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CHALLENGES OF HUNGARIAN SCIENCE POLICY: THE EVOLUTION OF A KNOWLEDGE-BASED ECONOMY AND SOCIETY

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SUMMARY

The last two decades of world economic development were earmarked by several important changes. From the angle of a transition economy in Central Europe two of them stand out the most: (i) the economic transition from central planning back to market economy and (ii) the evolution of a new technological and economic paradigm, *i.e.* a knowledge-based economy and society. The parallel appearance of the two processes opened up a rare window of development and catching-up for these economies, since mass scale replacement of production inputs specialized on the needs of central planning and eastern-block alliance became unavoidable. This urgent need for massive investments in new capital goods, education and corporate networks could incorporate production means and other carriers of codified knowledge of the new technological paradigm. It could also help define the new role of these countries in the currently reshaping new world-economic labour division. This study makes an attempt of evaluation of the corroboration of these two processes in Hungary.

Based on an extensive review of literature on the evolution of the knowledge-based economy the authors tried to define the extension to which Hungary has been affected by the new development processes until recently. The paper also highlights some special aspects of the Hungarian development path of the knowledge-based economy. Two of them stand out. One is the size and the background of Hungarian firms that rarely allow the direct participation in knowledge-based international co-operation networks. Instead, they may still find many market niches that cannot be covered by the new ICT-based technologies. There are also market segments where the use of cheap labour provides an alternative to the expensive application of ICT. The other important aspect is the mass-scale employment of Hungarian labour in ICT-based production networks through the local affiliates of multinational companies.

Since Hungary has not been left untouched by ICT and other elements of the knowledge-based economy and society, it is crucial to define the specific requirements of this development model towards the supply of manpower and economic policy. After the definition of the changes that were brought along with the new development, the paper concentrates on these two distinct areas. First, it describes the potential roles that Hungarian economic agents, companies and employees may play in the new labour division. Here the circumstances of increased international tasks and labour mobility are also taken into account. Second, the paper assesses those institutions and policies that were aimed at facilitating the Hungarian integration in the new technological paradigm. The role of Science Parks and Cooperative Research Centres are at the core of this discussion.

1) THE KNOWLEDGE-BASED ECONOMY[*]

Functional description

Traditional economic theory recognized only land, labour and capital as factors of production. Knowledge was formerly considered as a source of increasing returns, because it can be reused without cost once created. Recently, this has been radically changed, because technology developments in the last century have transformed the majority of wealth-creating processes from a physically based platform to a knowledge-based one. The Internet now means information can be transported instantaneously around the world, and any advantage gained by one company can be eliminated 'overnight'. The only comparative advantage is the company's ability to derive values from the information flow resulting in knowledge. Technology and knowledge have become essential factors of production in what amounts to an emerging new era.

According to OECD researchers, the knowledge-based economy is directly based 'on the production, distribution and use of information and knowledge' (OECD 1996, p. 7). This definition emphasizes the importance of two elements in an emergent continuum represented by the sequence of data information knowledge wisdom (Miller 1999, p. 87). To demonstrate their differences, it is necessary to draw a distinction between knowledge on the one hand and information and data on the other.

Because information requires a relation to subsist between data (Fleming 1996), data as such is not information. This relation is strongly dependent on the present context and has few implications for the future. Because the relation depends on the emerging associations influenced by prior cognition by the recipient, it is possible to derive various stocks of information from the same data. As Bellinger (1997) has shown, *information* relates to description, definition or perspective (what, who, where and when).

Beyond the relations, there is a pattern (Bateson 1988) among data and information with the potential to represent *knowledge*. It only becomes functional, however, when the pattern and its implications are grasped and understood. When applied to information, such a pattern bestows greater completeness, so that knowledge includes strategy, practice or method (how).

Knowledge theory draws a fundamental distinction between explicit (codified) and tacit knowledge. Boutellier (2000, p. 208) described codified knowledge as being embodied in products or documented knowledge. He also placed tacit knowledge in two categories: experienced knowledge (know-how) and social knowledge. The transfer processes of codified knowledge clearly differ from those of tacit knowledge, which is not easily transmitted and thus not an obvious source of increasing returns. Langlois (2001) has proved nonetheless that

[*] This study was prepared for the KNOGG research project, Work Package No. 4.

knowledge does not have to be codified to generate economic growth.

Apart from speeding up economic growth, knowledge can bring structural changes in the economy. Neef (1998) stated that new products and emerging services resulting from knowledge-mediated growth can bring profound changes in the nature of the work, *e.g.* from low skill requirements to high.

Development path and a working definition

It was pointed out by Amidon Rogers (1996) that five major forces influencing the global marketplace have to be understood to grasp the business opportunities provided by the global economy: shifts from information to knowledge, bureaucracies to networks, training to learning, national to transnational, and competition to cooperation. All result in the emergence of virtual networked organizations working by collaborative learning systems that enable flows of knowledge throughout the organization.

Rogers describes such changes in the five-step evolution of *R and D management*, but it can easily be extended to the *general business strategy* of the firms, as they radically affect even the strategic management of firms. Such an extension allows documentation of a four-generation evolution of management approaches towards a knowledge-driven economy comprising knowledge-based companies.

(i) Mainly *tangible assets* were managed. In those days, the strategy was effectively to manage equipment and production lines to provide maximum value to owners. The core strategy operated in isolation and tangible assets provided the majority of the economic value of a company.

(ii) The combination of different functional areas made the *project* the prime asset to be managed, which resulted in successful product development and greater market focus. Later, as formal linkages between functional areas stabilized, the *enterprise* became the asset to be managed, and managers considered as their main task risk minimization and sharing of rewards across the firm.

(iii) Management turned to customers, because the best way to achieve rapid changes in the global marketplace was seen to be concurrent learning with customers. New product ideas were validated at an early stage by customer comments. In this phase, the *customer* was the asset to be managed and customer satisfaction the overall focus.

(iv) Nowadays, as the knowledge-driven economy dawns, *knowledge* is the asset to be managed. Business performance in this phase can be measured by the ability to create and apply new ideas. Such production of knowledge calls for special tools of knowledge management, such as monitoring of knowledge flow, in the same way that the flow of capital or raw materials in a company need managing. Customer-relations management is also transformed into customer-knowledge management (Gibbert 2002) as a new knowledge-sharing process, focused on customer success rather than customer satisfaction. The main share of company value is attributed to intellectual property and companies should be devising strategies for managing their intangible assets.

The changing value of knowledge has also changed the means of technology transfer and the institutions involved in it. The traditional model, in which technology moves from one well-defined economic unit to another, has given way to complex process (Amesse and Cohendet 2001) resulting in special knowledge-sharing platforms, such as the technology clinics in Finland (Autio and Wicksteed 1998) or cooperative research centres in Hungary (Buzás 2002). Market players with significant knowledge need to access complementary forms of knowledge from other players if they are to use their internal knowledge with maximum efficiency. Such knowledge-sharing networks also reduce the risk of overspecialization.

A functional description of the knowledge-based economy and the managerial approach to its development yields the following main features:

* The technology and knowledge are the main factors of production.
* The intangible assets are the primary subjects to manage.
* Networks are characterized as knowledge-based partnership with constant trade-off, through by the accession of the complementary forms of knowledge.

2) Changing nature of production factors in a knowledge-based economy

The impact of information and communication technology (ICT) on economic growth is commonly considered the main impetus behind the new economy. Such technology also brings organizational change and larger-scale changes in society. ICT plays a crucial role in knowledge production:

* It enhances the productivity of R and D, by increasing the codification of knowledge and digital communication between researchers.
* It promotes the diffusion of knowledge, through digital transparency.
* It increases the rate of return on 'learning', through digital forms of education.
* There are three laws that describe the expansion of ICT quantitatively (Gilder 1996). *Moore's Law* holds that the upper limit on the processing power of microchips at a given price doubles about every 18 months. According to the *Gilder's law*, the total bandwidth of communication systems triples every 12 months. Finally, *Metcalfe's law* states that the value of a network is proportional to the square of the number of nodes. The emergence of the knowledge-based economy is principally affected by these laws because the quality and penetration of ICT equipment and services determine the effectiveness of knowledge transfer and sharing processes.

The unusual expansion of the ICT sector has been associated with an extremely high, sustained rate of investment in it (OECD 2000), which can be explained by its strong impact on productivity. The unit cost of computers has dropped dramatically in recent decades. This has been associated with key Internet advances, including the development of HTML in 1989 and of the first browser, Mosaic, in 1993. These were huge contributions towards enlarging the potential of ICT and, for instance, to the development of the new industry of e-commerce.

To gain a better insight into ICT in Hungary, the telecom (CT) and computer (IT) sector must be studied separately. Hungary under the former political regime had been extremely backward telephone service, for political and financial, rather than technological reasons. On the other hand, the delayed demand for telecommunications was very high, as the present rate of mobile phone users (65 per cent in 2002) makes clear (Szentgyörgyi 2003). Hungary now has a liberalized telecommunications system, with several fixed-line and three mobile telephone companies providing a good level of telecom density. The total spending in the telecom sector has reached an annual EUR 2.3 billion, of which telecom services account for 80 per cent (Dömölki 2002).

Unfortunately, the IT characteristics are not as impressive. In 2000, there were 8.6 home computers installed per 100 inhabitants and non-business access to the Internet was confined to 7.1 per cent of population. By the end of 2000, the number of Internet hosts had reached 105,000 and there were 45,000 .hu domains registered. These figures area bout a third of the European average (*Table 1*). The service market accounts for only 30 per cent of the total computer market of EUR 1.3 billion, which means that the proportions are the opposite of those in the telecom sector.

Table 1 shows that Hungary holds a much worse position in ICT penetration than the smaller economies of the EU, although it is not far behind Portugal. Even the major difference in the number of mobile phone subscribers had been eliminated by the end of 2002. Of the 'advance party' of countries joining the EU in 2004, Hungary lies between Poland and Czech Republic for each variable.

The weak penetration of home computers in Hungary was considerably influenced by high local telephone charges, which are the main factor costs for households and small business entities, representing two-thirds of the cost of accessing the Internet at off-peak hours. Intensive Internet access via telephone lines, if priced at voice rates, becomes extremely expensive. Liberalization has brought a decrease in telecom prices, as have new technologies (cable TV and ADSL).

Table 1
Information-society measures for selected European countries, 2000, units per 100 inhabitants

	Personal computers	Internet hosts	Internet users	Mobile phone subscribers
EU 15	28.6	2.9	26.3	62.6
Ireland	36.0	2.3	27.5	66.8
Belgium	34.2	3.5	28.3	54.9
Portugal	10.5	1.2	10.0	66.5
Czech Republic	13.0	1.6	9.7	42.2
Poland	6.9	0.9	7.2	17.5
Hungary	*8.6*	*1.0*	*7.1*	*29.6*

Source: Eurostat Yearbook, 2002.

To catch up in ICT and create a supportive ICT environment for the knowledge-based economy, a Government Commissioner for Information Technology (GCIT) was appointed in the summer of 2000, working within the Prime Minister's Office. The commissioner is responsible for the development and application of IT in public administration, and for coordinating all governmental efforts at ICT regulation. The development of a 'Strategy of the National Information Society' (NISS) was designated a principal task. The tasks of *e*-government were summarized in a separate Electronic Government Programme. Elaboration of a strategy is also formulated as a separate chapter in a medium-term economic development projection (the Széchenyi Plan), with a budget of EUR 160 million for the first two years of implementation. The rapid change in ICT prevents the development of a conventional mid-term strategy, so that the preliminary document of the NISS, covering a 3–5-year initial period, is revised based on annual estimates.

Considering the ICT lags that must be eliminated as soon as possible, the NISS defined seven programmes, implementing a joint 'Man-Instrument-Content' rule, aimed at promoting the development of skills, enhancing accessibility, and cutting prices on the national market (NIT 2001). The 'Sulinet' Programme for schools was launched in 1996. Its aim of providing direct Internet access to every Hungarian *secondary school* was extended by the Strategy to *primary schools*, with a deadline of 2002. The administration provided access to ICT devices to key knowledge multiplier entities (*e.g.* schoolteachers, public service employees), through a tendering system. In the field of Internet services and telecommunications, a minimum service has been defined, which has intensified competition in the Internet access market.

Under the Széchenyi Plan, the GCIT Office called for 15 different tenders for adapting international experience, maintaining and publishing databases, promoting the infrastructure of voluntary organizations, supporting contents in the Hungarian language, and promoting initiatives on scientific topics related to information-society build-up (Széchenyi 2000). More than 3500 applications had been granted by 2002.

3) The spread of ICT technology and its impact on the knowledge-based structure

The spread of ICT technology throughout manufacturing industry has clearly altered the demands made of machinery and of the labour force. The nature and scope of codified knowledge in the production process has also changed. The Taylorist principles of scientific management – the main carriers of the first major spread of codified knowledge – only affected production areas slightly. The production flow could not continue without the discretionary activity of skilled workers. ICT technology, notably electronic automation technologies and remote sensing devices, has led to a further reduction in skilled and manual work in manufacturing. This process reduces the overall role of skilled workers possessing tacit knowledge and alters the content of that tacit knowledge. There have been changes in the qualities required of the labour force, in understanding and implementing codified knowledge and in the nature and use of tacit knowledge.

The set of knowledge required to carry out production is partly embedded in codified routines and includes tacit knowledge of workers acquired through experience. Codified knowledge,[1] as information, is defined as a message containing structured data imparted by the cognitive context of the receiver. Knowledge is this entire cognitive context, an attribute of individual agents. Humans also possess knowledge not acquired as information, which is not reduced to symbolic representations (or codes), and is held in forms that are not readily available for communication to others. This type of knowledge is tacit knowledge. A main point at issue is the extent of the potential for codification of knowledge. Codification is the process by which modifiable tacit knowledge is transformed into and replaced by codified procedures and information or routines.

Taylorist work organization carried out the codification of production knowledge previously held by workers, by clearly articulating and subdividing it into elementary tasks easily transmissible via operational protocols. Control of knowledge was thus transferred from the heads of skilled workers to the production management and individual skills transformed into organizational competencies in coordination routines. The method was mainly applied to operations consisting of a set of simple, repetitive decomposable acts. Such rationalization brought marked increases in productivity, especially with products whose final assembly constituted a crucial act. But many operations in the processing phases relied inherently upon specific cognitive competencies – tacit knowledge acquired by skilled workers through experience. Codifying this tacit knowledge and making these activities routine[2] could only be done by deploying technologies capable of measuring the physical phenomena that skilled workers were used to sensory evaluation, and controlling and guiding devices that substituted for human judgement and action.

All manufacturing today is being reshaped by computer-based automation, for assembly is also affected, though at a much slower pace than processing. In fact, manipulations accomplished simply by humans are often difficult by robots, so that the cost of automated assembly can still often outweigh the benefits. The tasks assigned to operatives on the rare computerized assembly lines have become similar to those performed on processing lines. The main role of operatives is to monitor and control the actions of intelligent machines that are fully freed from direct human intervention. Since various anomalies may occur, operatives act mainly as problem-solvers and no longer participate in physical manipulation of materials. Moreover, the rapid changes in products bring successive new problems.

Another important feature of the new technology is that formalization of

[1] The definition is based on Cowan, David and Foray 2000.

[2] Routines play an important role in the behavioural approaches of firm theory. Management decisions and technology decisions are based in day-to-day contexts on repetitive routines, while strategic decisions are supplemented by a continuous search for innovation. The best known description of this approach is provided by Nelson and Winter 1982.

the technological process opens the way to continuously improving it. Although the scientific laws behind the technologies are not always understood, modelling physical processes helps to introduce improvements. This contrasts with the previous practice on the tacit, opaque knowledge in the heads of the operatives. A further important feature is the use of computers in design of activity (CAD). CAD makes it easier to standardize the components of objects to be designed and retrieve existing solutions. In this way, it enhances concentration of efforts on true innovations, and so lowers the cost and increases the speed of innovation, which is crucial in market competition. A rising proportion of employees are engaged in problem-solving tasks to do with designing products, planning their manufacture and bringing them to the marketplace. The crucial role of problem-solving shows that codification of technological knowledge does not absolutely imply that tacit human knowledge has ceased to be important.[3]

The first step in codification in the knowledge-based economic system was a collective enterprise, made possible by the increasing availability at low cost of measuring instruments and computers, which provided the quantitative data to be organized into models and the computation ability to run models and simulations. While the code collections are in use, they continually change and improve. Long-term evolution is carried out by innovative firms: equipment suppliers and users, universities and research teams. The various actors gain benefits from doing the codification process. The main benefits of specific codified procedures stem from the chance to use automated manufacturing technologies. This allows firms to achieve perfect repetition of the processes and levels of productivity and precision that would be impossible simply with human capabilities. The throughput of innovation activities is enhanced by using easily retrievable databases and automated design and research technologies.

Codification has fixed costs: the codification cost is the same regardless of the scale of production. So there are increasing returns from codification and its profitability relates to the intensity with which the codified information is used. Small firms may therefore find codification uneconomic and prefer to rely on the tacit knowledge of their employees. However, once a firm has codified its know-how, it possesses a resource that can be used at no additional cost and shows no decline in return. A multi-plant producer may gain a considerable competitive advantage over one with a single plant, since it incurs no extra cost with further codification or from hiring the tacit knowledge of workers at the additional plants. Transnationals (TNCs) operating in Hungary immediately started utilizing codified knowledge. Most Hungarian-owned companies, on the other hand, do not possess the means to implement codification. Their strategy does not usually include mass investment in integrated ICT production facilities. The usual argument is that for the time being, the tacit knowledge of skilled employees coupled with traditional equipment can produce the same quantity and quality of output. This argument certainly presupposes limited production series and reflects a serious

[3] Balconi 2002 provides thorough analysis of change in the tacit knowledge required in manufacturing, based on extensive field research in manufacturing industries.

shortage of capital to invest in knowledge codification.

Since at least some technological knowledge is product specific, the cost of codification increases with product differentiation. So firms specializing in customized products rely less on codified procedures and specifications than firms producing more standardized goods. This argument underlines the important sector-specific aspects of the potential benefits of knowledge codification. As long as there is a market for customized goods, there will also be room for actors utilizing tacit, instead of codified knowledge. Mass customization – the use of ICT for mass production of goods available in several versions may – further limits the chances of tacit-knowledge-based firms to find market niches that escape codified-knowledge-based production.

In general, codification of technical knowledge has brought deep changes in the types of skills required to carry out manufacturing activity. Tacit skills made obsolete due by codified know-how are those that rely on sensory perception and manual skills. Acquiring these calls for imitation of a master by an apprentice and long-lasting practical applications and experience, but no formal education.[4] They cannot be transferred by simple symbolic communication, as the rules to follow are not precisely known. Two types of ability are required: ability to evaluate physical phenomena based on sensory perception and manual dexterity at various levels. These skills mark craftsmen, skilled workers indispensable to the production process, who conduct operations based on non-codified knowledge. The age of such skilled workers began to decline as their tacit knowledge was codified and execution of their activity assigned to a machine or instrument, or a technological innovation was made that changed the production process and made their specific knowledge obsolete. While some functions and jobs based on tacit skills still exist, the trend towards eliminating them is clear.

The tacit skills that complement codified and automated manufacturing process are heuristic and interpretative skills that serve to decode and assign meaning to information-bearing messages (structured data inputs and codified know-how) and to create innovations.[5] They are based on new types of inherently tacit knowledge. They presuppose a basis of formal education and develop through experience. Several abilities are required in different sequences of the production/marketing process. The first is enhanced analytical capability of evaluating codified information, recognizing underlying drifts from weak signals, drawing not easily predictable conclusions from known data and establishing unexpected correlations among variables. Problem solving ability to work out improvements to known solutions is used for instance in the case of machinery breakdowns. There is an increasing need for capability to draw interpretations of qualitative nature, for example an interpretation of changing consumer tastes. These new categories of tacit skills rely based on pattern matching. Humans have an advantage over computers in situations that need to be addressed through a method of pattern matching instead of

[4] Balconi 2002 provides much anecdotal evidence of the specific nature of transferring tacit knowledge. For a full description of the process, see Rosenberg 1976.

[5] Descriptions and uses of new types of skills can be found in several articles by various authors. The account here relies on Balconi 2002.

computing. This is clear for example in the activity of creating novelties or controlling production process depending on imperfectly known interplay of many variables and circumstances.

The task of interpreting codified information n the shop floor is assigned to operators who monitor and control automated processes, as supervisory controllers of computer-managed machines that execute the production process. They must promptly face the anomalies that hinder the correct functioning of machines and quickly intervene when the information shown on computer displays reveal that some problem emerged. The reasons underlying deviations from prescribed operation procedures may be numerous, the more this is so the higher the number of variables that come into play in relation to the complexity of the process. The task of interpreting available information in order to keep variances under control calls for the exertion of judgement. The seriousness of the anomaly must be evaluated by the operator in order to decide whether the case is one that requires him to request the help of a specialist or whether his problem solving capability may suffice.

The emerging new technological paradigm does not diffuse immediately at all levels and everywhere, one may still find very different work situations in the same sector or even in various departments of the same firm, where the two types of workers coexist. Current supervisory controllers must have a higher level of formal education than old craftsmen, in order to interact with computers and to have some understanding of the technological process they supervise must. However, crucial part of their competence (problem solving) is also based on experience and insight, and is enhanced by process innovation. Controllers' knowledge is more general and can be redeployed across various sectors after some retraining, whereas the knowledge of craftsmen was extremely sector-specific. The takeover of physical tasks by machinery and the higher level of education of operators widened the scope of their responsibility. They are generally responsible for quality and carry out preventive maintenance. Specialists are assigned the most sophisticated maintenance operations.

Adoption of innovative computer-based technologies and inclusion of automation into traditional technologies have had the effect of increasing capital intensity. Unskilled workers performing repetitive tasks not calling for the application of knowledge have usually been displaced. The operations that have remained manually performed in the main are loading, moving and unloading. However, some branches are still little affected by these changes, and much of their activity is still manual. Such areas include certain phases of various production processes, for example the assembly phase in most sectors.

In the new setting, increasing importance attaches to creating new operating practices, to exploit fully the potentials of new complex pieces of equipment to produce a wide range of products and to obtain a high level of quality. This is not the task of technical personnel assisting production, not managers. The result is proprietary knowledge taking the form of specific codified know-how expressed, for example, in some kind of software. Thus, learning by doing and learning by using become the planned activity of technical personnel, who supplement researchers in corporate laboratories and contribute to creating proprietary knowledge assets that are the basic source of a firm's competitive advantage.

In general, tacit competencies have lost ground since the previous, Taylorist model. They have also changed character, in most cases to something complementary to a codified content. However, they remain crucial, so that the performance and survival of firms still depend on individual workers' ability to solve problems, control and improve processes, find new technical solutions, design new products, develop relations with clients and interpret market trends. While the product of searching in the technological field is now codified knowledge, the actual process of searching and creating new artefacts (innovative efforts) remains embodied in individuals. This contrasts with the previous situation, where production processes relied largely on craft knowledge; technological knowledge did not exist as a structured set of information and rules. The tacit competence of problem-solvers, complementing the explicit knowledge mastered by them and acquired from a formal education, is a dynamic capability, instrumental to carrying out the tasks of continuously producing new products and learning new things.

The changing pattern of employment in manufacturing changes the types of skills and education required. These generally include a basic technical education, except for workers still engaged in manual operations such as easy assembly or loading and unloading. In engineering, for example, unskilled workers move objects that machines have transformed, having been set up and controlled by skilled workers, who also monitor product quality, while specialist problem-solvers intervene as required. A growing proportion of overall working time is spent on innovations, organizing the introduction of them, and optimizing the production cycle, with the aid of computers.

4) The spread of ICT usage and organizational changes

Codification of technological practices and the use of ICT, together with the accelerated pace of innovation, have significantly affected the decisions of firms about their boundaries and led them towards vertical disintegration.[6] In general, firms feel the need to change the cost structure by transforming rising fixed costs into variable costs. Outsourcing reduces risks and increases flexibility, so that sales can be increased at lower investment cost. Given the accelerating rate of innovation in all fields, firms applying technological knowledge need to narrow their field of activity to a limited set of increasingly complex core activities. To these they may allocate scarce resources, so developing distinctive competencies on which they can rely to maximize profits. Investment becomes concentrated on strategic functions (*e.g.* R and D and marketing) and on manufacturing phases where proprietary know-how offers a competitive edge, or where feedback from research laboratories is particularly

[6] For a concise description of the general reasons for vertical disintegration, see Hamel and Prahalad 1992.

important. Specialized suppliers selling to a number of clients have an incentive to invest in specialized equipment and knowledge that permit optimal batch sizes and minimize production costs. Outsourcing may also yield big external economies of scale for the whole production process. Integrated firms may become active supporters of the spin-offs and start-ups of highly competitive specialized suppliers.

Codification of technological knowledge and the spread of ICT have facilitated the process of vertical disintegration in various ways. The rationalization facilitated by computers and the concept of components have led to standard families of non-firm-specific products that can be produced on a large scale and sold to large numbers of buyers. This also permits firms to break up tasks that used to be perceived as a complete process of problem-solving and production. The convergence of firms operating in a given technological context, based on certain codified patterns of definition of given sub-problems, have allowed the global problem-solving task to decompose and spurred the emergence of actors specialized in the various sub-tasks.

Codification and ICT also help directly to reduce transaction costs. The evolution of a common language among market actors and the habit of codification help customers to define their requirements more precisely. They may provide suppliers not just with detailed specifications, but with codified procedures for the production process. This also enhances the precision and quality of the product supplied. For example, numerically controlled equipment in metalworking allows component producers to make products with tolerances within microns, so that they are practically perfect for most applications.

There is a decline in the specificity of various resources, components, equipment and human capital. The new concept of components as autonomous products, not specific to a particular use and available from flexible means of production suitable for a whole family of similar components, has helped to reduce the specificity of resources and so cut transaction costs. Standardization of components allows customers to avoid being dependent on a single supplier. Craftsmen too were a specific human resource, but a firm’s dependence on them was easier to manage in a hierarchical relationship than it became in a market one.

Vertical disintegration is often regarded as a new chance for small firms and small countries to take up new patterns of the international division of labour. However, there are various patterns of outsourcing. The technology-based cooperation just described and the creation of specialized spin-offs and start-ups assume an adequate level of technology and skills, as well as capital to invest in highly specialized equipment suitable for mass batch production of specialized components. Want of any of these factors may lead to different cooperation patterns and the dominant patterns in Hungary vary according to the availability of such inputs. A growing number of foreign-owned firms, and even some Hungarian ones, may still be capable of deploying such highly specialized equipment and recruiting a labour force that possesses the new qualities of tacit knowledge. Such firms may still struggle with capacity utilization problems, as many TNC customers effectively block their suppliers from selling to competitors.

On the other hand, the various reasons for vertical disintegration offer opportunities for cooperation at lower levels of technological sophistication. These patterns too are greatly enhanced by transfers of tacit knowledge. Subcontracting, for example, became widespread in the Hungarian economy because suppliers possessed the necessary equipment and expertise for 'breaking the codes' of codified knowledge. This does not mean, however, that they use highly specialized equipment. On the contrary, they use old equipment and rely on tacit craft knowledge as a substitute for automated equipment. It is obvious that this kind of substitution is possible only until transaction costs are pushed up to a prohibitive level by increasing wage costs.

Vertical disintegration and subsequent outsourcing may occur on an international level. The following section looks at task mobility in the light of the changed character of the knowledge used in the production process.

5) Impacts on the division of labour: task mobility in a global information society

The emerging global information society is generally assumed to have two main features: materials replace information as the key economic input, and there is a concurrent shift in the economic process from passive information to active knowledge and the use of analytical information skills. These features are usually bracketed with de-industrialization of the developed economies, which is the subject of a massive body of literature dating back to the early 1980s. In an era of global economic organization, movement of material goods becomes less important than flows of information and knowledge. An idealized picture shows developed economies becoming 'weightless' – no longer dependent on production industries. Others take the view that industry still 'matters' – an abrupt change in the structure and characteristics of industries is perceived rather than elimination of industry. In fact, there is statistical evidence that the GDP share of manufacturing ceased to decline in most developed economies in the late 1990s. However, the de-industrialization process has big implications for the organization of economic activities and the global division of labour.

The later stages of the process can be seen as a shift from a firm-specific, geographically contained, technical division of labour to one that is spatially more fragmented. Previously, certain information or knowledge tasks were undertaken within the manufacturing enterprise. The spread of outsourcing, with the emergence of specialist providers, has given rise to whole new industries around specific industrial functions. Competition in manufacturing and services oblige firms to look for ways to reduce costs and improve efficiency. One strategy is to focus on core business and contract out some services. This spread of contracting out has contributed by definition to a declining share of manufacturing and an increase in the tertiary sector, although the combined industrial output may have remained stable or even increased. Tasks that used to be included in the statistics under manufacturing are now re-coded as services. Reclassification in itself is not a revolutionary change in production. However, the process has great importance, as tasks regarded as information-related, when no longer tied to a location, potentially become internationally 'footloose'.

A parallel process in the international division of labour has been the movement of much low-skill, highly labour-intensive manufacturing to areas with lower labour costs. This major shift has been encouraged by a relative decline in shipping costs and fewer barriers to international trade. Nevertheless, control of the transferred activities remains with the multinationals based in the developed states.[7] This is also apparent in the rapidly increasing share of intra-firm turnover in world trade. Since much manufacturing takes place elsewhere, some of the workforce in developed states face a choice between unemployment or work in the services. This kind of employment impact is somewhat different from what was previously attributed to technological change. The labour-saving effects of technological development have always been recognized, but now there is also a labour-diversion effect – movement of jobs to low-cost locations.

Empirical evidence supports the conclusion that the diffusion of information and communication technologies helps to create jobs to compensate for the job losses. This job creation is assumed to take place mainly in the service sector and is hardly threatened by foreign producers. As the nature of employment in developed economies changes, their workforces continue to benefit from proximity to the most developed markets and from the non-tradable nature of most services. The common presumption about services is that emerging market economies are exporters to more developed regions only of unskilled, labour-intensive services, while developed economies specialize in skill-intensive activities. Typical services to make intensive use of unskilled labour are shipping, tourism and construction services. However, there was also a shift in the 1990s into certain semi-skilled information tasks (*e.g.* data processing). The adoption of the Trade-Related Intellectual Property Rights agreement (TRIPs) by the WTO has widened and harmonized the legal regime governing protection of intellectual property. This stronger legal protection has reassured information owners that their data and other knowledge resources will be safe from infringement in the global system. The international exchange of information is now as robust as the exchange of other forms of property: a precondition for swift expansion of international data circulation. A complex division of labour has started to emerge in the core industries of a global information society.

The emergence of cross-border information service networks has laid some labour, managerial and information tasks open to pressures hitherto found mainly in manual occupations. International task mobility used to concern transfers of low-skilled employment to low-cost locations. The transfer of knowledge tasks is

[7] Technical conditions for wider international production networks were created with by four innovations: (i) the spread of ICT in corporate management, allowing firms to organize and control cross-border activities, (ii) innovations in goods and passenger transport (jet airliners, container shipments), (iii) flat M-shaped corporate organization charts, facilitating decentralized decision-making, and (iv) ICT in production, facilitating international sequencing.

even more mobile internationally, since its deployment to low-cost locations does not require large-scale investment in production facilities or costly transportation infrastructure. Knowledge tasks mediated through electronic networks call for little of this specialist preparation. While it may take some time for a location to become a site for inward task migration of physical manufacturing, the requirements for offshore supply of a considerable proportion of knowledge work are simply a telephone line and a PC. The other key element is an educated workforce with computer skills and adequate knowledge of the requisite language (typically English), as well as an ability to learn how to manipulate data.

The emerging pattern in the international division of labour for services is also transferring to emerging economies certain traditional low-skill occupations (personal services, construction, *etc.*) that form a growing part of business services. Business services auxiliary to the circulation of goods through international production chains have so far been concentrated in the developed industrial states. Now they are becoming open remote providers competing on cost and quality. Retail and personal financial services have begun to move towards electronic provision. Banks, for example, increasingly offer online services, while mail-order retailing is starting to globalize through the Internet. Business services often take the character of information processing (back-office activities) that does not call for proximity to the actual service interface. Data processing is also being moved to low-cost locations by the insurance and airline industries. The most extensive globalization of service provision has been in the financial-services markets. Once these back-office functions have been separated geographically from their originating sites, there remains little to keep them in the same state or region. Overnight processing may be done better and faster overnight on the other side of the globe. This migration of back-office tasks is boosted by better protection of intellectual property under the WTO TRIPs agreement and greater reliability in data imaging and handling technologies.

The effect of improving technical conditions for transferring service tasks is enhanced by better reception conditions in several emerging economies, thanks to rapid technical modernization and efforts to improve educational standards in many developing and transition economies. The two areas seemingly most likely to be affected by the employment of offshore facilities are professional and technical tasks, where technical knowledge is brought to bear on a specific problem, with little direct physical contact with clients (engineers, programmers, analysts), and clerical jobs (data entry, record keeping, *etc.*) An important factor behind the relocation of many MNC jobs from developed to developing countries has been the rapidly rising quality of the workforce in many countries, such as China, Brazil and India.[8]

Turning to Hungary's position in the migration of service tasks, the country takes part in both the high and low ends of the business. Qualified engineering tasks and programming used to be a key area of specialization for many Hungarian software firms. On the other hand, data processing on a mass scale is

[8] May 2000 provides a good description of the evolving Indian software industry and how it provides back-office services and performs simple programming tasks.

also carried out. Hungary's competitive positions in the IT services markets seems to be changing. The low-end activities are seriously threatened by the developments in competing countries in the Third World, as Hungarian wage costs no longer match them. These tasks can be transferred rapidly to less expensive locations as it requires little material effort to do so. In the longer run, Hungary may be able to retain only the better-qualified jobs. The loss of low-skill occupations in IT services creates similar problems to those caused by job destruction in other low-skill branches. There is a popular assumption that unemployment in the segment can be eliminated through better and more accessible education, but this could be a long process, even according to an optimistic scenario.

Employment tensions may hit the developed countries even harder. The information society destroys more jobs than it creates, since its effects on current work practices outweigh the increase in jobs in the new industries. Productivity rises affect the remaining jobs, leading to a net loss of employment, despite the emergence of new information industries and services. One conceivable way to handle the problem would be a radical reduction in working hours, to spread the available work more evenly among the available workforce. The effects of improvements in education on employment may be mixed, especially for unskilled labour. Possession of basic skills in handling ICT-related equipment would facilitate the retraining of the labour force for jobs that are currently moving out of Hungary to lower-cost locations.

6) Policy aspects of a knowledge-based economy

An OECD definition describes the knowledge-based economy as one directly based on the production, distribution and utilization of knowledge and information.[9] Interpreters of this and other definitions usually emphasize that the knowledge-based economy does not rely solely on a few high technology industries for growth and wealth production. Several authors regard this new economic system as an evolving technological paradigm[10] or trajectory,[11] directing the development of the whole economy, not just the branches that produce the equipment to diffuse and integrate it. This is often regarded as the backbone of a new Kondratieff cycle. The essence and driving force of the new paradigm is creation and use of knowledge facilitated by specialized ICT devices.

An OECD paper concludes that support for long-term growth in the knowledge-based economy should concentrate on ICT production and deployment, human capital development, innovation and firm creation. Differences in growth between OECD countries are attributed mainly to different levels of investment in ICT, to the use and quality of labour, and to efficiency in combining labour and capital.[12] In successful economies, entrepreneurial behaviour is encouraged

[9] OECD 1996.

[10] Dosi 1982.

[11] Teece 1988.

[12] OECD 2001.

by a competitive environment, an efficient labour market, and a legal and financial environment that protects intellectual property and supports start-up firms. Furthermore, productivity in the ICT sector improves overall economic productivity, while ICT-facilitated innovation increases labour productivity. Successful economies are the most likely to experience rapid spread of ICT, particularly in the service industries.

The importance of human capital in innovation underlies the demand for increased skills, including teamwork and cognitive skills, and lifelong learning to allow continual adaptation to change. The impact that knowledge accumulation is seen to have on productivity underlines the importance of adequate education systems, with their spillover effects on society. Investment in the knowledge base means support for the science sector and R and D, to take full advantage of new technologies. The innovation process and the pace at which new technologies spread are increased by the knowledge flow between individuals, firms and other organizations, and between national economies. Knowledge networks reduce the costs of R and D and speed up the innovation process.

The OECD study[13] draws some important policy conclusions.

ICT is an enabling technology. Governments should: focus policy efforts on increasing the use of new technology; increasing competition and continuing telecom regulatory reform to enhance the uptake of ICT; ensuring sufficient competition in hardware and software, to lower costs; building confidence in the use of ICT for business and consumers; and giving e-government priority.

Its proposals for fostering an innovative environment are to give greater priority to basic research; improve the effectiveness of government innovation funding; make greater use of competitive funding and evaluation in supporting public research; tackle new challenges in intellectual property regimes; and remove barriers and regulations that limit effective interaction between universities, firms and public laboratories.

It advocates priority for policies to enhance human capital (skills and competencies embodied in labour): investing in high-quality early education and childcare; improving basic and vocational educational attainment and the quality of the system; easing the school-to work transition; strengthening links between higher education and the labour market in a cost-effective way; providing wider training opportunities; and reducing obstacles to workplace mobility and giving workers a greater voice.

It argues for an entrepreneurial climate: promoting access to financing; facilitating entry and exit by firms; reviewing and assessing the relevance and effectiveness of government support programmes; and encouraging an entrepreneurial spirit in society.

The economic and social fundamentals have to be in place: preserve macroeconomic stability; encourage openness; make financial systems more supportive of innovation; mobilize labour resources; and address the redistributive implications of structural change.

[13] *Ibid.*

7) A FITTING ENVIRONMENT FOR A KNOWLEDGE-BASED ECONOMY IN HUNGARY

Creating an appropriate institutional environment

In trying to define the key institutions a less developed country will need to provide a suitable environment for a knowledge-based economy, the first thought is often to adapt existing institutions found to be effective elsewhere. These, however, have usually been operating in a developed economy for many years, and will not live up to expectations if they are adapted with small modifications for a transition economy, for instance.

This suggests that the best way forward for Hungary is not institution-based, but obstacle-based adaptation. First, the economic functions of the institutions found in developed countries have to be revealed. When they have been clarified, the obstacles that impede the effective environment for the knowledge economy and need to be overcome by the institutions can be identified. As the next step, a comparison of such obstacles in developed economies and the internal economic background of a transition economy (such as Hungary) makes it possible to identify the challenges for the institutions of the latter. Finally, taking into account social and economic traditions, the optimal institutional system for the less developed country can be established. For these reasons, the features of the institutions could differ strongly from the ones serving as models in the initial step.

Following this train of thought, a comprehensive institutional survey was made to identify some challenges that Hungary has to face if it is to create appropriate environment for a knowledge-based economy:

* Encouraging entrepreneurial activity in knowledge-based industry.
* Intensifying the knowledge flow from university to industry and knowledge-sharing within a triple-helix relationship (university–industry–government).
* Increasing the proportion of private funding of R and D expenditures.
* Boosting knowledge-based regional development and specialization.

The missing, but essential institutional elements and promotion activities are discussed in the following sub-sections.

Cooperative research centres: increasing private money in R and D

Traditional theory describes innovation as a linear process of consecutive phases starting with scientific research, followed by development and production, and ending with distribution of a product or technology. It has been recognized more recently (see OECD 1996) that innovation is not an immediate act. Success calls for interactions between actors such as academic institutions, product developers, sellers and consumers. These inputs and this feedback produce the network characteristic of the innovation process, including, most importantly of all, cooperation partners.

Under the system of central planning prevalent in Hungary before the economic transition, there was regular contractual cooperation between public research institutions and state-owned firms, which more or less assured the transfer of results to industry. The ownership structure of the economy has been radically altered by the transformation. Hungary's early institutional development towards a market economy has made it one of the most advanced transition countries in this respect, with more than 80 per cent of assets owned by the private sector (Tihanyi and Roath 2002).

The emerging institutions of the market economy included private ownership, commercial banking and liberalized foreign trade. Priority was given to privatization, monetary policy and limiting government intervention. This meant that major industrial investors were supposed to finance high-risk scientific research projects based on long-term interests, instead of the state:

* Results of research become the property of those financing it.
* Human resources are produced by using research projects as a training site.
* Cost-effective research facilities are created by sharing them.

The integration of private firms into the common research projects is of importance also because the proportion of private funding in R and D expenditure is much lower than in the EU: 40 per cent, as opposed to about 65 per cent, or approaching 75 per cent in Sweden. Nor is this typical of all post-socialist countries, as the pattern in the Czech Republic is similar to the EU's (Eurostat 2002).

Contrary to expectations, however, traditional bigger firms showed limited interest in research networks and little willingness to build up an R and D infrastructure outside the firm, for fear of losing control over their investment. This means the public sector still has to play a major role in creating a business environment that can serve as a model of European research practice, to enable SMEs to retain their competitiveness after Hungary integrates into the EU. Such governmental intervention results also in increased integration of the academic, public and private sectors.

To reinforce scientific and technological standards by integrating R and D capacities and activities, the R and D secretariat at the Hungarian Ministry of Education invited competitive applications for finance thematic cooperation research centres (CRCs) in 2001. The host institution had to be a university with a certified PhD programme and the criteria for business partners included involvement in the centre's activities. For 'seed capital', the government granted half the budget for the first three years, in a range of USD 0.2–1 million. Centres have to develop a cooperative way of doing business and yield returns to cover the burn rate of the CRC at least for the first 3–6 years.

This government intervention changed the approach of private companies immediately. For one thing, the frame guarantees within the organization (votes on the CRC board) mean the project can be influenced directly by all partners. The private companies have benefited from various cost-based advantages. They have access to low-cost university facilities and PhD students supported by state scholarships, as a well-trained human resource. On some occasions, private companies can use 'no-cost' facilities in universities or other public institutions (*e.g.* hospitals). Moreover, co-operative research qualifies for special tax relief.

Five CRCs have been established in the first round.

The *Trans-University Centre for Telecommunications and Informatics* in Budapest was established by three departments of two universities. The corporate partners include Hungarian subsidiaries of multinational informatics companies (Ericsson, Compaq and Sun) and Westel, the market leader in Hungarian mobile communications. The main purpose is to develop Internet-based and mobile communication systems for the 21st century.

The *CRC on Industrial and Medical Application of Lasers* was set up in Southern Transdanubia by five partners from the academic sector in association with 13 private companies. The research centre, headquartered in Pécs, draws on more than local knowledge, because the academic and private partners both include expertise groups in laser technology located in Budapest and Szeged as well.

The University of Miskolc and 30 industrial partners lie behind the *CRC on Mechatronics and Material Science*. This has the widest geographical spread of the five CRCs, as it includes a steel company in Dunaújváros or subsidiaries of the household-appliance firm Electrolux in Jászberény.

The *CRC on Rational Drug Design*, based in Budapest, consists of two academic, one non-profit and four private pharmaceutical and biotech partners, as well as ten 10 university [???] departments as associated partners. The last have made no financial contribution, but make their knowledge freely available.

The *CRC for Chemical Industrial Development Based on Green Technologies*, was established in Veszprém by the Institute of Chemical Engineering of Veszprém University, the main Hungarian oil company (Mol Rt.), and five other chemical and pharmaceutical firms. The research centre draws on the city's long connections with the chemical industry.

Due to multiplying effects, the first launches were followed by other CRC-like organizations (for example, a renewable energy and green technologies R and D centre in Szeged), working under similar conditions to those of supported CRCs.

All such organizations develop and use a joint research infrastructure and manage jointly any knowledge produced. All rights to products, technologies and intellectual property are shared under a contract drawn up before the first step in joint development is taken. A CRC offers parties the chance to develop cooperative, interdisciplinary research in stimulating directions. The formation of CRCs and similar organizations has greatly increased the proportion of private capital involved in innovation processes.

Spin-off companies: diversification of the knowledge-based industry

Spin-off companies occur when a former employee or employees of a company with a certain technology or essential knowledge leave to start their own firm. The features of small technology-based companies make spin-offs one of the most promising ways to commercialize technology or knowledge. While established companies only adopt easily new technologies closely aligned to their existing products, spin-offs are able to absorb technologies at an early stage and build them up for market entry. Technology start-up companies have flexibility, so that they can change business direction as the market requires, whereas established companies have standard procedures and much less ability to adapt and tailor early-stage technologies as needed. Furthermore, the proximity of spin-offs to the birthplace of technologies can assure ongoing support from inventors in completing the process of transferring the technology.

Spin-off companies can be categorized according to the attributes of their source organizations (Oakey 1995), as higher-education institutions (university spin-offs) or industrial firms (corporate spin-offs). The former type predominates because universities more frequently encourage transfer of knowledge than private companies do.

The entrepreneurial spirit is particularly important in the formation of spin-off companies, irrespective of their features. Research shows that the EU lags behind the United States in entrepreneurship (COM 2003), the main factor being a general European aversion to risk-taking. In the United States, the brightest young people found their own businesses, and in case of failure, keep trying to found new companies until they succeed, or after *several* failed attempts, apply for a job instead. In Europe, those starting new businesses tend to be the ones who cannot find a decent job. This has resulted in a huge 'entrepreneurship deficit' in Western Europe. The US entrepreneurial philosophy popularized many years ago spin-offs that built up into legendary prestigious clusters such as Silicon Valley in California and Route 128 near Boston. Meanwhile the lack of motivation in many European countries has meant that spin-off companies are less favoured among scientists and launches have been opposed by universities on several occasions.

The spin-off formation process has been investigated in Hungary, as a way of studying how the European tendency is prevailing in a developing economy and what main obstacles are impeding the establishment of technology-based companies (Buzás 2003). The study treated all scientists with marketable scientific results and university students as potential entrepreneurs. The latter provided valuable information on the deficiencies in an education system focused mainly on the needs of multinationals and neglectful of topics specific to small businesses. The results pointed to three main gaps: in motivation, competence and reputation.

Many scientists refuse to go into business on the grounds that they prefer invention to selling (a motivation gap). This barrier could only be overcome by reducing fears of an uncertain financial future.

If scientists are motivated enough, an academic career can serve as a good platform for a launching company, but this is impeded by limited experience in commercial matters (a competence gap). Even commercially-oriented researchers have limited capabilities in finance or intellectual property rights. They need an advisor with managerial abilities to transform the research results into a business success.

Even a successfully launched spin-off company, however, cannot guarantee prosperity, for which the credibility and trust are required (a 'reputation' gap). Entrepreneurs do not have much time to become known. Young spin-off companies are in constant need of guarantors to vouch for their technical expertise and creditworthiness.

In 2002, the Hungarian government set out to encourage the formation of spin-off companies by calling for applications for establishment grants of 40,000 each. This can use for preparing a feasibility study, adapting research results, acquiring know-how, protecting intellectual property rights, or preparing prototypes. However, the small number of applications (34) confirms that entrepreneurship in Hungary primarily faces motivational, rather than financial obstacles. The main task, therefore, is to induce an entrepreneurial climate in universities through training and by disseminating success stories.

Missing TLOs: the imperfect Triple Helix

A number of modelling concepts for university–industry–government relations have been proposed in the last decade, one of the better-known being the Triple Helix (Leydesdorff and Etzkowitz 1996), which defines the three separate spheres institutionally. In this innovation model, knowledge transfer is no longer considered a linear process from origin to application, but a complex system with unique communication interfaces operating in a distributive mode. The interactions between the spheres are mediated by special organizations such as technology transfer offices and innovation agencies.

Technology transfer offices were not prominent in the university–industry nexus until the end of 1980, when the US Bayh-Dole Act allowed universities and other non-profit organizations to patent and commercialize the results of discoveries made under government-funded research (Schmoch 1999). Because most research at US universities is so funded, the act marked a breakthrough in university–industry relations, with technology transfer offices being established throughout North America in the 1980s and completing the Triple Helix. Many other countries then followed the US practice by setting up similar institutional frameworks for university–industry technology collaborations and commercialization of university inventions (WIPO 2002). These, now known universally as TLOs (technology licensing offices) regardless of their institutional arrangements, play a crucial role in identifying technologies with high commercial potential and assisting inventors in their licensing negotiations.

Countries have followed different patterns in commercializing scientific discoveries, in line with traditional differences in innovation policy. The bottom-up US policy is focused mainly on creating incentives for universities to commercialize their inventions themselves. Federal action fosters experimentation in university policy, on how best to exploit the windfall of intellectual property rights created by the Bayh-Dole Act. The Swedish way, on the other hand, differs strongly, for the government attempts to create directly a mechanism facilitating the commercialization. Bureaucratic interventions push Swedish universities towards an internal policy focused on marketing intellectual assets. According to Goldfarb and Henrekson (2003), this top-down model resembles the one found in most EU countries. This 'European way' has proved much less effective than the US approach, because it lacks incentives for European scientists to become personally involved in the transactions.

Economic policy in Hungary in the second half of the last century broke the traditionally close relationship between research and production. Since the change of economic system in the 1990s, the knowledge flow from companies to universities has resumed increasingly, but the opposite flow of information is still not supported by the institutions concerned (Papanek and Borsi 2001). Despite increasing governmental financial support for R and D, the lack of effective TLOs at Hungarian universities has left an imperfect triple helix that hinders effective commercialization of inventions.

This situation has been induced primarily by the status of intellectual property rights on inventions. Because of shortage of capital, universities and research institutes had no funds to cover the submission and maintenance costs of patents, so that they had to release their primacy rights on in-house inventions. Intellectual property rights in recent decades have therefore been awarded directly to inventors or entered the unprotected public domain. This is the opposite to US practice, where patent rights are generally awarded to universities.

Without a solid patent portfolio, units dealing with technology transfer at Hungarian universities have been unable to establish fruitful industrial links in the last decade. The emerging TLOs have not found an established business environment, so that they cannot act as effective knowledge dealers. Despite their relative inefficiency, the self-organized TLOs and their route-searching lend a bottom-up character to Hungarian policy on commercialization of university knowledge, while the governmental interventions described (CRCs and spin-off encouragement) reflect top-down characteristics.

Science parks in Hungary: seedbeds or fantasies?

There is no uniformly accepted definition of a science park, and as was pointed out by Kung (1995), there are thirty terms used to describe similar organizations, including science park, research park, technology park, innovation centre, and so on, with no clear distinctions between them. MacDonald (1987) concluded that most of these terms share two characteristics:

* property-based development close to a place of learning;
* high-quality units in a pleasant environment.

Westhead (1997) emphasized that such parks could serve as catalysts for the transfer of research into production. Using a business-focused approach, Storey and Tether (1998) defined the role of science parks as enabling commercialization of the research ideas at local universities and establishing businesses using sophisticated technologies. An overall definition was given by the UK Science Park Association, which described them as property-based initiatives:

* with formal and operational links with a university or other higher educational institutions or major centre of research;
* encouraging the formation and growth of knowledge-based businesses and other organizations normally resident on site; and
* with a management actively engaged in transferring technology and business skills to the organizations on the site.

The development of science parks in Europe received its impetus from the success of early parks in the United States. Many European countries did not have a significant number until the 1980s. By the mid-1990s, there were 310 science parks in the 15 EU countries, with 15,000 firms employing more than 230,000 (Storey and Thether 1998).

However, writers express doubts about the role of science parks in innovation processes. Massey *et al.* (1992) found that geographical proximity between a university and a science park was only a weak promoter of technology transfer and styled such parks 'high tech fantasies'. An empirical survey of over 160 on and off-park high-tech firms in Israel found only a weak relationship between location and innovation level (Felsenstein 1994). These results suggest that the parks play an innovation-entrenching role rather than an innovation-inducing one. Reporting on a survey of Surrey Research Park, Vedovello (1997) argues that proximity cannot strengthen the formal links between university and industry, but proves important for *informal* connections. Bakouros *et al.* (2002) also found mainly informal links between firms and a local university in Greek science parks, but an absence of research-type synergies.

By contrast, Löfsten and Lindelöf (2002) recently described significant differences between on and off-park companies in their links with a local university. Their analysis of 10 science parks and 273 firms in Sweden by statistical methods detected a role for university-industry formal links in the development of new technology-based firms. Concerning the effectiveness of those located in science parks, however, they found no greater R and D outputs from on-park than from off-park firms.

These uncertainties about the relation between intensity of formal technology transfer and geographical proximity in science parks might be resolved by a service-based explanation. Science parks are a particularly suitable type of location for new businesses and are associated with entrepreneurs with a stronger motivation to innovate than off-park locations are. The new technology-based firms, however, are generally unable to utilize such advantages without training courses, business-placement programmes (Löfsten and Lindelöf 2002) and assisted networking organized by the park management. For this reason, the factor of success in a science park rests in managed business services creating more formalized technology relations, which result in more profitable new technology-based firms.

Several organizations in Hungary describe themselves as an innovation or research park. However, they cannot be classed as 'seedbeds' of innovation in the sense envisaged by Felsenstein (1994), as they lack a critical mass of private firms and have hardly developed technology-based relations with universities. Only one site in Hungary (Infopark in Budapest) possesses the commonly accepted features of a science park. Infopark Incorporation was established at the end of 1996 by the Budapest University of Technology, Loránd Eötvös University of Sciences (ELTE), the Ministry of the Economy and the Prime Minister's Office. Two universities hold 25 per cent +1 of the voting shares, and Hungarian state has a gold share to ensure use of the park remains the same. The location is ideal for links and synergies between firms and universities, as it lies adjacent to their Danube-side campuses. In line with the two universities' existing profiles, the park specializes in information and communication technologies, aiming to attract firms with experience in computer technology, telecommunications and multimedia. The first settler was the biggest Hungarian telecom company, Matáv, with a new R and D centre. It was followed by Hungarian subsidiaries of IBM, Hewlett Packard, Nortel and Panasonic.

After five years, Barta (2002) surveyed the functional linkages and real services of the Infopark. She found that Infopark was still unable to attract further settlers with any technology information services, contract R and D services, market studies, auditing, quality management services or product promotions. The lack of accessible central services obliged the firms to build up such services in-house, which constrained future cooperation within the Park. The absence of real services means that Infopark cannot serve as an intermediary. Despite some excellent facilities, it operates simply as an 'office park'.

The government, regarding innovation processes as vital to regional development, decided two years ago to define various evolutionary paths for the many industrial estates in Hungary. One of the four desired goals was to be a science park with participation by universities or research institutions. As Barta (2002) concluded, successful science parks in a transition economy need considerable, persistent governmental support if they are to offer the services that can give life to them. Since transition governments have limited resources, they should focus on a small number of estates, where the conditions are promising for value-added internal services. Otherwise firms will continue to ignore them.

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