Technology Market in the European Union

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Abstract

The common market of factors of production in the European Union (EU) involves the free movement of labour factor, financial capital and innovation/technology. Technology as a separate factor of production in an integrating area is rarely incorporated into theoretical analysis. From a theoretical point of view, there are different relationships between various segments of the market of factors of production. Importance and strength of the relationship between them changes with each shift in the economic development of the EU member countries and deepening of integration processes. No doubt, however, that the central element becomes innovations / technologies, that lead to structural changes and local changes in integrating areas. Therefore, the purpose of this article is to assess the progress of the integration processes on the technology market in the EU and the identification of the relationship between this segment of the market of factors of production and its remaining segments.

The first part of the article presents the technology as a factor of production in an integrating area. Next we describe the influence of R&D on the region's competitiveness and we identify the main characteristics of the technology market in the European Union. The main aim of the next part of the paper is to indicate the role of international business in the creation and transfer of technology in the European Union. The analysis conducted in the paper is based on specialist literature and statistical data.

Keywords: Technology, European Union, Integrating Area

1. Introduction

With the economic opening up of Eastern Europe and the advances of Asian newly industrializing countries in the world market global competition has intensified - especially in the field of labor-intensive products and medium intensive technologies. For European Union's countries and regions facing intensified import competition and the relocation of production in the context of foreign direct investment outflows it is therefore important to increasingly position themselves in advanced technology fields. Hence Research and Development (R&D) are increasingly important for growth and international competitiveness. It particularly enables the development of new products and process, the reduction of production costs and the improvement in the quality of production.

When regional differences in the European Union are discussed, the focus is often on economic differences. However, if the analysis is extended to research and technology factors, it becomes clear that the gap between strong and weak countries is even more pronounced in connection with research and technology than the economic gap. Furthermore, pronounced differences exist not only between the member states, as there are also major differences between regions within individual countries (European Commission, 1994; European Parliament, 1997).

2. Technology as a factor of production in an integrating area

Technology as a factor of production in an integrating area was not the subject of comprehensive studies in the theory of integration. Technology understood in the broad sense includes not only the production technologies (product and process technologies), but also managerial knowledge, marketing skills, and other so-called intangible assets on the level of a company (Pavitt, 1999; Van Tho, 1993). Constant development and spread of technology is widely recognized as a key factor distinguishing modern and modernizing societies.

Technology can be transferred in the form of tangible assets such as new products and equipment; in the form of intangible assets such as patents and licenses and in an informal way, by exchanging information and knowledge (Howells, 1998). It can be transferred through various channels, which are divided, generally speaking, into public and private. In the first case, the transfer is carried out by public organizations: the governments of highly developed countries and international agendas. Technology is then the public good. Its transfer is a part of technical assistance and economic cooperation with developing countries. In the second case, the technology is transferred by private companies on commercial basis.

Creating a technology is subjected to the process of internationalization starting from the early '80s, what is expressed in the so-called R&D internationalization (Gerybadze, Reger, 1999). Traditionally, this process was characterized by a unilateral transfer of technology, i.e., ideas for new products and technological knowledge have been created by a dominating parent institution and copied in other peripheral locations. This process can be interpreted as learning from the outside or the exploitation of knowledge moving from the center to the periphery. In contrast, the new innovation process is characterised by: 1/. Multiple centers of knowledge in different geographic locations; 2/. A combination of learning through the transfer of knowledge from the parent company and the knowledge created in a given location; 3/. Technology transfers, both between different geographical locations and between organizational units. Developments in science and technology (Note 1) have led to crystallizing of the polycentric structure of national research and innovation systems. In every important area of research there have developed two - three so-called “centers of excellence”, which compete with each other and which rankings can change quickly.

3. Research and Development as a Factor of Competitiveness

Research and technological development or, more generally, the ability to innovate and produce new products and knowledge are important factors for competitiveness and hence for an economy’s growth potential (O.E.C.D., 1996; European Commission 1997; Schmookler, 1966; Solow, 39/3; Kaldor, Mirlees, 1962; Gomulka, 1971). Since continual change is the feature of the market, on-going research and technological development and innovation are essential. Access to technological development and innovation is of crucial importance for a region's capacity to compete in a global market.

The post-war view of R&D policy was based on an implicit routinized model of innovation in an economy where the most important inputs were land, labor and capital. R&D and technological change itself were viewed as being simply supplement to these factors of production. This was also an economy of relative certainty and stability. The international competitive advantage was generally achieved through cost reduction resulting from large-scale mass production to exploit scale economies. The supplemental role of R&D in the post war economy was designed to reduce costs through process innovation and to generate incremental innovations. The routinized role of R&D was perhaps first articulated by Schumpeter who observed that, "Innovation itself is being reduced to routine. Technological progress is increasingly becoming the business of teams of trained specialists who turn out what is required and make it work in predictable ways" (Schumpeter , 1942).

Companies in the weaker regions can no longer compete with procedures in the developing countries on wage costs. At the same time, they are subject to the pressure of competition from strong countries and regions with rapidly changing patterns of innovation and a faster and shorter life cycle for products. In order to compete on high-tech markets, the weaker regions must adjust to the demanding pace set by the prosperous regions in the Community in the area of product and process invention and innovation (Note 2). R&D is needed for process innovations, which allow costs to be cut and hence markets to be widened - this could facilitate the exploitation of static and dynamic economies of scale (Audretsch, 1995; Scherer, 1992). R&D is also a requirement for product innovations, which allow firms to charge higher prices. Firms that are eager to recover R&D investment costs and to earn a Schumpeterian rent from innovation will try to ensure intellectual property rights, typically via patents. They will also massively invest into marketing in order to create preferences in favor of the novel products. R&D as well as marketing expenditures create market entry barriers because they largely represent sunk costs; newcomers will find it therefore difficult to successfully enter the market. Innovative firms thus can enjoy extra profits which partly will have to be shared with workers since trade unions in highly profitable industries will strongly lobby for wage rises. With continued product innovations the value-added by the firm will indeed rise continuously such that the wage bargaining process will result in rising real wage rates and higher real incomes in some sectors. This in turn will result in multiplier effects in the overall economy.

Launching product innovations will stimulate the growth of demand directly as was emphasized by Schumpeter who also stressed that entrepreneurship is the basis for long-term growth and economic cycles (Schumpeter, 1939; Korres, Lionaki, Polichronopoulos, 2001). Both for R&D devoted to product innovations and to process innovations it holds that unit R&D costs can be reduced if large output volumes are realized during a given innovation cycle. From this perspective the gradual increase of R&D expenditure - GNP ratios is bound to stimulate competitiveness. While competitiveness certainly has aspects of relative technological positing in world markets - typically emphasized in the literature - one should not overlook the global real income effect of process innovations (the price reduction effect). Product innovations create new markets and stimulate the expansion of firms as diffusion of novel products and processes follow a logistical expansion path. In the context of an open economy it is crucial that EU firms specialize in a way that is consistent with their respective comparative

technological advantage (Dosi, 1988). This could be an actual comparative advantage of a potential advantage that relies on strong domestic market growth or R&D subsidies in the context of dynamic scale economies.

4. Characteristics of the technology market in the European Union

Market of knowledge is highly imperfect, and when left to its own, functions improperly. This results from the characterization of knowledge as a public good, which discourages the supply of knowledge and investment in research. Three ways are indicated to improve the functioning of the market of knowledge and commercial ideas (Pelkmans, 1997): 1/. Subsidizing the supply side by the government; 2/. The internalisation of the market of knowledge within enterprises by controlling the internal R&D activity and a systematic commercialization of results; 3/. The introduction of and respect of the protection of intellectual property rights. It should, however, be noted that these methods could also be the source of distortion in the market. With regard to the subsidization of R&D sphere in the EU's support for R&D, activities can be made at the level of a member country and at EU level. (Basic data on the size, structure and effectiveness of expenditures on R&D are summarized in table 1and note 3). Functioning of multi-research programs funded by particular governments can lead to a reallocation of R&D activities among member states. Subsidizing R&D activities at EU level is, as it was evaluated, not more than 6% of expenditures of the member states on this purpose.

The internalisation of the market of knowledge within companies, as a method of correcting its deficiencies at the EU level, requires consideration of two aspects: i.e. the extent of internationalization (or to be more precise "Europeanization") of companies and their participation in cooperation for networks in the scope of R&D. Internationalization of production and R&D means the distribution of these activities in different EU member states and a free movement of knowledge within the integrated areas but exclusion of single companies from this activity. This can result in uneven distribution of R&D function in the whole European Union and in concentration of more developed countries, attracting these types of activities.

Creating a network of cooperation between companies in the field of technology is also an indicator characterizing the technology market in the EU. This cooperation is made between institutions of non-profit type and in business sector. Institutions which are not focused on gaining profit (such as various types of colleges and universities) are traditionally open to international cooperation. Business sector, operating in conditions of competition, is seen as an unwillingly cooperating with strategic rivals, especially in the field of technology. Data on cooperation agreements between the companies - not just in the European Union - collected in the 90s deny, however, this quite common view (Cantwell, Janne, 1999; Archibugi, Michie, 1995). An increase in creating networks of cooperation between companies is observed, especially in the field of so-called high technologies (biotechnologies, new materials, information technologies). According to estimates, approximately 70% of all monitored agreements were attributed to these sectors (Archibugi, Michie, 1995) .

Two main reasons for the increase in popularity of these agreements are indicated: 1/. Due to the nature of new technologies, which require a substantial „wealth" of knowledge for their mastering, the success of innovative activities of individual companies depends on the access to information about what is happening in a given field; 2/. In the case of emerging industries, particularly important is to gain and exchange information in order to reduce potential losses. Benefits of companies arising from this type of cooperation include distribution among partners considerable financial outlays necessary for the specific activity, which is the R&D, accelerating the return on investment incurred by a faster spread of the company's assets, risk spread, increasing efficiency owing to the benefits of scale, scope and specialization, turning of competition into collaboration.

In relation to companies from the European Union, a strong growth in the number of cooperation networks between them, especially in the field of information technologies. These are networks created independently by companies, and such, which are sponsored by the European Union. The available data suggest, however, that it would be unjustifiable to make a conclusion about the dominance of intra-EU relationships in the different segments of EU technology market, or the existence of general patterns of behaviour attributed to the operation of the market. Data collected at the stage of finalizing the construction of the Single Market indicated that, European companies in a greater extend cooperated with partners from the U.S. than with European partners. Intra-European joint research projects accounted for 19% of all such operations, while Euro-American – 21%. This would indicate that there is a more global rather than regional approach to technology issues. It should also be remembered that intra-European cooperation was not only a result of the shifts in market forces and effects of market integration in the market of the factors of production, but also the effect of policy to support the research and technological development, carried out at EU level.

4.1 Technology Policy of the European Union

The technology policy's objective (Note 4) is to promote technological research and technological development as one of the key factors of the improvement of the competitiveness of the whole EU on the international markets.

From the point of view of this analysis it is important to identify those elements of technology policy that affect the functioning of the market of the factors of production in the integrating area. This policy is based on the principle of subsidiarity. The Member States retain the freedom in the field of research and development, and at EU level, the attempts are made to coordinate and finance, with respect to these research areas which are of a super national meaning. The technology policy of the European Union covers both support for basic research and diffusion of technology, as well as for the development of technological cooperation of various organizations and institutions, focused on the development of scientific research base for small and medium-sized companies. Realization of such formulated objectives corresponds to the need of the improvement in functioning of the market of knowledge within EU functioning of markets previously discussed. Crucial elements here include: 1/. Support for the basic research, 2/. Support for the spread of technology, 3/. Promotion of the technological cooperation. The technology policy of the European Union is realized in practice within long -lasting research framework programs (the so-called Framework Programs). These programs, define the scientific and technological objectives, priorities and proposed projects necessary for their implementation, together with financial resources and their distribution among particular leading research tasks.

4.2 Technological specializations and the international competitive position of the European Union

Indirect answer to the questions posed above can be sought in analysis and evaluation of technological specialization of the European Union and its international technological competitiveness. Evaluation of technological specialization of the EU, in the scope of the deepening of integration came out unfavourably against its competitors: the U.S. and Japan.

The technological specialization of so-called Triad (USA, Japan, EU) measured by the sum of absolute differences in shares of patented ideas (which are assigned to specific industries in the tested period of time) and by so called Herfindahl index - which is a measure of the concentration of patent patterns (sum of squares of the shares of individual industries in the total number of patented ideas from each country, multiplied by 100) - shows significant differences. Between 1992 and 2002 the U.S. and Japan have reached a much stronger shift towards a concentration of innovative activity, and as a result, a higher degree of technological specialization than the EC. At that time the European Union experienced a reduction of technological specialization, what proved not enough use of their potential to achieve scale benefits within R&D activity. It is assumed, that the lack of an innovative specialization still results from parallel competitive functioning of R&D programs in various countries. Studies show that there is still a considerable scope for improving the effectiveness of European Union technology policy coordination between national policies in the field of R&D and policy at EU level.

Assessment of the position of the EU in trade in technologically advanced products come out more favourably, although they are geographically diverse and concern a slightly different period than that examined above. In the years 1999-2005 the trade in high-tech products was characterised by a deficit. Japan is the top net exporter, through with a negative trend (42beuro in 1999, 31beuro in 2005). US has a negative balance in 2002 and 2003 (-20beuro); its balance was positive in 1999 and become positive again in 2004 and 2005. China had negative balance till 2004 (-2beuro), but in 2005 it becomes positive. EU25 has the highest negative balance over the period 1999-2005 (-28beuro in 2005) (European Commission, 2007)

Other studies conducted for the years 1999-2005 are based on the amount of exports/imports of high-tech products per capita. This provides the magnitude of high-tech trade in relation to the population of the country considered. (Table 2 and 3).

The data show that exports of high-tech per capita (i.e. the intensity of high-tech exports) are higher in Japan than in US, although the world market shares of Japan's exports are consistently much lower than those of US. In EU25, exports of high-tech products per capita are much lower than those of Japan, despite the fact that EU25 has higher exports world market shares. China's figures are very small compared to the other countries: its intensity in high-tech trading is still very low and it will take many years to catch up with the other countries. The statistical data show that the picture of EU and Japan for imports across years is very similar (around 500 – 550 euro/cap in 2005). However, such intensity is highest in the US (US population and enterprises are eager of high-tech products, above 700 euro/cap). China, due to its large population, has very small intensity (about 120 euro/cap).

These results allow only in an indirect way to answer the questions previously raised about the legitimacy and effectiveness of technology policy of the EU. Critically evaluating the technological specialization of the Union one should pay attention to the need for a better coordination of efforts in the scope of R&D, non-spreading and non-replication of R&D programs at the national level. By contrast, the observed improvement of the competitive position of EU in relation to its main rivals was a joint effect of activated mechanisms and conducted technology policy. One should agree with the view that the establishment and proper functioning of this market is, so far, the

most important incentive for private innovations .Technology policy corrects imperfections of the European market of knowledge which are being revealed.

5. Creation and technology transfer in the European Union. The role of international business

The European Union is an area where the largest transnational corporations operate. Change in behaviour of these companies in the process of deepening European integration were the subject of research, whereas, an attempt to define the specific processes of internationalization of technological activity of transnational corporations in the EU faces difficulties due to lack of research focusing on this aspect of the problem.

From the empirical research conducted in a wider context than the integration and focusing on a selected group of 21 largest transnational corporations it can be concluded that European companies are characterized by some identity in internationalization strategies of research - development activity (Gerybadze, Reger, 1999).These strategies depend on the size of the country of origin, specificity of industry and features of enterprise itself. We can distinguish companies of a global range that come from small, but highly developed European countries. The size of their national R&D base is limited, so the transnational companies which come from these countries are obliged to actively participate in foreign researches. However, many transnational companies from large European countries, characterized by significant technological base (Germany, France, United Kingdom), still shows a tendency to focus a substantial part of their research in country of origin. This concerns in particular the engineering industry and the construction of means of transport and electrical equipment. By contrast, the strategies of companies of chemical and pharmaceutical industry are different, since they are characterized by a substantial share of foreign R&D in their activities. For comparison, transnational corporations which came from the U.S. based on their own, and a strong national research base and were less internationalized in R&D than European companies. Major Japan corporations were characterized by the low degree of internationalization of R&D. By contrast, studies conducted on a sample of 244 transnational corporations operating in technologically intensive fields indicate that European companies were characterized by the greatest share of R&D activity located abroad, in total capital expenditures on R&D in comparison with their major competitors that are American and Japanese companies (Roberts, 1999). This share was shaped on the level of 30%, but the European companies had a tendency to focus on intra-European investments.

Deepening of European integration, that is passing through its successive stages pushed researchers to formulate hypotheses that with the advancement of integration processes there are changes made in specialization of innovative activity of transnational corporations in an economically integrated region. In J. Cantwell model (Cantwell, 1987) on the cumulative causation in the scope of specialization of innovative activity in integrated area, two types of production undertaken by transnational companies are distinguished: 1/.Intensive research production usually associated with local research and development works; 2/. Assembly production type does not require support of local research and development.

Production of research intensive components final assembly operations can be separated by location but integrated through intra-European market, as a result of the strategic decisions of transnational companies. Regularity is that the research intensive production is drawn in to places of strong innovation activity. In countries where local firms are strong in the innovation sector operations of transnational companies are becoming an additional incentive for the development of this sector. They induce increase in the share of research intensive activity in the whole of local production; and this in turn, is associated with a higher rate of productivity growth and -by increasing local competitiveness – with a higher rate of production growth. A kind of virtuous circle is being activated.

Conversely, is in the case when local companies in a given sector are technologically backward. If a transnational company invests there in production, this will be the type of an assembly production, and innovation and advanced components will be imported. Local activities in R&D field may be then in danger. Highly competitive transnational companies may strengthen their position by increasing the transfer of funds from local sales to the parent company, intended to further develop their R&D. Local companies lack the resources and are forced to cut their expenses on this purpose. It moves down the function of technical progress in countries where companies are relatively weak in important innovative industries. Mechanism of a vicious circle is activated. In countries that are not quite able to compete effectively with TNCs, the activity of the latter can stop this "vicious circle" through indirect influence on the function of technical progress. Then the local innovations take the form of skills development, improvement of manufacturing processes, better technical equipment of the production process, a new quality of technical control, etc.

Today's global economy reveals a tendency for geographical concentration of innovative activity in areas that bring investors the benefits of technological agglomeration. These are benefits arising from conducting innovative business activity in geographic proximity to other entities involved in such activity. Knowledge, unless it is

codified, does not spread in an automatic and simple way. Its diffusion is made easiest through direct personal contacts. Then the concentration of innovative activity in a certain geographical area, in which other innovators are present, strengthens and facilitates innovation processes.

6. Conclusions

Integration in the scope of market of production factors is not yet a completed process in the European Union and proceeds unequally. The European Union technology market is just emerging. Because of the specificity of this market, that is its encoded imperfection which results from character of knowledge as a public good, the integration efforts in this field will not be able to bring quick results. On the one hand, the EU's Common Technology Policy is trying to support the emergence of a more integrated technology market, on the other - the internationalization of creation and technology made beyond the borders of EU countries and integration groups, as a result of the activities of transnational corporations, can constitute a serious barrier in realizing the common technology market.

It is necessary to create now in all regions of EU a basis for future growth and development. Short-term solutions to a number of problems are not enough, as they jeopardize future growth. As a result of the changes in economic activity, which have meant that knowledge has become the crucial factor for economic growth, policies must also be adjusted to keep pace with those changes. The increasing importance of R&D requires regional, national and union's R&D policies to be adapted to the new structures and requirements. Among them it is worth to mention: the formulation of favourable conditions at universities and research institutions for commercialization of research and development results, support of innovation in non-industrial sectors of the economy, cooperation of research and educational institutions at developing spin-off firms in the first phases of their existence. How exactly new structures and policies-are to be formulated is still open to debate and this paper can be seen as an introduction to that debate.

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Notes

Note 1. In this paper the term "science" is understood to cover the creation, discovery, examination, classification, reorganization and dissemination of knowledge on physical, biological or social subjects. "Technology" is science application know-how. As such, it belongs to a large group of like activities, which embrace the creation and use of artifacts, crafts and items of knowledge as well as various forms of social organizations. Technology does not only signify the application of scientific results, but any purposive treatment, methods, working method and skill in the exploitation of scientific knowledge together with the products of so doing. The significance of the "research" process in the materialization of the innovations nowadays is uncontested. According to the rules of present day research statistics, a distinction must be made between fundamental research, applied research and experimental development. The three subsequent differentiated concepts are often combined under the heading "Research and Development". See: *Frascati Manual,* OECD 1992; *Proposed Standard Practice, for Surveys of Research and Experimental Development,* Fifth Revision, Paris 1993.

Note 2. Invention can be defined as the discovery of new solutions and new ideas for acquiring new knowledge. Innovation is when an invention is for the first time implemented and put into production or a new idea is for the first time put into practice.

Note 3. In October 2008, the EU industrial R&D investment scoreboard was released. This presents information on the top 1,000 companies in terms of R & D investment whose registered offices are in the EU. The report shows that R & D investment by these top 1,000 companies grew in 2007 at a faster pace than for non-EU competitors from either the United States or Japan. It should be noted that there was a marked reduction in investment activity in the United States at this time. Nevertheless, the data presented show that R & D investment by EU companies grew for the fifth consecutive year. The regional distribution of companies in the top-50 R & D investors in 2007 was split: 20 in the United States, 18 in the EU and 9 in Japan.

Note 4. Technology policy can be defined as comprising the sum of all state measures promoting new or existing technologies for economic application in broad sense. Although Ergas concluded that "precise boundaries of technology policy are often difficult to identify", there are district technology policies, which have been pursued in the European Union. The legal basis for supranational research and technology policy in the European Community is laid down in specific articles of the ECSC Treaty (steal and coal union), the EAEC Treaty (nuclear research) and the European Community Treaty, the Single European Act and the Treaty of Maastricht on European Union. The main objectives of the common R&D policy are to provide impulses for welfare-increasing progress in important technological fields and to stimulate the diffusion of new technologies. The idea is to develop coordinated national policies as well as supranational research activities, where the concrete aims are: 1/. Strengthening the scientific and technological bases of Community industry and encouraging it to become more competitive at the international level, 2/. Eliminating unwarranted duplication of national R&D programs, 3/. Improving the efficiency of projects by task and cost sharing or use of pooling resources, 4/. Helping to reduce unemployment in the EU through new technologies and product innovations.

Table 1. Basic data on the size, structure and effectiveness of expenditures on R&D

	1998	2001	2003	2005	2007
Research and development expenditure, by sectors of performance % of GDP E.U. 27	1.79	1.86	1.86	1.82	1.85
Research and Development expenditure, government sector	0,27	0,25	0,24	0,25	0,27
Share of research and Development Personnel (%of the labour force)	na	1,29	1,33	1,37	1,41
Total European patent applications (in 000's)	45,2	50,8	51.5	55.1	56.7

Source: Eurostat, European Commission

Table 2. Exports (euro/cap)

	1999	2000	2001	2002	2003	2004	2005
EUR25	307	401	414	371	356	389	437
JAPAN	771	1096	872	796	743	796	791
CHINA	21	34	42	55	73	99	132
USA	725	843	894	683	575	694	747

Source: European Commission, 2007

Table 3. Imports (euro/cap)

	1999	2000	2001	2002	2003	2004	2005
EU25	400	536	507	458	437	474	499
JAPAN	439	644	563	520	486	516	543
CHINA	24	39	50	64	80	101	126
USA	658	932	811	749	645	666	719

Source: European Commission, 2007