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Foreign direct investment

Foreign direct investment in R&D: skin-deep and soul-deep cooperation

Annamária Inzelt

The new categories of 'skin-deep' and 'soul-deep' cooperation introduced in this paper offer good tools to determine whether penetration of foreign direct investment (FDI) in R&D is able to speed up the transformation of the Hungarian system of innovation. Small-scale projects (skin-deep) may pave the way for larger-scale ones (soul-deep) by encouraging strong knowledge-based business relationships and introducing new partners into international business collaboration. The first period of FDI has had a positive impact on transformation and performance in the economy: R&D can play a bigger part in the second stage of transition.

Dr Annamária Inzelt is Director, IKU Innovation Research Centre, Pf.12, Hungary-1428; Tel: +36 1 318 5674; Fax: +36 1 338 2438; E-mail: ainzelt@iku.omikk.hu.

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IT IS CRUCIAL FOR Central and Eastern European Countries (CEECs) to respond to the new challenges of the world economy. During their transformation procedure they have had to witness a process of increasing internationalization of innovative activity. The emerging new paradigm of transnational innovation has coincided with the opening up of post-socialist countries for foreign direct investment (FDI).[1] The new trend towards internationalization can be observed in FDI and foreign investment enterprises (FIEs) in research and development (R&D).

It is assumed that FDI is a factor of economic transition that can speed up transformation by facilitating internationalization and technological integration, and helping these countries to 'catch up' or at least to keep up. Effective technological integration and the improvement of competitiveness through FDI depend on both sides. Internationalization of research and technology is not limited to FDI for R&D, but this study concentrates on those cross-border activities in which foreign business organizations (as investors) are involved.

In analyzing the impact of FDI on host post-socialist economies, the first question is: can FDI integrate or marginalize host economies? This is closely followed by: can FDI help to exploit inherited S&T capabilities in these countries and support them in becoming innovative? Although foreign direct investors in CEECs have generally invested little in R&D facilities, it is worth investigating this element of linkages. The present and future mode of exploitation of the knowledge base of CEECs is a critical condition of their climbing up.

Hungary is an emerging economy among the transition countries and FDI plays a crucial role in the transformation. This article investigates the

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Annamária Inzelt, PhD, is Founding Director of the IKU Innovation Research Centre in Hungary. She is the Hungarian representative at OECD NESTI (National Experts of Science and Technology Indicators) group, former member of the National Committee for Technological Development and holder of the Hungarian Szchenyi Professorship. She is author and editor of several books, chapters and articles. Her most recent publication is "Transformation of the relationship among the actors in R&D as reflected by financing" in M Heitor, D Gann, D Gibson, R Martins, S Shariq and C Xuelim (ediotrs), *The 21st Century Opportunities and the Challenges for the Asian Economies: Science, Technology and Innovation Policy* (2000). She has been co-director of three NATO ARW (Advanced Research Workshops) in Budapest, and organised some other workshops.

relationship in Hungary between FDI and R&D activities, on the macro-economic level. It looks only at inward FDI, though outward FDI has already started to develop. The first section considers different modes of FDI in R&D. It investigates foreign investments by type of R&D activity and the expected influence of these activities on research, including networking, and on economic performance. It illustrates each type of collaboration with brief case studies.

The second part describes briefly Hungary as a host country. Hungary is a good case study of this phenomenon because it has the highest level of foreign investment and the longest experience with foreign investors among the post-socialist countries. The third part analyzes the penetration of FDI in the Hungarian economy. It makes a distinction between the first and second periods of transition that have been providing different environments for foreign investors. In the fourth part some conclusions are drawn.

Modes of FDI in R&D[2]

Growth of FDI has been uninterrupted over the last five decades and expansion has accelerated in the last decade. This trend to globalization of innovation can be observed in FDI in R&D. The international trend is for rapid growth of FDI in R&D. Countries can participate in this process both as recipients and funders of FDI. The key question is how the post-socialist economies can fit into the world picture.

The literature distinguishes two principal modes of foreign direct R&D investment: market- and technology-oriented.[3] Each creates a different relationship between host and home countries in terms of FDI in R&D. The first mode is motivated principally to adapt and tailor products for foreign markets and provide technical support for offshore manufacturing operations. I call this demand-side-motivated type 'skin-deep collaboration' (Mode 1).

The mission of the second mode of FDI in R&D is to gain and secure access to science and technology and scientific human capital, and to develop links to the scientific and technical community. I call this technology-oriented, supply-side-motivated type 'soul-deep' (in other words, root-and-branch) collaboration (Mode 2). In this case, collaborators enter a deep relationship, with their interests in cooperation well balanced. Both types of collaboration have

Table 1. Foreign direct investment in R&D: results in the host country

Type of activity	Mode 1Skin-deep collaboration		Mode 2Soul-deep collaboration	
	Type 1	**Type 2** (Bangalore type)	**Type 1**	**Type 2**
R&D	Producer and user of results	Only producer of results	Producer and user of results	Only producer of results (inter- nationalization)
Type of R&D				
- Basic research	–	–	+/–	+/–
- Applied research	–	–	+	+
- Experimental development	+/–	+/–	+	+
- Testing	+	+	+	–
- Trial	+	+	+	–
- Training	+	–	+	–
Innovation	Incremental	–	Radical and incremental	–
Outcomes				
Competitiveness	Preserves follower positions	–	Improves long-term competitiveness	–
Economic performance	Improves	–	Improves	–
Spill over effece				
Job saving/creation				
- S&T	–	+	+	+
- General	+	–	+	–

very important roles in transforming less advanced countries into more advanced ones.

Foreign direct R&D investment is a heterogeneous process with considerable variation across industrial sectors and change over time. Foreign R&D activities take different forms of collaboration. FDI-related techno-scientific cooperation takes place not only among companies but also between companies and universities and other R&D organizations.

Table 1 summarizes the key characters of skin-deep and soul-deep collaboration.

The deepness of collaboration characterizes the partnership between host and home organizations. As Table 1 illustrates well, both categories have positive and negative effects on the host country. The evaluation of effects may differ if we concentrate on the impacts on the economy or on S&T development. In each group the first sub-categories have impacts on both spheres. Cooperation in the first sub-categories relates primarily to R&D conducted as a secondary activity by organizational units whose primary interest is elsewhere, such as corporate divisions or industrial plants.[4]

The second sub-categories are more frequent in the case of independent contract research laboratories or stand-alone foreign-affiliated R&D laboratories (without production lines) engaged principally in research, development, and design activities. They usually have direct impacts only on S&T and indirect impacts on the economy.

High-level capabilities in particular sectors can encourage foreign investors to launch soul-deep collaborations, and weak or incomplete science and/or technical capabilities will tend to give birth to only skin-deep collaborations.

Skin-deep collaboration type 1

In the first sub-category of skin-deep cooperation, the investor organization is a short-term profit seeker. The connection between foreign and host company may last for decades although the foreign organization can secede easily within a short period. The interruption of collaboration has a minor effect on the investor organization but usually it has important consequences for the host organization. This mode supports incremental innovations and offers little prospect of radical innovation at the host companies that conduct R&D as a secondary activity.

Box 1

In the Hungarian food processing industry, foreign investors introduced a lot of incremental innovations. Many new products were launched onto the domestic market, some of them occurred in the export markets too. The quality of the products has been uniform. However, the Hungarian companies still remained at arm's length from their foreign headquarters. The centers provide crucial information to the firms in a narrow field just to support centrally decided innovations. The Hungarian subsidiaries have no link yet to the extranet of the mother companies.

Box 2

Bangalore-type software contracts are well known in the software industry and are to be found in Hungary too. As another important case, several large pharmaceutical companies have contracted Hungarian universities for clinical testing. The research content of these contracts is tests for introducing new medicines in Hungary and previous stages of experimental developments.

Box 1 is an illustration of this type of collaboration.

Skin-deep collaboration type 2

The second sub-category of skin-deep collaboration may be described as Bangalore-type agreements (Dyker, 1999a). Western companies have hired scientists, computer and software engineers from transition countries to do contract work on major projects while continuing to live and work in their native countries. The main advantage of outward research is the cheap higher-educated labor force for investors. The host organizations can preserve their R&D personnel because foreign contractors offer steady work in (temporary) over-populated sectors at wages which are usually much lower than Western standards but are above the average for the transition country. These contracts usually contain some soft technology transfer too.

Another positive impact of such R&D contracts is that they make the self-transformation of R&D organizations smoother: there are fewer job losses, and it may possible to earn some income to cover the transition cost of R&D redeployment. Besides these short-term effects, it may contribute to developing business relationships. However, the content of these contracts is usually 'mass' research tasks which are more experimental development than research. Scientists and development engineers are involved in highly skilled work but not in basic, applied or engineering/medical research.

This type of skin-deep cooperation reduces the brain drain but cause an internal brain drain. This mode of FDI in R&D has a more positive impact on the host economy if it is only for a short period of transition. If the host economy can create more demand for the R&D talents it has produced they are less likely to be lost to an external brain drain. Without stabilization and successful re-deployment of the economy, the Bangalore type FDI (Dyker, 1999a) in R&D may be long lasting. This type of FDI will have the same influence on transition economies as on developing countries.

Box 2 is an illustration of this type of collaboration.

Soul-deep collaboration type 1

This mode gives the opportunity for the host company to launch radical innovations and become a first-mover in a range of fields that will be determined by the host country's characteristics.

Box 3

General Electric–Tungsram is the best known case of soul-deep cooperation. This company was the first among foreign investors that invested in crucial R&D in Hungary. (It came into the country in 1988 and enjoyed first-mover advantages in the host economy.) The General Electric corporation decided to allocate all its lighting research activity to Hungary.

Another example is Phylaxia-Sanofi Veterinary Biologicals Co Ltd. The company was founded in 1991 by the Hungarian Phylaxia and the French multinational company, Sanofi. In 1995, Sanofi became the 100% owner. Company production is divided geographically, thus the only vaccine producer subsidiary is the Hungarian firm and consequently the field-related research is only carried out in Hungary. Since the founding, a continuous increase in income, investments and expenditure on R&D activities has occurred. In the second half of the 90s, the share of export has reached 50% of income and the technology-related investments have become very significant: this coincides with the establishment of some very new plants.

Moreover, the firm has had an interactive and strong connection with the Hungarian professional institutes in cooperative research and training. As an example, in 1998 cooperation started with the Microbiological Department of the Eötvös Lóránd University. Within this joint research a new virus-detecting method has been elaborated. Since that time, the company has been using this technology in the quality control of production for all products. These vaccines are sold both on domestic and international markets.

Since the mid-90s, the firm can be considered as an example for soul-deep cooperation.

Source: Phylaxia-Sanofi compiled by Zsuzsa König

In the case of soul-deep collaboration the danger of sudden interruption is rare. It is usually part of strategic restructuring and has a definite effect on the host organization. Withdrawal involves some adjustment for both parties.

Box 3 is an illustration of this type of collaboration

Soul-deep collaboration type 2

In this type of collaboration, the R&D organizations of the host country are the main partners of foreign investors. They are involved in strategic research for foreign organizations but the investors use their R&D results only *outside* the host country.[5] This contributes to financing R&D and develops knowledge assets, but gives little support for the improvement of economy-wide competitiveness as column 5 of Table 1 shows. Product and process innovations may be based exclusively on visible and invisible technology transfer.

Discussion

The pattern of FDI inflow for host country is different for skin-deep and soul-deep cooperation. Countries or regions with a relatively large base of excellence in research are obviously the most interesting for firms seeking partners and locations. The partners in soul-deep collaboration are advanced countries, and the US tops the list of countries targeted by soul-deep FDI in R&D (Pavitt and Patel, 1991; Patel, 1995; Niosi, 1996; Florida, 1997).

From the point of view of economic influence, skin-deep type 1 FDI in R&D may be much more important for the host country than soul-deep. The important policy issue is: how can a society transform valuable enclaves into main fields, and diffuse throughout the host economy the R&D results created by soul-deep FDI in R&D? Improving the innovativeness of a country via FDI is clearly a complicated issue. Much is expected of FDI in CEECs, and these expectations are often justified. At the same time, there is a real danger that FDI will not reinforce integration in the post-socialist countries, but rather marginalize them.

The pattern of FDI inflow for the host country is different for skin-deep and soul-deep cooperation: countries/regions with a relatively large base of excellence in research are the most interesting for firms seeking partners and locations

Hungary as a host country

The impact of FDI on technological integration and the R&D activities of the host country depend, in any given case, on the interaction between recipients and donors. As Radosevic and Dyker (1997, page 113) state: "Chain-reaction technological upgrading consequent on FDI will only occur if domestic firms are prepared to make the effort to raise their game." The Hungarian case gives some insights into how a less advanced country can become a host country of FDI in R&D.

In the transition case, FDI behavior is strongly motivated by the uniqueness of the period of emerging from isolation, with rapid liberalization of trade and mass privatization. In that sense, this is a learning process not only for the host countries but for the home countries of foreign investors too, as FDI behavior changes over time.

Hungary, like other post-socialist countries, has some unusual characteristics as a host country. From this point of view two things are crucial:

The transition period brings privatization on a massive scale, with FDI playing a prominent role. Foreigners have usually entered the Hungarian market, for example, through acquisition of existing industrial firms, and very few green-field investments occurred in the early years (Sass, 1999; Hamar, 1999; Hunya, 1999)

The inherited national system of innovation has some peculiarities. For example, business

enterprises were isolated from the domestic R&D sector. The levels of commercialization and technology transfer were low. The networking capabilities were very poor. Enterprises were cut off from the major international clusters of innovative suppliers and users. There was a gap between the technology used and state-of-the-art technology. Accumulated human capital, education and training systems are relatively well developed in some fields. The domestic R&D system of Hungary still suffers from the inherited constraints on the scope for effective technology diffusion. However, some burdensome factors have been eliminated (for more details see OECD S&T reviews, and related literature).

As recent studies show, international trends indicate that large markets, large pools of talent, and a friendly environment attract FDI in R&D. Another important lesson from the experience of many countries is that FDI relates to pools of talent as things given; foreign investors are not prepared to invest in improving education (Pavitt, 1997). Let us investigate briefly the state of each of these four preconditions in Hungary.

1. Hungary definitely does not have a large market, but her former CMEA (Council of Mutual Economic Aid) links, as a form of path dependence, makes her market bigger for potential investors, even though foreign investors can go directly into other post-socialist countries.
2. The OECD evaluation found that Hungary has strong S&T potential despite reductions in spending on R&D, a decreasing number of R&D personnel, and the enfeeblement of many R&D institutions. Knowledge assets and production capabilities are relatively well developed in some fields. There are a number of key reasons, of an institutional, economic, and historical nature, which explain the pattern of utilization of resources.

   The accumulated knowledge of the post-socialist countries was previously locked into a bad structure. It may be supposed that the current changes can help Hungary retain her intellectual potential and use it for the advancement of society. Some R&D performance indicators suggest that Hungary is the leading country in her region. Time series (of admittedly limited comparability) back up this statement (see Inzelt, 1999a) In some fields, competition can be observed among foreign investors for the talents of Hungarian new graduates (for instance, software development engineers.)
3. The domestic environment in the host economy is a critical factor in gaining FDI and in its success. Laws, regulations, enforcement of them are satisfactory for foreign investors. An indirect measure of the friendliness of the environment is that Hungary is the host country for one of the largest aggregate levels of FDI in Central and Eastern Europe. Within the transition region, as figures show, Hungary is a magnetic country for FDI. According to UNCTAD data for 1991–96, US$12.9 billion out of a total of US$45.6 billion of FDI in the transition region (28%) went to Hungary.

   Hungarian advantages in the region include the relatively well developed IT network and the more or less sufficient general, and specifically S&T-related, legal environment. So the Hungarian environment is evaluated as very friendly by investors in the region (though if we compare Hungary and the Southeast Asian economies as hosts, the former looks less attractive). If the foreign investors put the country on the list of 'worth investing in" the further selection criterion is the difference in public inducements. The next section deals with this issue.
4. Enhancing the pools of talent may be worth some investment for foreign investors in Hungary. In several cases they have been ready to invest in Hungarian graduate and post-graduate higher education. This is important but it would be premature to evaluate the results. This 'deviation' from the international trend may be only temporary. However, it may be an emerging paradigm for the group of transition economies or for special sectors. In Hungary, FDI into education in the ICT (information and communication technology) sector is active. As we know this sector faces a lack of educated people and investors are hunting for talent among graduate students.

Penetration of FDI in Hungarian R&D

Two periods of transition can be distinguished from the point of view of FDI in R&D. In each period Hungary provided a different environment. The behavior of foreign investors also shows two phases: their own acquaintance phase and phase of 'feeling at home'. In most cases, the first period of transition and the first phase of FDI coincided. During these periods, the relationship between foreign investors and their Hungarian firms or research organizations has developed gradually.

First period: acquaintance and adjustment

This period started in late socialism. In 1988, Parliament passed an Act on the Investment of Foreigners in Hungary to develop international economic cooperation with the direct involvement of foreign capital, and to promote technological development in Hungary.[6] The period ended around 1996/97. By this time, one of the important tasks of transformation — mass legislation for building a market economy — had finished. (Fine-tuning of the system has remained a task for the second period.) The country has taken the most important steps towards stabilization; a large part of

Table 2. Ratio of BERD to sales by category of owner and type of expenditure in manufacturing industry, 1992–95 (%)

Year	Owner	Spending on in-house R&D	Spending on contract R&D	BERD total
1992	All	0.49	0.12	0.61
	Domestic	0.32	0.07	0.39
	Foreign	0.94	0.25	1.19
1993	All	0.53	0.15	0.68
	Domestic	0.31	0.09	0.40
	Foreign	0.96	0.27	1.23
1994	All	0.54	0.16	0.70
	Domestic	0.33	0.11	0.44
	Foreign	0.67	0.19	0.86
1995	All	0.76	0.09	0.85
	Domestic	0.58	0.06	0.64
	Foreign	0.86	0.11	0.97

Note: BERD = business expenditures on research and development

Source: Central Statistical Office

manufacturing industry has been privatized.

In the first period, the firms and R&D laboratories of the semi-autarkic economies of the socialist period were unknown to investors because of the closed state of the countries involved. In this period, however, its role was very limited but important.

Since the beginning of privatization, foreigners have become important players. The process of acquisition started with minority shareholding, and then graduated to majority. The number of majority or totally foreign-owned firms has been increasing.

Analyzers of FDI in R&D are facing difficulties because of the shortcomings of the data available. FDI data usually do not provide information on whether only production plants were established or whether also R&D facilities were taken over during acquisitions or were set up in new start-ups.

The performance of FDI in R&D may be analyzed statistically between 1992 and 1995 in Hungary.[7] The Government statistical source covers a part of FDI in R&D for this period and provides useful data on R&D spending in joint ventures and foreign-owned firms (for detailed description of the sample and quantitative data see Inzelt, 1999b).

The main messages gleaned from the statistical data are summarized here.

Because of relative isolation before the transition period, the knowledge of the S&T capabilities was poor among potential foreign investors. The willingness of foreign firms to invest in R&D gradually increase. In 1992, R&D expenditure per foreign-owned firm in manufacturing was 58.8 million HUF. By 1995, it had increased to 91.2 million HUF.

The majority of new owners continue to operate R&D laboratories acquired along with production lines. The companies with foreign equity had a higher R&D to sales than domestically owned firms. The average ratio of R&D expenditure to sales was 0.63% for the whole economy and 1.5% for firms with above 75% foreign equity. The corresponding indicator was 0.57% for domestic-owned firms (see Table 2). Thus the share of foreign ownership seems to be an important influence on R&D spending.

The growth indicator of R&D expenditure per manufacturing firm increased by 55% for foreign-owned firms. It was 3.6 times higher for foreign firms than domestic ones in 1992. The disparity increased significantly over the period studied, the first group spending 4.5 times more than the second group in 1995. Gradual increases may be observed too in the risk-taking by foreigners. The ratio of business R&D expenditure to sales has a positive correlation with the size of the foreign stake in the given company (the value of the rank correlation coefficient is 0.575). In the first phase of transition, foreign investors have been reluctant to set up new laboratories attached to production lines.

The character of the research may be assumed to be far from basic and applied research; it was very close to the end phase of product and technology development. This assumption is strengthened by the ratio of expenditure to sales, and is supported by scattered empirical studies, which suggest that foreign investors have low research intensity in Hungary. Thus, on the whole, Hungarian firms are involved in Mode 1, skin-deep cooperation in R&D with their foreign investors.

The innovation survey conducted in 1994 yielded further details on the structure of R&D expenditure, which show that foreign companies may prefer innovation-related marketing and licensing agreements to R&D cooperation and contracts (Inzelt, 1996). The former type of agreement is important, but there is no substitute for R&D contracts for institutes and firms in transition countries with relatively strong competence.

Broad learning and less innovation orientation of business R&D activities accumulated value in R&D assets. The substantial difference between the number of firms performing R&D and the number spending on R&D reflects the weight of firms which reported sales from R&D activities and tangible assets, but which did not incur any current cost on R&D in that year. (Of the 478 firms, 362 spent money on R&D in 1992.) These firms abandoned or interrupted their R&D activities during or after privatization, but they still had some income from their former activity (patents, know-how, licenses, and so on).

This discontinuity was a legacy of socialism; companies were able to sell their accumulated knowledge. Among the forced knowledge traders there was no typical sector or size. Discontinuity in R&D investment can, of course, occur in market

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economies too, but it has size and sector characteristics, and differs significantly from this transformation-induced phenomenon.

The size of R&D investment in absolute terms and in relation to sales focuses attention on the behavior of foreign investors. Foreign owners have not taken the risk of investing in leading research fields. They have paid attention to R&D fields that are closed to competition, and to those sectors in which the critical mass of R&D expenditure to personnel is low. It means they spent on introducing quality control systems, ISO (International Standards Organization) standards, and so on. Between 1992 and 1995 the largest proportion of R&D expenditure to sales by foreign-owned firms went into the food and beverages, chemicals, and machinery and equipment sectors. These are mature industries (pharmaceuticals apart) in which usually only small incremental innovations occur. Radical innovations are very rare in these industries.

Figures on the ratio of R&D expenditure to sales (Table 3) back up the assumptions that it is largely Mode 1 R&D activities that were financed by foreigners. In the machinery and equipment sector, the BERD (business expenditure on R&D) to sales indicator is lower for foreign-owned firms than for domestic. In the non-R&D-intensive food processing and beverages sector, however, the corresponding ratio is twice as high for foreign-owned firms as for domestically owned. Even so, the indicator never went above 0.15%, which means that the R&D activity involved merely supported the introduction of mature product licenses and process know-how, and the development of adaptation capabilities. The situation was the same in the chemicals industry even if foreigners did record a ratio of almost 5% while domestic owners could muster only 0.7%.

Our statistical analysis shows that the essence of R&D by foreign-managed companies is technology transfer and its support. These organizations are performing the traditional tasks of FDI laboratories in facilitating some degree of adaptation of the basic design (Ronstadt, 1984, cited by Niosi, 1996).

The main lesson of the statistical data is that R&D expenditure by foreign-owned companies has financed small-scale intramural and extramural R&D

Table 3. Ratio of R&D expenditure to sales in 1995, by owners and sectors (%)

Sector	Domestic	Foreign-owned			Total
		Below 50%	Above 50%	All	
Non-manufacturing	0.50	0.07	0.08	0.07	0.31
Manufacturing, all	0.57	0.50	0.88	0.97	0.86
Food and beverages	0.08	0.11	0.15	0.14	0.12
Chemicals	0.71	4.30	4.95	4.74	2.58
Machinery and equipment	1.12	0.36	0.71	0.81	0.66
office, computers	0.77	–	0.15	0.15	0.21
Total	0.57	0.50	0.8	0.68	0.63

projects. The activities were usually close to the end of the development phase and far from research. The usage of R&D capacity helped the foreign investor to learn the real value of R&D liabilities, the impressive level of general engineering skills and assets in a well-educated labor force in the host country.

It may add to this statistical information to mention that only a few internationally famous Hungarian academic/university research groups could be involved in crucial research tasks financed by foreign business. However, these foreign business contractors were hardly foreign investors in production. According to university reports on their R&D contracts the firms usually start with small-scale projects. In the initial phase, the tasks are usually (clinical) testing, with minor technology development. These agreements are followed in some cases with larger-scale projects to do industrial research. The newly created Bay Zoltán Foundation's institutes (a clone of the Fraunhofer model) could establish strong business relationships and have become partners in international business collaboration during the first period (Inzelt, 1998).

Bangalore-type R&D contracts also were present in this period, but this type of high qualified work also occurred in the 1980s: Hungarian software engineers were commuting to Austria from Budapest and the western part of the country. This type of R&D was marginal before the transition period and then started to spread. If multinationals without a Hungarian production line are outsourcing Bangalore-type research or testing, they are involved in skin-deep research. The most important motivation of such contracts is a cheap research labor-force. That means they can relocate relatively easily such research contracts.

A very special phenomenon of the transition economy is that Bangalore-types R&D activities occurred as in-house R&D for a short period. Foreign investors used the existing laboratories or recently acquired firms in a limited manner. In the first period, the acquisition of an R&D laboratory usually was an accident. The laboratory was part of the privatized

company's package. In the first period, they had not developed new local R&D and design capabilities.

During the first period, FDI in R&D had a positive impact on the transformation and performance of the economy. FDI has generated a certain amount of economic integration and internationalization of Hungarian firms. The establishment of several multinational companies in the country has had demonstrative influence on others to penetrate into Hungary (for example, other Japanese companies followed the investment of Suzuki; the entrance of one ICT giant encouraged others). However, it tended not to involve the serious development of R&D/design activities in the host firm (Dyker, 1999b; Inzelt, 1999; Radosevic, 1997; Urem, 1999).

The majority of skin-deep cooperations have helped to keep alive in-house and outside R&D capabilities. They have made transformation smoother for R&D laboratories and personnel. However, it remained an open question at the end of the first period of transition whether foreign investors would close down or redeploy and use their acquired R&D laboratories as production lines. Would they set up new laboratories as well as production lines?

In this period, the relationship between host and home country was closer to the traditional paradigm of innovation.[8] The role of host countries is technology adoption: pre-determined technical solutions are generated in the home countries of FDI in one central location near the corporate headquarters, and are later replicated in peripheral locations. This process involves mainly outward learning and one-way technology transfer (typically a flow of information from the center to the periphery).

Second period: new trends

The second period started around 1996–97. At this time, the economy was recovering and many actors and factors in the national system of innovation were becoming market-economy orientated. These changes have helped the Hungarian economy to create incentives for commercialization. In the first period, Hungary got into the targeted countries by foreign investments, including into R&D.

In this 'club', a country can make itself more attractive to foreign investors if it offers more public inducements to conduct R&D than the home country of the potential investor. Thus, reducing the cost of conducting research in the foreign location is an important factor. The Hungarian Government launched some direct measures to encourage FDI in R&D, including public–private R&D collaborations. Also, it supports the diffusion of new knowledge throughout the economy. Recent policy encourages investment in R&D by tax concessions, co-financing schemes for establishing competence centers, and university–industry cooperative research laboratories.[9]

It is worth highlighting that the new policy was born from the feedback loops between economic actors and policymakers. Multinational companies (MNCs) have initiated this type of governmental policy when, during the period of acquaintanceship, they have evaluated the knowledge base of the country and have found it worth investing in. Their initial investments made governmental agencies open to such facilitating policy measures.

Foreign investors are motivated to establish or expand R&D in Hungary (as in other countries) to gain access to talents in certain fields (for instance, in the ICT sector, companies such as Nokia, Ericsson, Compaq, IBM). In the framework of the (high-tech) competence-center program, three R&D laboratories were set up in which Audi, Knorr-Bremse and Nokia have invested. Three others active in the electronic industry are in the pipeline.

We may assume that R&D can play a much bigger role in the second stage of transition than in the first. In the second phase, new behavior is emerging with investment in R&D by MNCs starting to increase. Comprehensive statistical data are not available,[10] but case studies carried out by different research organizations together with scattered administrative data give some food with which to investigate the second period.

According to news reports and case studies, some multinationals have acquired or set up R&D laboratories in Hungary with or without connections to their Hungarian manufacturing activities.[11] Others do not have any manufacturing activities in Hungary, but set up laboratories or form partnerships with Hungarian universities/institutes. Several multinationals with or without a production line in Hungary are becoming active partners of Hungarian universities and research institutions.

In the second period, we may observe the appearance of some characteristics of a new paradigm of transnational innovations: Hungarian R&D laboratories are among the centers of competence (for instance, Ericsson, Knorr-Bremse, GE Lighting).

If multinationals have production lines in Hungary we see a dual relationship with Hungarian research activities. One is represented by the Hungarian enterprise: the agreements contain development, technical advice, technology adaptation tasks. The other is represented by contracts with headquarters. These cases have both skin-deep and soul-deep characters at the same time. The Hungarian subsidiary and its partners

MNCs with production lines in Hungary have a dual relationship with Hungarian research activities: one represented by the Hungarian firm where the agreements contain development, technical advice, and technology adaptation tasks, the other by contracts with headquarters

Box 4

Ericsson established its Hungarian affiliated company in 1991. Its activity covers the Hungarian sale of Ericsson products and technologies, the regional engineer consulting activity, and strategic research and development (R&D).

Ericsson has conducted software development since 1992. In 1996, it established the Traffic Lab, which analyses network performance and possible bottlenecks through traffic measurement. In 1997, research activity was supplemented by conformity analyses. Between 1991 and 1999, the number of Hungarian R&D personnel multiplied by a factor of 12, and last year it reached 170. R&D personnel represented 30% of total staff.

The Hungarian R&D Unit is one of the integral parts of the Ericsson Research Branch. The Hungarian R&D activity is closely connected with two of the 19 strategic research areas of Ericsson, namely radio access and network management. There are not previously well defined research tasks in the enterprise group. With every new idea, units have to prove the existence of necessary resources and competency, and try to win the internal financiers. The R&D expenditure does not depend on Hungarian turnover or income, but on the importance of these ideas in the strategic objectives of headquarters.

In January 1998, Net Perf was founded with the aim of providing competitive products and services based on Hungarian research results. Recent work focuses on the development of PlasmaSIM. This software supports network design, performance analyses, optimization and decision making. Research, development and 'production' related to PlasmaSIM takes place in Hungary. At present there are some research outputs in varying stages of development, which could become successful Hungarian products (for instance, an Internet management system).

Within the enterprise group, R&D is a cross-border, international activity. The other key element of the fruitful R&D activity is the wide range and amount of cooperation with universities.

The relationship with national universities is bilateral. Ericsson utilizes the knowledge accumulated by universities and also employs professionals who were educated according to the standards of the company. On the other hand, Ericsson offers both teachers and students a possibility to solve real problems and gives financial and professional support to the educational and research activity of the universities. Within the Faculty of Electrical Engineering of the Budapest University of Technology and Economics, there are two laboratories which were established with the support of Ericsson — the High Speed Networks Laboratory and the Ericsson Laboratory.

Ericsson functions as a sort of a bridge between Hungarian and foreign universities. Through Ericsson, student mobility and personal and professional relationships are being set up.

Source: Compiled by Noémi Gál

are producers and users of R&D results in the first case. In the second case, Hungarian research organizations are only producers of results. This outsourcing research activity may mean that MNCs are internationalizing Hungarian business-related R&D activities at a strong collaborative level. Another possible outcome is just to exploit some competencies without any collaboration. These Bangalore-type agreements are less frequent in this group.

Hungary offers some cases on the borderline of soul-deep 1 and 2. Ericsson is a good example (see Box 4). This case may illustrate a new organizational cooperation structure for internationalized firms, although it may be a new version of soul-deep 2. In the early 1990s Knorr Bremse was a good example of such cooperation.

In the second period, acquisition of R&D laboratories is becoming an important consideration for some firms because they want to obtain complementary knowledge and R&D capabilities (for instance, the Hungarian non-prescription medicine firm, Pharmavit, was acquired by Bristol-Myers Squibb).

Conclusion

The new categories — skin-deep and soul-deep cooperations — introduced in this paper offer good tools to respond to the question: is penetration of FDI in R&D able to speed up the transformation of the Hungarian system of innovations? The future success or failure of Hungary greatly depends on how Hungarian knowledge-creating institutions can persuade domestic industry and foreign industry to work in tandem, and on how international research partnerships will develop and commercialize new products, and discover new and better ways of doing things.

The role of FDI in R&D proves indirectly that R&D outputs are more valuable than their generally poor return suggests in the Hungarian economy. FDI offers some efficient capacity to transform S&T results into new products and processes. The enterprises in this circle have the ability to embody innovation activities. The crucial task of policy-makers is to create an environment in which FDI is increasingly active in soul-deep 1 type R&D cooperation.

The role of host countries is technology adoption: pre-determined technical solutions are generated in home countries of FDI in one central location near the corporate headquarters, and are later replicated in peripheral locations. This process involves mainly outward learning and one-way technology transfer (typically a flow of information from the center to the periphery).

In the context of transition, our analysis allows us to confirm that FDI has a positive influence on commercialization, moving from a one-way linear model of innovation to one based on feedback loops, in order to foster the capabilities of enterprises. Microeconomic actors can overcome one of the main hampering factors — weak commercialization and low efficiency of fragmented technology transfer.

FDI in skin-deep 1 helps by propagating incremental innovations. Foreign-owned companies have financed small-scale intramural and extramural R&D projects. The activities were usually close to the end of the development phase and far from research. The usage of R&D capacities helped the foreign investor to learn the real value of R&D liabilities, the impressive level of general engineering skills and the assets in well-educated labor force of the country.

Much like developing countries, the most important motivation of skin-deep 2 type contracts is a cheap research labor-force in Hungary, allowing the foreign investors to relocate relatively easily their

research contracts. A very special phenomenon of the transition economy was that Bangalore-type R&D activities occurred as in-house R&D for a short period. Foreign investors used the existing laboratories or recently acquired firms in a limited manner. In the first period, the acquisition of an R&D laboratory was usually an accident. The laboratory was part of the privatized company's package.

To qualify as soul-deep 2 cooperation there must be a positive evaluation of Hungarian S&T assets. There are only a few internationally famous Hungarian academic/university research groups that could be involved in crucial research tasks financed by foreign business. It is still an open question whether penetration of FDI in soul-deep R&D collaboration will contribute massively to economic 'catch up'.

Many factors influence the spin-off effects of FDI in R&D. How are the relationships changing among investors and other economic actors, suppliers and customers? How does the changing national system of innovation encourage or burden further investment in R&D and in talent? Another role might be to open/broaden the channels for brain drain either physically or Bangalore types.

We can observe foreign investments in pools of talent in Hungary. This phenomenon is important but it would be premature to evaluate its effect. This 'deviation' from the international trend may be a temporary tool for adjustments. However, it may be a new emerging paradigm for the group of transition economies or for special sectors. We can suppose this investment will become a good basis for soul-deep cooperation, however, it may have negative outcomes as a cheap brain drain too.

One of the specific characteristics of a transition economy is that there are two stages in the development of cooperation. The small-scale projects and skin-deep cooperations may have the role of a waiting room for larger-scale projects, being strong knowledge-based business relationships introducing new partners into international business collaboration. They may also keep the country on the periphery of advanced economies and form leading alliances.

During the first period, FDI in R&D has had a positive impact on the transformation and performance of the economy. FDI has generated some kind of economic integration and internationalization of Hungarian firms. The establishment of several multinational companies in the country has been a model for others to follow suit (for instance, other Japanese companies followed the investment of Suzuki; the entrance of one of the ICT giants encouraged the others to be present). However, the inability of domestic enterprises to manage innovations still remains an important factor hindering Hungary from climbing further up the ladder.

We may assume that R&D can play a much bigger role in the second stage of transition than it did in the first. In the second phase, new behavior is emerging. Investment in R&D by MNCs started to increase in the second period. The increasing internationalization of innovative activities cannot replace weak local capabilities. It goes beyond this paper to investigate spill-over effects of MNCs on innovativeness and upgrading of domestic firms' R&D activities.

Notes

1. FDI is defined as those investments which are made with a view to acquiring a lasting interest in a foreign enterprise, and to having an effective voice in its management (IMF, 1993).
2. This part is taken partially from Inzelt (1999b). It develops further the category of skin-deep R&D collaboration introduced in a previous article. It splits skin-deep collaboration into two groups, introducing the new group "Bangalore-type".
3. See the summary of the literature in Florida (1997).
4. According to ISIC Rev3./NACE Rev1. (International Standard Industrial Classification) "Principal (or primary) activity is identified as the activity which contributes most to the total value added of the entity under consideration. Principal activity does not necessarily account for 50% or more of the entity's total value added." NACE Rev. 1§ 37, EUROSTAT 1993, Luxembourg. Firms with R&D as principal activity are classified under 73.
5. There are many examples of non-use of R&D results in the host country, from Portugal to India.
6. Hungary was the first country in the COMECON (Council for Mutual Economic Assistance) system that passed a law on foreign investment in 1972. This strict law made it not very attractive for foreigners to invest in a 'risky' country. The new law and its accompanying measures were attractive for foreign investors and really opened the country for such investments. Companies from multinationals to small foreign investors entered the Hungarian economy.
7. The revision of the Hungarian statistical system resulted in a good business survey. This survey was introduced in 1992 and contained some questions about R&D activities (sales from R&D activities, non-intangible assets, gross fixed capital in R&D facilities, direct cost of own production of R&D, indirect cost of own production of R&D, cost of bought-in R&D activities.) That survey was valid until 1996, then the new vice-president of CSO cancelled the R&D-related questions from the business survey. The available file data do not cover many aspects of R&D activities at companies hosting FDI. However, these data are the best we have, and the analytical part of our study is based on them.
8. The traditional and new paradigms of innovations were described by a research team led by Frieder Meyer Krahmer (Meyer Krahmer, 1998).
9. Those firms which set up R&D laboratories employing at least 30 researchers and invest at least HUF 500 million are supported by state grants of up to 25% of the value of their investments.
10. This lack of data does not allow us to compare two periods statistically.
11. There is a group of firms which have both production line and R&D laboratories, but the latter do not cooperate within Hungary. The production lines manufacture products at the mature stage of their life-cycle. The R&D activities in the Hungarian laboratories produce novelties for the international market, but do not interact with the host economy. This type of division of labor does not help to diminish the gap between the level of R&D and the innovative performance of the economy.

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