products on the market remains a challenge for the high-tech goods' producers, who need to show flexibility in adjusting to the ever changing conditions.

Competitiveness model in the high-tech sector, similarly to this in industry in general, has undergone changes. At first producers competed using prices. Even in the 1960s and 1970s producing goods cheaper than others seemed to be the most effective form of competitiveness. In the following decades, however, a more and more demanding consumer market showed that, besides price, quality and diversity also pose important elements of competitiveness. Companies realised that the value of the end product is based on its difference and thus the old products were upgraded in order to make them stand out and totally new products were introduced to the market. It is estimated that in the 1970s new products generated about 20% of the profit of an average company, while a decade later the profit based on newly introduced goods amounted to about ⅓ of the profit.

At the end of the 20th century quality and rate at which new product were introduced intensified even further. Specialty, as well as strategies such as Lean, Just in Time, TQM (Total Quality Management), and others led to a strongly diversified range of products which reached a larger number of consumers. At the beginning of the 21st century companies began to compete using new unique products and services. Design, innovations, exceptionality, and new ideas, especially in the high-tech sector, have become the basis of competitiveness (New Products…, 1982).

The increase in the high-tech share in creating the added value and profits in the EU industry in total (Fig. 1) shows that in terms of the high-tech products the EU is able to compete on the global markets. This is the consequence of effectiveness of using high and unique skills, especially indispensable at the initial phase of a product design.

In accordance with the research, profits based on the above rule are mainly gained by the 'old' EU states, especially Ireland, Finland, and Sweden. In those countries the high-tech sectors creates over 20% of the added value and over ¼ of profits in manufacturing. At the same time, these are the countries which are leaders in terms of the amount of R&D (Research and Development) resources in the high-tech sector. In 2007 their high-tech sectors absorbed over half of the R&D resources from the section D (Manufacturing by Nomenclature statistique des Activités économiques dans la Communauté Européenne Revision 1.1). It can be assumed, thus, that in the states of the lower share of the high tech in the total industrial production and absorption of the R&D resources only a simple added value consumed by the market is generated, which is the outcome of the final stages of production.

The growing tendency of profitability of the high-tech sector in the states of the high share of this sectors in the production value and adsorption of the R&D resources indicates that the added value is created at the final but, most of all, the beginning stages of goods' production. The added value included in new constructions, technologies, and unique instrumentation is much more valuable, as when it is introduced into the market it creates new workplaces. The relation between the share of the high tech in the AV (Added Value) and the expenditures on the R&D stems from the fact that the R&D expenditures in the high-tech sector are mainly generated by scientific research which are the basis for the high-tech sector of industry, as well as by modernization process which is crucial for constant improvement of quality parameters of the produced goods (Grupp, 1995). According to the studies conducted by the OECD Secretariat, the top positions in the ranking of high-tech branches do not change. Thus, investment into the R&D sector favours technological advancement, and the other way round – technological advancement favours investment into the R&D sector.

The distribution of the resources transferred to the R&D within individual branches of industry delimited on the basis of the R&D's intensity correlated with the distribution of labour force in the R&D sector in the EU states (R = 0.886). Simplifying a matter a bit, it can be stated that basing the development strategy on quality-structural factors, which make the media of innovation, creates large profits and high added value. Thus, the elements which indicate international competitiveness depend on the ability to produce highly transformed and technologically advanced goods, which generate the available level of knowledge and technology.

Table 2. Correlation between the high-tech share in the production value (PV), added value (AV), surplus (SU), employment (EM), and the expenses in the B&R sector (BERD) in industry in the EU states in 2006

Variable	PV	AV	SU	EM	BERD
PV	1.000	0.897	0.792	0.922	0.484
AV	0.897	1.000	0.964	0.792	0.638
SU	0.792	0.964	1.000	0.631	0.616
EM	0.922	0.792	0.631	1.000	0.411
BERD	0.484	0.638	0.616	0.411	1.000

Source: Own compilation

In 2007 the R&D labour force amounted to about 10% of total employment in the high-tech sector, while in industry in general it equalled only 2.43%. Small dynamics of changes in the labour force structure indicates that work efficiency, which is a measure of good management, has become an important element of

competitiveness. On average, in 2007 in the EU work efficiency in high-tech industries was twice as high as the value recorded in industry in total. However, the growth rate of work efficiency was diversified. High level of efficiency, which also grew faster than the efficiency in industry as a whole, was recorded in Denmark, Ireland, Sweden, and Belgium. At the same time, the EU countries of lowest work efficiency in the high-tech sector showed various tendencies. In Slovakia and Romania work efficiency in the high-tech sector grew much faster than in industry as a whole, while in Lithuania and Bulgaria the correlation was the opposite.

$$DQ = \frac{P_{HTa} / P_{HTb}}{P_{Pa} / P_{Pb}} \quad \text{(a)}$$

P_{HTa} – mean value of production (employment, surplus, added value) in the high tech in a given state in 2007
P_{HTb} – mean value of production (employment, surplus, added value) in the high tech in a given state in 2002
P_{Pa} – mean value of production (employment, surplus, added value) in industry in a given state in 2007
P_{Pb} – mean value of production (employment, surplus, added value) in industry in a given state in 2002

$$LQ = \frac{E_{HTa} / E_{HTUE}}{E_{Pa} / E_{PUE}} \quad \text{(b)}$$

E_{HTa} – mean value of production (employment, surplus, added value) in the high tech in a given state
E_{HTUE} – mean value of production (employment, surplus, added value) in the high tech in the EU
E_{Pa} – mean value of production (employment, surplus, added value) in industry in a given state
E_{PUE} – mean value of production (employment, surplus, added value) in industry in the EU

Considering the dynamics of the selected indicators in total industry and in the high-tech sector, expressed by the DQ index (Dynamics Quotient – a) and the level of the specialty in the high-tech sector expressed by LQ (Location Quotient – b), similarities between the EU states in terms of the rate and directions of the changes in the sector of the most intensive R&D was conducted (Table 2). This analysis enabled the author to delimit three clusters of states which are similar in terms of the competitiveness of the high-tech sectors (Fig. 2).

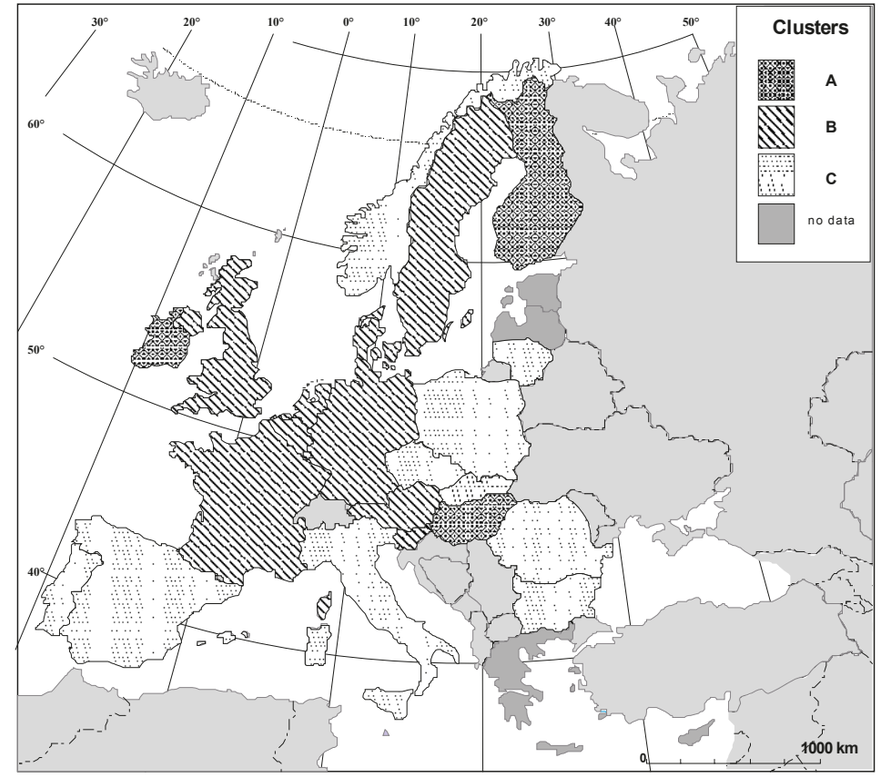

Fig. 2. Similarities of the DQ and the LQ of modernity of industries in the selected EU states based on the analysis of clusters in 2007
Explanation: A – cluster A; B – cluster B; C – cluster C

Source: Own compilation on the basis of Eurostat

Table 3. Arithmetic mean for groups of EU countries delimited on the basis of similarity of industrial modernization

Variable	PV-LQ	PV-DQ	AV-LQ	AV-DQ	SU-LQ	SU-DQ	EM-LQ	EM-DQ
A	2.40	1.18	1.87	1.11	1.86	1.06	2.32	1.08
B	1.46	1.02	1.45	1.11	1.52	1.14	1.39	0.94
C	0.55	0.99	0.51	0.86	0.41	0.82	0.62	1.09

Source: Own compilation

In the period of time in question, the highest level of modernity of industrial structures expressed by a high dynamics of the increasing role of the high-tech sector in industry, as well as a clear tendency to develop their specialty in the high-tech sector, was recorded in Finland, Ireland, and Hungary. These states showed a clear specialty in the high-tech sector and, at the same time, the growth in the share of the high tech in generating profits and added value was much faster than in total industry. They modernized the structures of their industries thank to their openness to new technologies and attractive surroundings of businesses. During the researched period the LQ of the high-tech in Hungary was a bit lower than in Finland and Ireland (20%), but this sector showed a very high dynamics of its development. In terms of the value of production the dynamics of growth of the high-tech share in relation to industry in total was much higher than in the remaining countries in the group A.

The development of the high-tech sector, the products of which generated 30.3% of the export value in 2007, was significantly supported by foreign investments into this sector. To ease this process, a number of legal, administrative and financial instruments were created. Paradoxically, besides its developed infrastructure the attractiveness of Hungary was increased by the relatively restrictive law regulations on the protection of intellectual property. However, at the beginning the investments Hungary followed the same path as the other states under transformation. International companies invested in Hungary mainly due to low labour costs and the accessibility of the home market. With time, however, the possibility to use the country's technological potential was becoming more and more crucial. As a result, the local system of research and development had to take the challenge of supporting research of large international corporations as well as increasing the existing subvention systems. Last but not least, it was important to strengthen the interrelations between science and firms which would foster the development of their own high technologies. The key element of attracting foreign investments into Hungary was the development of the national system of innovative institutions which cooperated with large international corporations. As a result, at the end of the 1990s the research and development undertakings and other pro-innovation processes were intensely stimulated by foreign investment. Today, thank to the fact that more and more international companies locate their research and development activities in Hungary this state has become the headquarter of numerous research and development centres which stimulate the engagement of firms into innovative activities of R&D (Woodward, 2003).

The cluster B included the other states of the 'old' EU (excluding Spain, Italy, and Portugal) as well as Slovenia. These countries belong to the strongest economies in the EU, which are propelled by the highly developed industry. In 2007 they all created about ⅔ of the value of the total industrial production of

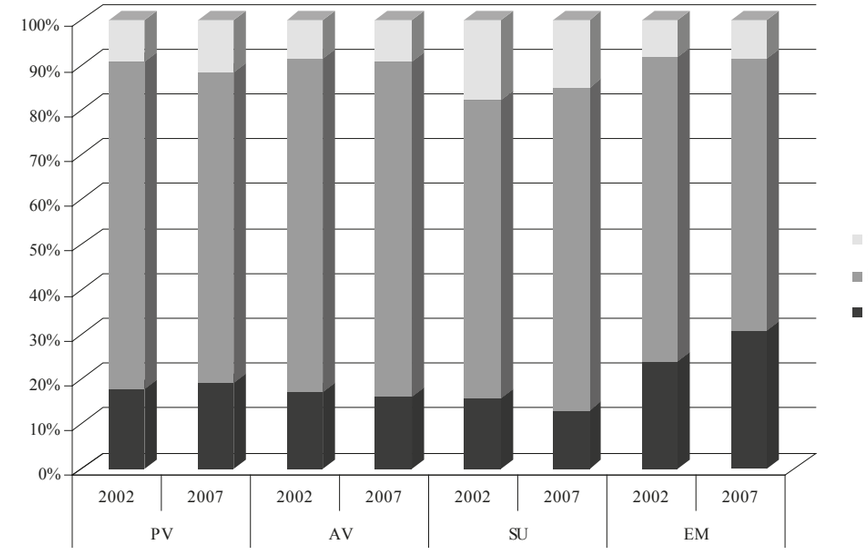

Fig. 3. Share of groups of EU countries delimited on the basis of similarity of industrial modernization in the structure of production value, added value, profits, and employment in the EU high-tech industry in 2002 and 2007
Explanation: A – cluster A; B – cluster B; C – cluster C; PV – production value; AV – added value; SU – surplus; EM – employment

Source: Own compilation on the basis of Eurostat

the EU, and the structure of their industries is dominated by goods of medium-advanced technologies. Simultaneously, in terms of their engagement in the R&D activities they belonged to those states which actively 'created' knowledge in industry, and this activity not only referred to the high-tech sector but also to the less technologically advanced sectors which were based on the previous achievements. As a result, in the study period in terms of the production value and labour force the high-tech industry in this cluster of states was developing at the similar rate as total industry (Table 3). In terms of the added value and the profits, however, the rate of the development of the high-tech sectors in relation to the remaining sectors of industry was much higher, similarly to the cluster A.

In 2007 the cluster B showed the average share of the high-tech sector in the profits and AV in total industry at the level of 15–20%, while the production value was at 10–12% and labour force at 5–7%. It means that the average labour force efficiency in this cluster was twice as high as in total industry. Thus, besides the advantages of the traditional factors of production, the states of the cluster B are

building their competitiveness on the basis of production of high contents of the R&D, especially in the areas of high effectiveness. The decrease of the share of this cluster in the production value and the structure of the labour force in the high tech of the entire EU but, at the same time, the growth of their share in the AV and profits indicates (Fig. 3) that the most effective stages of the production process of the high-tech goods are done within those states, while the stages of standardization or those which necessitate larger labour force resources are outsourced.

The cluster C aggregated mainly the states of the 'new' EU (excluding Hungary and Slovenia) and some states of the 'old' EU, namely Spain, Italy, and Portugal, which were closer to this cluster than to any other. This cluster showed an insignificant percentage of those employed in the high-tech sector (2–6%), as well as a low share of the high tech in creating added value, profits, and production value (4–8%). Low values of the LQ in the high-tech sector indicate that the industrial development refers to other than high-tech sectors. The dynamics of growth of the employment in the high tech, a bit higher than in total industry, shows that there are certain symptoms of restructuring the industries at the intellectual level. However, modernization of industrial structure is more reflected by the saturation of the high tech with the R&D workers rather than those generally employed in the high-tech sector. In accordance with the research results, the R&D workers in the cluster C oscillated between 2% in Cyprus and Poland and 6% in Spain, while in the Scandinavian states they reached ¼ of those employed in the high-tech sector. The states of the cluster C showed a relatively high dynamics of the growth of the high-tech share in the labour force structure which was strongly correlated with the increase of the high-tech share in the production value. Considering a very low level of 'production' of knowledge in the industries of these states it can be concluded that they are mainly the places where the final stages of the high-tech goods' production take place. Similar rate of changes in the labour force structure in the high tech and in industry in total indicates that in the states of the cluster C the human capital composes the main source of labour force used in the production of the high-tech goods, and not in the production of the knowledge.

Generally, in EU countries, the development of employment in high-tech manufacturing is, although more favourable than for low-tech manufacturing, relatively modest. This was shown by a pan-European study (Tether, 2000) pointing to the fact that for the aggregate high-tech manufacturing sector no clear-cut trend of an increase in employment could be observed. Also, a national Austrian study (Lettmayr et al., 1997) found that high and medium high-tech industries by far outperform low and medium low-technology sectors in terms of employment change is seen to be rather modest (High-tech…, 2002).

But in the words of Kaloudis et al. (2005) there is no evidence supporting the argument that the high-tech economies are also the high growth economies. This suggests that different economies can follow different paths of economic growth. Countries play different roles in the differentiated international economic system with clear patterns of division of labour among the highly developed economies.

Based on these conclusions we would hypothesize that growth is not primarily rooted in the creation of new sectors but in the internal transformation of sectors which already exist and/or are growing, such as, the service sector. Overemphasising the role of the high-tech sectors as isolated contributors to growth ignores this major dimension of change due to transformation in advanced economies. Such oversimplifications in the conventional wisdom are rooted in fundamental assumptions supporting modern research and innovation policies, which by overemphasising the role of R&D in economic growth often underestimate processes of change and the needs of those sectors of the economy with low R&D investments.

Concluding, we see limited technological progress of the Eastern European nations. European prospects appear somewhat uncertain given the dramatic competitive thrusts from Asia (Johnson et al., 2010).

CONCLUSION

In the circumstances of the knowledge-based economy formation, the restructuring processes in industry should be turned towards the development of branches and enterprises producing the up-to-date goods, which are much more in demand than some traditional industrial goods. However, the EU is a conglomerate of states which show a diversified level of modernity in their industries. The grade of advancement of modernization changes in industry does not depend on the time a given state has belonged to the EU, but on the abilities to apply the results of the R&D research in industry. The states which invest in the R&D sector absorb benefits from the development of the high-tech sector, mainly in the form of surplus. As the examples of Ireland and Hungary show, a high level of modernity in industry can be achieved by diffusion of innovations from the outside, but then the benefits from the development of the high-tech sector concentrate in the scale of production and the development of the labour market. In the states which cannot activate the R&D sectors in their industrial entrepreneurships (irrespectively from the source of financial input), the gap between them and the leaders increases. This is due to the fact that the benefits of the scale of production and the development of the market in the high tech arise slower than in the other sectors of industry.

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