Case Study Evidence of the Extent and Nature of Foreign Subsidiaries' R&D and Innovation Capability in Hungary

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Abstract: Multinational companies increasingly locate their R&D activities outside their home countries, thus being one of the main contributors to the ongoing process of the internationalisation of R&D. The internationalisation of corporate R&D is gaining momentum and the New Member States of the European Union, including Hungary are increasingly taking part in that process. The present paper analyses three aspects of this topic, first, the characteristics of R&D activities carried out by foreign affiliates in Hungary. Second, what are those locational factors which attract these types of investments to Hungary, distinguishing between production-related and knowledge-seeking R&D and relating locational factors in Hungary to those in the home country. And third, we analyse what the impact of this type of investments on the local economy is, where we also distinguish between production-related and "stand-alone", knowledge-seeking projects. In the analysis, company case studies were used based on questionnaire-led semi-structured interviews with leading managers of 20 foreign-owned automotive and electronics companies.

Introduction

Multinational companies increasingly locate their R&D activities outside their home countries, thus being one of the main contributors to the ongoing process of the internationalization of R&D. The internationalization of corporate R&D is gaining momentum and the New Member States of the European Union, including Hungary are increasingly taking part in that process, mainly on the receiving end. These countries opened up their economies to FDI, offering a beneficial environment for it. Certain sectors and activities, deemed to be of strategic importance or to bring outstanding benefits to the host country, including R&D receive generous incentives, indicating that governments consider these investments important from the point of view of economic development. There are numerous papers, mainly econometric studies, which analyze the locational advantages of the countries in question from the point of view of FDI and the local impact of FDI generally. However, there are only a few studies examining FDI in R&D.

The aim of the paper is to analyze three aspects of this topic, first, the characteristics of R&D activities carried out by foreign affiliates in Hungary, second, what are those locational factors, which attract these types of investments to Hungary, and third, what is the impact of this type of investments on the local economy. The paper concentrates on the qualitative aspects of these areas because of the method used for the analysis, as it relies on case study evidence.

Theoretical an empirical approaches to R&D internationalization

This paper deals with three aspects of the internationalization of R&D on the basis of the case of Hungary as a host country. First, it tries to find out in the internationalization of what type of R&D activities Hungary as a host country takes part. What types of R&D activities are located to Hungary by multinational companies? How does this relate to the strategy and motivations of a multinational firm? Second, what are the main location advantages, on the basis of which Hungary is selected for such activities by multinational companies. Third, how these activities impact upon the local economy, what are those main channels through which this impact is realized? The paper concentrates on two sectors: automotive and electronics. In these two sectors there are important foreign R&D capacities operating in Hungary. On the basis of these research questions, a short review of the related literature is presented, first, on the company level factors, which influence the internationalization of R&D, second, on those locational advantages, according to which a country becomes host to these activities and third, on those impacts, which occur in the local economy due to the presence and local interactions of R&D activities carried out by foreign-owned affiliates. Sector-specific issues, causing differences in the analyzed two sectors will also be reviewed shortly.

Drivers of the internationalization of R&D at the company level

Multinational companies, by definition, have one or more advantages over companies operating only in one country: superior knowledge, technology, organizational skills, production processes, management capabilities, etc. The various combinations of these advantages form those firm-specific assets, which enable the firm to be competitive internationally and to carry out an investment abroad. (See among others Dunning, 1993 or Caves, 2007.) These firm-specific assets are usually concentrated in the home country, because of various factors, including its embeddedness into the local innovation system. Thus this "home-country-bias" in R&D should be compared to those advantages, which result from transferring R&D activities abroad. What can be the motives of companies to internationalize R&D activities?

The internationalization of production is still the most important factor for the internationalization of R&D, but the significance of getting access to foreign knowledge is on the increase. (See for example le Bas and Sierra, 2002 or Sachwald, 2008.) It is important to note that the different motivations at the company level are connected to differing requirements concerning the host country and location, affect different R&D activities and result in differing types of foreign sourcing of R&D with different impact on the host countries. Thus indirectly, through the changes of the composition of factors affecting location choices, the changing trend in motivation can also be indicated. For example, Serapio and Dalton (1999) showed that besides demand considerations, supply factors are also important in locating R&D in the US by foreign companies. Pearce (1999) also showed that product development increased at the expense of adaptation. On the other hand, Patel and Vega (1999) revealed that companies locate those technologies abroad, in which they are strong in their home countries.

In the literature, two main company motivations are distinguished. Usually the main aim why R&D is internationalized is to support foreign production at the affiliates. In these cases, the local sales of affiliates are supported through adaptation to various local regulations and/or to local consumer or buyer preferences. The adaptation must be carried out close to production. Another aim may be to get access to foreign knowledge, when it is irrelevant if production is present in the given country (though in certain sectors this may be important). In that case, the knowledge created in the foreign location is used in the whole network of affiliates of the multinational company. In the literature, various denominations are aimed at distinguishing these two different motivations for internationalizing R&D. For example, the asset-exploiting strategy is using the existing stock of knowledge of the multinational company itself, adopting it to the market of the host country. In the case of the asset-augmenting strategy, the host country knowledge enhances the stock of knowledge of the MNC. In the latter case, the company must be able to manage, organize and combine the various sources of knowledge. Home-base augmenting versus home-base-exploiting strategies or market-driven versus technology-driven international R&D organizations depict the same difference between the motivations of firms. (See e.g. von Zedtwittz and Gassman, 2002; Narula, Zanfei, 2005) Other authors (for example Granstrand et al., 1993 or Sachwald, 2008) add a third motivation for explaining why companies internationalize their innovation activities. According to their categories, besides knowledge-seeking and market-seeking, the efficiency-seeking motive in the internationalization of R&D may also be relevant (Grandstrand et al., 1993). According to Sachwald (2008), there are three types of foreign affiliates dealing with R&D: local development centers (LDC), global research laboratories (GRL) and global development centers (GDC). The number of LDCs is the highest in the world economy, and this corresponds to a great extent to the R&D support provided for local production and sales by affiliates, i.e. the market-seeking type. GRLs support the global innovation processes of the multinational company. The number of these is much lower, though growing. This may be the equivalent of the knowledge-seeking type. GDCs are responsible for those tasks and projects, which can be separated, fragmented from the overall innovation process of the multinational firm, and the solutions found by the GDCs can be „fed back" into these processes. In that sense, this is a type of vertical, or vertically integrated foreign direct investment (Caves 2007) through which these R&D centers in the host economies are established. In this case the dominance of the efficiency-seeking motivation is clear-cut.

Motivations of investing firms should be analyzed in the light of their home country characteristics as well. The level of competition in the home country, barriers to innovative activities in the home country may be acting as push factors for the internationalization of R&D for the firm. An even more important factor can be the lack of relevantly skilled personnel in the home country, which forces the company in question to transfer certain R&D activities abroad (see e.g. Kinkel and Som, 2010 in the case of Germany), problems with carrying out certain R&D activities in the home country (see e.g. Overby (2007) for the US) or high innovation costs at home may act similarly (Schmiele, 2009).

What are those company characteristics, which are connected to the internationalization of R&D? Empirical studies found that previous international experience (export) and absorptive capacity (for example Ito and Wakasugi, 2007 or Schmiele, 2009), firm strategy and organization (for example Zanfei, 2000), firm size, age and location (larger, older firms are more inclined to internationalize according to Schmiele, 2009) and the sector where the company operates (for sectoral differences in the internationalization of R&D see EC, 2010).

As in the case of the internationalization of other activities, companies have to deal with a trade-off between the benefits originating from carrying out R&D in a cheaper, more efficient locations, or in locations offering new knowledge or which are situated closer to technology, scientific or knowledge centers and the costs arising from the disintegration of R&D or simply carrying it out further away from the headquarter. There are thus centralizing and decentralizing forces at play. (Pearce, 1999) Changes in that respect over time are obvious: for example the reduction in the costs due to technology developments understandably increases the benefits and induces firms to internationalize R&D to a greater extent. This may result in changes in the motivation of firms over time, introducing dynamism in the process.

Locational advantages

Locational advantages show, which country characteristics matter for attracting R&D from abroad. These need to be in correspondence with those motivations and drivers, according to which multinational companies decide for the internationalization of their R&D activities. Locational factors of the host country for foreign R&D investments are analyzed by various empirical studies, which usually do not distinguish between the locational factors according to the motive of R&D internationalization. According to empirical evidence, the level of development of the host country positively affects FDI in R&D, as it takes place predominantly between highly developed countries. (Manning et al., 2008 or EC, 2010) Moreover, larger countries usually attract more R&D. As another locational factor, the stock of relevantly skilled labor and in connection with that, the structure (absolute number of relevantly skilled graduates) and efficiency of the local education system also influence the location choice of firms (see e.g. Thursby and Thursby, 2006); however, labor costs both in absolute and relative terms (the home and host country compared) play a minor role (See e.g. Lerni, 2010, who shows that labor costs are important for the internationalization of US R&D only in the case of developed host countries or Belderbos et al., 2009). In a wider sense, the technology capacities, expertise and competencies of the host country are also important, especially for home-base augmenting projects. (Pearce, 1999; Cantwell and Piscitello, 2000) Geographical, cultural proximity as well as a common language or the language of the home country relatively widely spoken in the host may also be an attracting factor especially when R&D activities require a day-to-day cooperation and interaction between persons or teams in the home and host countries. Various elements of government policy (usually in terms of determining the overall business and R&D environment) and institutions may also influence the location decision. (See e.g. Kshetri, 2007 or Doh et al., 2005) In some cases, potential local knowledge spillover and externality opportunities are the most important locational factors. (See e.g. Feinberg and Gupta, 2004 or Lerni, 2010, who shows that sectors with different technology content are relevant from that point of view for developed (high and low tech industries) and developing (medium-tech sectors).) Cantwell and Piscitello (2005) found that these may occur due to the agglomeration effect of firms in the same or different sectors and the availability of the relevant scientific and educational infrastructure. It may also be a plus, if certain inputs and services (relevant equipment, testing services, laboratory services etc.) are available locally. Intellectual property rights and their protection in the host country (see

among others Overby, 2007 or Ito and Wakasugi, 2007) can also be an important factor. Certain location decisions may be accidental or may depend on the "luck" factor. Besides host country characteristics, home country, "push" factors or centrifugal factors (see e.g. Benito et al., 2002) do also play a role in the internationalization of R&D, especially if host and home country characteristics are compared to each other. This may affect the decision to invest abroad in R&D, the locational choice and later the behavior of the foreign affiliate among others in terms of its R&D activities. Thus according to the various motivations of firms internationalizing R&D, of the specificity and sector of R&D activities and home country and firm characteristics, the relative importance of locational advantages may differ.

There are a few studies examining specifically former transition economies from the point of view of the internationalization of R&D in a comparative way. Kalotay (2005) notes the emerging importance of Central and Eastern Europe for R&D investments, emphasizing that especially European multinational companies in the automotive and electronics industries located R&D in the Czech Republic, Hungary and Poland. Kokko and Kravtsova (2008) examine four former transition economies (Estonia, Hungary, Poland and Slovenia) and they found that the following characteristics matter the most for the innovative capabilities of foreign-owned firms. The relative development at the sector level is important; they note that if there is a substantial gap between foreign-owned affiliates and local companies, it negatively affects the innovative capabilities of foreign-owned companies. At the same time, education expenditure has a significant positive impact on it. In terms of entry mode, greenfield projects and in terms of the level of intra-firm exports, highly integrated affiliates are less likely to have their own innovative capability in product and process technology. Schmiele (2009) analyses among others the location choice of German companies concerning their R&D activities. For the Eastern European region, only the export experience of the German company is a significant factor. However, there are certain push factors in the home country (though not significant), which influence the choice of that region: for example lack of qualified labor and high innovation costs.

Impact on the host economy

Technology and productivity spillovers from FDI are especially important for former transition economies, which are in a less advanced phase in technology compared to the affiliates of multinational companies operating there. Spillover effects may take two distinct forms: those of technological and pecuniary externalities, because FDI goes together with costs and benefits which are not directly transmitted through the market. (Barba Navaretti, Venables, 2004). Direct technology transfer may be important in the case of R&D, as the companies use the highest level technologies, and they also use high quality management and production organisation. Other types of effects, for example acquisition of labour skills concerning technology, managerial skills, know-how, knowledge about the markets and even "business ethics" in a wide sense, and their transmission to local companies is an important channel through which these foreign-owned companies may impact upon the local economy. The mobility of employees and demonstration effects may also bring benefits. (Blomström, Kokko, 1998) Pecuniary externalities may occur through the use of local suppliers, including local services providers and through selling products to local companies (backward and forward linkages). This may result in an increase in the quantity and quality of local output, and in the increase in the productivity of local companies, through providing access to high quality goods and services and an opportunity to outsource certain activities. In the case of R&D activities, spillovers may take as well the form of local cooperation with other firms, including competitors or with local universities and research institutes, which also may bring considerable advantages to the host country's innovation system. A rarely analyzed "instant" gain and benefit for the host economy is from taxing the companies in question. (Caves, 2007, p. 239) Here not only profit tax is important, but all other taxes, minus the extra costs (incentives, additional public services required to deal with foreign- owned companies). However, none of these beneficial impacts occur automatically. Many studies on former transition economies could not find conclusive evidence of these positive impacts. (See e.g. Damijan et al., 2003) One reason may be that not all local firms are able to absorb spillovers. (Kinoshita, 2001) The local economic environment, especially

the level of education and infrastructure, a strong financial sector, the level of competition and other factors help spillovers to occur. On the other hand, spillovers also depend on the strategies of the parent companies of affiliates and the various characteristics of affiliates. For example, Dachs et al. (2008) found that differences in corporate behavior may be important in the case of foreign-owned R&D units: for example European firms tend to maximize the stakeholder value, while Anglo-Saxon concentrate on maximizing the shareholder value, which may result in differences of the behavior of affiliates. In the case of R&D-units, their level of independence and autonomy, their innovative capability may differ substantially, which then results in a differing level of interaction with the local economy. Kokko, Kravtsova (2008) for example among others underline the technological characteristics of the industry, the strategic objectives of the MNC and the entry mode as important factors from the point of view of the innovative capacities of foreign affiliates.

It is important to note that there may be significant changes over time in the position in hierarchy, level of independence and R&D capacity of the affiliate, with the direction of this change usually pointing at increasing autonomy. Various papers analyzed, what type of factors may influence that change. For example, according to Rugman and Verbeke (2001) during its operation, which is thus related to its age, its size and its actual activity, the affiliate accumulates resources, the stock of which may be an important factor from that point of view. Hakansson and Nobel (2001) underline the importance of local embeddedness. Moreover, even the various characteristics of the host country (e.g. the quality and quantity of education, the technology level, certain elements of the infrastructure) and those government policy and regulatory system's elements, which either directly or indirectly influence innovative and R&D activities may exercise an impact in that respect. For example, Kokko and Kratsova (2008) analyses the innovative capability of affiliates, using three sets of independent variables: subsidiary role, host industry and host country characteristics; subsidiary characteristics (share of foreign ownership, entry mode, trade orientation, degree of diversification, size and age), which factors they deem important from the point of view of shaping the innovativeness of the foreign-owned firm.

It is important to note, that as we could see, there are studies, which emphasize the role of spillovers from the point of view of locational advantages. For example, Feinberg and Gupta (2004) showed that a firm's ability to "seize" spillovers of external knowledge and use it may influence the location decision.

Methodology and data

As the basis for the analysis, company case studies were used based on interviews with leading managers. Altogether, 20 interviews were conducted. As far as representatives of various company associations and organizations are concerned, three of the interviewed managers were leading representatives of various associations, thus they were asked to present the views of these organizations as well. Moreover, one additional interview was conducted with the representative of the Hungarian Investment and Trade Agency.

Additional information was also collected from the balance sheets of the companies and through indirect channels such as specialized newspapers. We built a semi-structured questionnaire and organized personal in-depth interviews with top managers of the electronics and automobile companies in December 2012 and January-February 2013. In the majority of cases heads of the R&D unit (11 cases) were the interview partners, but CEOs (5 cases) or other top managers (5) were also interviewed (for one company, both the CEO and the head of R&D were interviewed).

Altogether 35 companies were approached out of a total of around 72 companies carrying out R&D activities in the automobile or electronics sectors, according to the registry of the Central Statistical Office. Furthermore, we used company databases of ITDH and HITA (Hungarian trade and FDI agencies), balance sheets of the companies, and information from previous and other research and newspaper articles in order to identify the most important companies.

The aim was to interview some of the largest R&D spenders and to have a differentiated sample in terms of geographical and value chain position as well as of the size group (small, medium, large) of the companies. There are also two minority foreign-owned companies among the interviewed ones.

They represent very interesting cases and can be considered as the odd-ones-out of the sample. In order to have more accurate answers and to reflect company specificities, the interviews were conducted anonymously.

Interview techniques may be a good supplement to other, mainly econometric techniques as well as representing certain advantages over them. During the interviews, we collected primary quantitative as well as qualitative data, whereas econometric techniques are based on secondary quantitative variables, the reliability of which, as it was reinforced by the interviews, may be doubtful. In case studies there is place for heterogeneity of firms and strategy and there is room for concentrating on those aspects of the problem, which prove to be the most important in the given case. Case studies are usually rich in details and may well include a dynamic perspective. Overall, the case study approach is more flexible and thus it can grasp a wider spectrum of factors affecting the analyzed phenomenon and it can change focus during the interview process according to the new information collected. We were nevertheless aware of the main limits of company interviews. They provide very valuable material of the behavior of firms, but generalization may be difficult due to the small number of firms involved in the interviewed group, compared to the usually large number of company data analyzed in econometric studies. The collected material may also be biased by problems of selection of the firms as better performing firms seem to be more inclined to react positively when asking for an interview. Another problem may arise from the subjectivity of the answers. The information collected during the interviews reflects mainly the perspectives and opinions of the leading managers of the companies, which obviously are in correspondence and compliance with the strategies and ethical values of the company in question. We used the questionnaire as a flexible 'guideline' for a conversation, thus company managers had time and room to elaborate on questions they deemed more important, even to raise new problems not addressed by the questionnaire. There was time for clarification and for posing further questions if needed from the side of the interviewer.

Our semi-structured questionnaire was organized around four main topics. In Section one, we asked for information about various basic characteristics of the company (year of establishment, controlling owner, sales, exports, imports, employment and R&D). In Section two, various characteristics of the R&D and innovation activity of the affiliate were addressed. In Section three we asked about those locational advantages, which attracted these activities to Hungary. Section four dealt with the various channels of the impact of the affiliate and especially its R&D and innovation activity on the local economy. (See the questionnaire in the Annex.)

It is important to note that in the sample there are certain companies, which do not belong to the automotive or electronics sectors in a strict sense, but they have very close contacts with them through providing them with various sector-specific R&D. Five companies, no. 2, 5, 10, 11 and 16 are carrying out mainly services activities, though 2 and 5 indicated that a small share of their R&D is connected to the developments of electronics hardware. Company 11 provides telecommunications solutions, thus it is connected mainly to the electronics sector. Company no. 16 provides R&D engineering and informatics solution services for both the automotive and electronics sectors. Moreover, company no. 10 is carrying out R&D especially for the automotive sector, as it designs, analyses, tests and develops engines and at the same time it also develops software for application in engines. While these companies' main business line is in services, their R&D forms an essential part of the innovative activities in the two analyzed sectors.

Although the number of cases is relatively low (20 companies), the selected companies represent a significant part of Hungarian automotive and electronics R&D. The total number of private R&D centers in the two analyzed sectors was 72 (36 both in the electronics and in the automotive sectors, respectively) in 2011. Thus our sample, without the service companies represents 21% of the total number of R&D centers in the two sectors (22.2 % in the electronics and 19.4 % in the automotive sectors). The number of R&D personnel of the sample is 1884, while that of the two sectors was 1652 (electronics) and 1330 (automotive), thus the sample represents 63 % of the total R&D personnel of the automotive and electronic sectors in Hungary (by sectors: 37.5 % in the electronics and 92.8 % in the automotive).

Characteristics of the two sectors in Hungary and their R&D

In Hungary, after 1989, the re-appearance of automotive industry started at the beginning of the nineties with investments realized by three important OEMs: Suzuki, Opel and Audi. In the subsequent period, OEMS have chosen other countries in the region for establishing new capacities. This trend was broken in 2008, when Daimler (Mercedes) located its new capacity in Kecskemét, Hungary. In the meantime, Hungary attracted numerous first tier suppliers, which either followed the three OEMs to Hungary or supplied their traditional partners from capacities relocated or newly established in lower cost locations in Hungary. As far as the main economic actors in the automotive sector are concerned, they are the following. First, foreign owned OEMs: Suzuki, GM/Opel, Audi, and more recently Daimler-Mercedes. According to Pavlinek (2002), they can be characterized by their relationship to the remnants from the socialist era, i.e. their entry modes and along their level of embeddedness in the local economy, measured through the extent they use local suppliers. Thus Suzuki is a greenfield and embedded firm; GM/Opel, Audi and presumably Mercedes are greenfield, and not-embedded companies. The second group consists of foreign-owned suppliers, as for example Robert Bosch, Luk, Zollner, ZF, Knorr Bremse. They are usually large-sized companies. Altogether, in regional (CEE) comparison Hungary is more specialized on suppliers than on OEMs in the automotive sector. The third group of economic actors contains Hungarian owned suppliers. There are a few large companies (e.g. Videoton, Karsai, Hajdú), but the group is dominated by SMEs. They supply local foreign-owned OEMs and suppliers or foreign firms. The group of Hungarian automotive suppliers is very heterogeneous. (Rugraff, Sass, 2012) They operate in various industries: only a few of them are active in traditional car supplying industries, they differ in terms of the complexity of their products and in the level of diversification (in terms of the number of products, number of buyers, and even the number of sectors they operate in). It is also characteristic that with the exception of Suzuki, there are only a few Hungarian companies, which would be able to supply with components the serial production of the carmakers or first-tier suppliers.

While it is difficult to determine statistically the sector, OECD (2009) makes an attempt to analyze the role of the automotive sector and its suppliers in the member countries. According to that, among OECD countries, Hungary was among those in which the automotive sector played a significant role. For example in the automotive sector's share in manufacturing and total value added Hungary was third, following Germany and the Czech Republic. Hungary was also third, following Japan and Slovakia in terms of the share of the automotive sector in exports. Thus the automotive sector forms a significant part of the Hungarian economy even in international comparison.

In the electronics sector, the structure of the group of economic actors is similar to that of the automotive industry, but it also reflects the different organization of production in the sector, mainly through the dominant role of EMS (electronic manufacturing services companies). Thus in the electronics sector, there are large, foreign-owned OEMs, there are well-known EMS operating in Hungary (Flextronics, Foxconn, Jabil and Sanmina-SCI). Furthermore, there are a few Hungarian big companies and many SMEs operating in the sector. The electronics sector's importance in the Hungarian economy is also amongst the highest in international comparison. (OECD, 2010)

The two analyzed sectors play a determining role in Hungarian manufacturing output, employment, value added and exports. (Table 1) According to 2011 data, the two electronics sectors represent more than 22% of manufacturing output, with a slightly lower share (18%) in employment and almost 30 % of Hungarian commodities exports. The automotive sector accounts for one fifth of output, with a much lower share (12%) of manufacturing employment and more than one quarter of exports. As a relative measure of "complexity" of production, value added per employee in the automotive sector is almost 50 % higher than the Hungarian manufacturing average, while that measure is considerably below average for the electronics sectors.

Table 1 Share in manufacturing (2011, %)

	Output in % of	Employment in % of	Gross value added	GVA/ employee	Export in % of	Foreign direct investment	FDI in % of manufacturi

	manuf.	manuf.	in % of manuf	(manuf.=100)	manuf.	(million euros)[1]	ng FDI
Computers, electrical and optical equipment	17.96	11.53	9.95	86.30	24.89	2120.3	21.99
Production of electronic machinery	4.07	6.43	3.96	61.59	4.97	673.0	6.98
Production of transport equipment	19.58	11.62	16.94	145.85	25.41	-1724.1	n.d.
Altogether	41.61	29.58	30.85	104.31	55.27	1069.2	n.d.

Source: calculated on the basis of the data of the Central Statistical Office and the Hungarian National Bank

The relatively low share of local gross value added is reinforced by the data of the OECD-WTO, which contains information on the share of re-exported intermediates (goods and services) in certain branches. While the share for total Hungarian exports (goods and services) was 64.79 % in 2009, in electrical and optical equipment this measure was 89.7 %, and in the production of transport equipment 75.71 %, both higher, than the manufacturing average and the highest among all manufacturing and services branches in electronics and the third highest in the manufacturing of transport equipment.

As far as foreign ownership is concerned, sectoral data on inward foreign direct investments are misleading. (Table 1) Interestingly enough, the crisis period witnessed large investments and capacity extensions in the automotive sector in Hungary: besides the 800 million euro Mercedes investment, Audi announced a large capacity extension (basically building a second plant) in 2010 with the value of around 900 million euros, and also in 2010, Opel/GM announced a capacity extension with the value of 500 million euros. Furthermore, partly connected to the above large projects, various "follow source" and important further tier foreign owned companies also extended their capacities in Hungary, partly through relocations (for example Robert Bosch from Wales, Continental from Spain and Germany), partly through establishing new capacities (for example Knorr Bremse). Even automotive research capacities were increased in the analyzed period: Bosch substantially increased an existing small R&D capacity, Audi gradually extended its R&D center, Borg Warner even relocated development activities from Germany to Hungary in 2011. While on the basis of the above mentioned large projects we expect an increase in the stock of automotive FDI and in the share of automotive FDI in total, we could not find traces of this effect in the official FDI data published by the Hungarian National Bank. Having a look at the annual inflows, we could not find any impact of these large projects (all of them is expected to affect more than one year's inflow as the process of building up the new factories expands for several years). Instead, inflows in the automotive sector were negative starting from 2009. This may indicate that automotive multinational companies suffered large losses due to the crisis, which they tried to compensate among others through taking credits and transferring profits from their affiliates in Hungary. Furthermore, it seems they established holding companies in which they transferred ownership of the existing capacities, thus these latter do not fall into the foreign-owned category any more. For electronics, similar problems were not discovered; FDI data show a gradual increase of the stock of FDI in the sector throughout the analyzed period. In order to assess the real extent of foreign ownership in the two sectors, we rely on

[1] http://www.mnb.hu/Statisztika/statisztikai-adatok-informaciok/adatok-idosorok/vii-kulkereskedelem/mnbhu_kozetlen_tokebef

other data. According to these, both sectors are dominated by foreign-owned companies. For example in 2009, the share of foreign-owned companies in the total sales was 97.3 % in the production of computers, electronic and optical products, and 94.2 % in the production of vehicles. These are actually the highest shares among manufacturing and services branches in Hungary. Thus it can be stated that capacities in both sectors are predominantly foreign-owned.

Foreign affiliates in Hungarian R&D

In private R&D spending foreign owned companies play a determining role in Hungary (OECD, 2008). This is especially true for the two analyzed sectors, as it can be seen in Table 2. In these sectors, there was an especially high growth in private R&D intensity. (See e.g. Voigt, Brandsma, 2008 for NMS comparison.) This resulted in the dominance of foreign-owned affiliates in automotive research and three of the four electronics subsectors. The share of foreign affiliates is the lowest in the R&D activity carried out in the electronics subsector: Medical precision and optical instruments, where – partly due to the production and R&D capacities inherited from the pre-transition period, - Hungarian companies are dominant. (For developments in the Hungarian medical precision instruments sector see Sass (2012).) Not only statistics reveal that foreign dominance: Kiss (2009) also shows the determining role of foreign-owned companies in product and process innovations in Hungary on the basis of a questionnaire survey. However, in a previous study (Antalóczy, Sass, 2011) we found that Hungarian-owned, especially smaller-sized companies tend not to register their R&D activities, thus the foreign share may be slightly lower.

Numerous R&D centers were either newly established in or relocated to the country, mainly from Western Europe. There are a few R&D centers inherited by the new foreign owner through acquisitions in the framework of privatization, as in the electronics sector for example in the case of General Electric. Besides these, there are smaller sized Hungarian players, which are generally newly established SMEs offering engineering, software or other services and R&D units of Hungarian firms operating in these sectors (e.g. Videoton in electronics, Meditech, 77elektronika or Innomed in the medical precision sector). Also in regional comparison, R&D in the analyzed sectors is dominated by foreign-owned companies. Moreover, patents registered at USPTO and EPO also reinforce that.

Table 2 Share of R&D expenditure by foreign-owned affiliates in the two analyzed sectors (%)

	Electrical machinery and equipment	Electrical and optical equipment	Radio, TV, and communication equipment	Medical precision, optical instruments	Motor vehicles	Other transport equipment
Hungary	91.4	83.6	92.4	14.3	96.9	0.0
Czech Republic	57.2	61.3	66.9	68.4	95.2	9.8
Slovakia	…	…	…	43.7	50.3	7.0

Source: excerpts from Table A1., European Competitiveness Report, 2010, p. 141, http://www.oecd.org/sti/industryandglobalisation/amne.htm

The relative importance of foreign affiliates and contacts from various source countries in Hungarian R&D can be shown through the data of Table 3. The strong presence of Finland and Sweden is without doubt connected to the presence of Ericsson and Nokia (also through Nokia-Siemens-Networks). Interestingly enough, the relative importance of Germany is slightly smaller than in the case of the Czech Republic or Slovakia, in spite of the fact that there are many German firms carrying out R&D in Hungary. However, Germany is the third most important source country in Hungary.

Table 3 Relative strength of country pairs in foreign-owned patents, 2003-7, EPO

	Austria	Belgium	Germany	Finland	France	Netherlands	Sweden	UK	No. of patents
Hungary	0.55	0.25	1.56	3.34	0.67	0.07	2.31	0.38	196
Czech Republic	1.08	1.91	1.95	0.35	0.37	0.52	0.10	1.25	100
Slovakia	1.22	0.09	1.64	1.10	0.58	0.03	0.00	0.74	58

Source: excerpts from Table 3.1, European Competitiveness Report, 2010, p. 104

Note: applicant countries in column, investor countries in rows. A value larger than 1 indicates that the linkage between two countries in terms of foreign-owned patent inventions is stronger than the relative size of the two countries would suggest.

Data problems

The extent of the participation of a given country in the internationalization of R&D can take various channels and can be measured with at least three indicators, all of which have their advantages and shortcomings. (EC, 2010) The first one is to use international patent data, the second one is to rely on innovation surveys and the third one is to rely on R&D expenditures and number of R&D personnel of foreign affiliates. Understandably, our research relied on R&D data of foreign affiliates, because of its methodological approach: we could directly ask the companies about their R&D activities and if and how they declare them to the various authorities. In connection with that one of the results of our research is that – at least in Hungary – the reported data on R&D are at least partially determined by various elements of the regulatory environment.

In Hungary, the Central Statistical Office (CSO) and the Tax Authority both collect data on R&D . On the basis of the companies' tax declaration, the Hungarian tax authority publishes data among others on R&D. In order to promote innovation activities, various incentives are in place through which companies can deduce R&D-related costs from their tax base (including the local tax) or in certain cases from their pre-tax profit. The tax authority audits the claims of the companies. The CSO collects R&D data annually, and from a larger group of economic and non-economic actors, which may carry out R&D activities: besides companies, research and education institutes etc. The survey is based on a methodology elaborated by the OECD and EU. The problem with the data provided by the CSO for earlier years is that it did not include all firms carrying out R&D (for example companies with less than 5 employees, while especially in the software industry there are many small or even micro enterprises) and data are not controlled. (Barta et al., 2007) However, the first problem was resolved recently, and now data contain information on micro enterprises as well. (For a detailed description of the development of R&D and innovation data collection by CSO see Szunyogh, 2010.) As for the relationship between the two datasets, provided by the CSO and tax authority, there is a relatively large difference between the number of companies declaring R&D towards the CSO on one hand and towards the tax authorities on the other. For example, there were 205 companies in 2004, which reported R&D to CSO, but not to the TA. (Havas, 2007b, p. 25) Unexplainable differences in data published by international or domestic organizations and CSO data are also frequent. (Barta et al., 2007)

In a previous study based on company interviews conducted in 2010 in the ICT sector we showed that official statistical data (CSO) on R&D personnel, R&D expenditures and R&D activities could be considerably underestimated both in Hungarian-owned companies and in foreign affiliates operating in Hungary. Hungarian owned companies, where there was no additional benefit for example in the form of a tax allowance, did not declare neither their employees nor their activities as R&D related. Especially smaller sized (below 100 employees) companies did not have the administrative capacities to cope with the requirements of declaration. Moreover, they feared a tax authority investigation, when a deduction of R&D expenditures from the tax base was realized. Similarly, foreign-owned

affiliates in Hungary, even when they carried out highly complicated software development and R&D did not declare that if there was no specific interest. Some even voiced their problems with the increased attention of tax authorities after declaring R&D and reducing the tax base with related costs. (Fekó, Sass, 2012)

The interviews conducted in the framework of the present research revealed a completely different picture, which is all the more reliable as there are companies which formed part both this and the previous sample. The situation is now different, containing two regulatory factors, which increase the inclination of companies to declare their R&D activities. First, from February 2012, R&D projects are evaluated by the Hungarian Intellectual Property Office, and the decision of the office is binding for the tax authority. This resulted in a more stable regulatory environment for the companies, and encouraged them to declare and increase existing R&D activities. Second, according to two interviewed managers (both in the electronics sector), when applying for certain EU-funds, having (declared) R&D activities is considered to be a requirement or at least a plus. One of these companies even previously declared R&D, but the other one started to do that only last year. These changes seems to be translated into a higher R&D/GDP ratio: while in 2008 this indicator was 1 %, it grew continuously reaching 1,2 % in 2011 .

On the other hand, there are still other factors, which point to a possible "underreporting". The majority of the interviewed companies declared that they use production engineers flexibly: even those not working in R&D units, spend a part of their working time (depending on the requirements of the actual projects) on R&D activities. One automotive and one electronics company indicated that the dividing line between the R&D unit and the group of production engineers is not so strict. Furthermore, when comparing internationally, another factor, which should be taken into account is the fact that the Hungarian practice completely differs from the Western European one in terms of what type of activities can be declared as R&D. In Hungary, a stricter definition is applied by the authorities in order to prevent the erosion of the tax base. One manager noted that in Germany basically all those development activities are declared by the companies as R&D, what they have to finance from their own sources, for which there is yet no customer. Contrary to that, in Hungary there is the requirement of "novelty" when reporting R&D, which is taken very seriously by the authorities. This difference can be connected to the differing fiscal situation and dissimilarities in the inclination to avoid taxes in the two countries. A third factor is related to another change in the regulatory environment: since 2012, companies cannot reduce their compulsory innovation contribution paid to the state with their R&D costs, which is again a disincentive for declaring R&D costs.

There is a separate dataset compiled by the CSO on the R&D expenditures of foreign affiliates operating in Hungary. This forms part of the so-called FATS (Foreign Affiliate Statistics), for which data provided by the Hungarian National Bank on companies in which the foreign ownership share exceeds 10 % are also used. (CSO, 2012) The dataset is assembled on the basis of a methodology by the Eurostat, thus it enables international comparisons. However, it may presumably have the same problems as other data collected by the CSO.

Results of the research

The analysis is based on company case studies, which were prepared on the basis of interviews with leading managers. First, the main characteristics of the sample will be presented, followed by the characteristics of R&D carried out in the analyzed companies. Then the locational advantages of Hungary, attracting this type of activity will be discussed, followed by the analysis of the impact of foreign R&D activities on the local economy.

The sample

According to the year of establishment of the company (Annex tables), two companies were established before 1990, nine in the nineties, and another nine in the 2000s. However, the establishment of the R&D units is not so dispersed in time, 15 R&D units started operation only after 2000. On average, there is a five year distance between the establishment of the company and the foundation of the R&D unit. If we take only production-related R&D units, then the time-lag

increases to 6.5 years on average. Company no. 2 is among those companies, which transferred substantial R&D to Hungary relatively early. Another frontrunner in the automotive sector is company no. 4.

In the sample, eight stand-alone R&D units were identified and there are 12 production-related R&D units. However, there are cases, when the unit supports not only local production, but it also carries out R&D tasks for the whole multinational company, bearing a global responsibility. There are at least three such cases, though if we include small R&D segments, the number is considerably higher. As it will be described in detail below, this may be one of the phases of the development of these units.

Concerning the main products and services, the companies in the sample reinforce the notion of the automotive and electronics industries being intertwined to a great extent, as there are electronics companies, which – at least partly – carry out R&D tasks, which are used in the automotive sector later (for example company no. 12). In the automotive sector, there are companies, which deal with the electronic parts of the car (for example company no. 6). There are many R&D units in both sectors, which, as part of their activity, develop software. As it was already mentioned, there are five companies in the sample, which provide specific services for either the automotive or the electronics sector, or both (companies no. 2, 5 and 11 for electronics, 10 for automotive and 16 for both).

As far as the number of product lines is concerned, all companies in the sample have a higher number of product lines; however, the overwhelming majority of their sales come from one activity for the majority of the sample. There are two holding companies with rather diversified company "portfolio", for which the distant R&D units were treated separately in spite of belonging to the same company group. (Companies no. 3 and 13 and companies no. 12 and 18.) The reason for that was not only the distant nature of the activities, but also the fact that these parts of the holding companies were acquired in different times and were merged into one holding at a later point in time obviously for business and manageability reasons.

As for their mode of entry, half of the companies in the sample was realized through a greenfield project, four are privatization-related acquisitions and another six non-privatization-related acquisitions. The latter distinction is justified in the case of a former transition economy, as privatization-related acquisitions may involve the buying of an existing R&D unit. However, this holds only for three companies in the sample (3, 12 and 18). As for the remaining one, the production unit was acquired and R&D activities came later to Hungary.

In terms of the number of employees, as far as the "whole" affiliate is concerned, there are mainly large-sized companies (13) in the sample, six are medium-sized and only one is small. As far as the size of the R&D units are concerned, there are only four large sized ones, all of them stand-alones. Seven fall in the medium-sized category, and there are nine small-sized ones, of which six are production-related (and one more was production-related, but now is more a stand-alone with some related production). Thus no specific size pattern is present and thus we cannot make a connection between the size of the affiliate and the presence of R&D activities.

According to the nationality of the main owner, it is interesting to note that in 13 of the 20 cases, the immediate and final owner are not the same. There are "intermediary" affiliates between the parent and the Hungarian subsidiary, in four cases a Dutch company, presumably for manageability and tax optimization reasons. Holding companies usually put in-between a Hungarian holding company. As far as the final owners are concerned, they are predominantly European, and inside that German. From outside Europe, there are three Asian and three US companies.

There are usually no separate data on the export and sales of the R&D centers, with the exception of certain "stand-alone" companies, as companies no. 2, 5, 10 and 11, but these are operating in the services sector, offering specified services to the automotive and electronics companies. However, even in the case of these four companies, the export/sales ratios are above 90 %, with the exception of company no. 2, where it is above 80 %. Data on the companies where R&D units are operating all reveal a high export/sales ratio, for 15 companies in the sample it is above 90 % and for 17 above 80 %. Moreover, they are characterized by a high share of intra-firm trade: for more than half of the

companies in the sample this ratio is more than 90 %. Intra-firm trade is low for one of the minority foreign-owned companies (no. 16), and for certain first-tier suppliers in the automotive sector (companies no. 6, 15 and 19).

Characteristics of R&D of automotive and electronics foreign affiliates in Hungary

One important result from the research is the dynamism of the process concerning the location of R&D activities to Hungary. This process is different for stand-alone and for production-related R&D units. For stand-alone, the companies in the sample are more heterogeneous. There are "real" stand-alones in the sample, where no production precedent is present (company no. 2). The companies operating in the services sector are understandably without a production precedent (companies no. 5, 10, 11, 16). In other cases, there is production precedent, but the stand-alone unit was established in a relatively distant location, thus it is completely separate from production. (Companies no. 4 or 17) There are quasi stand-alone companies, which after the company was acquired through privatization, gradually got rid of the majority of production activities and now concentrate on R&D (company no. 18, part of a holding company). There are companies, which became quasi stand-alone R&D units; because production was relocated to cheaper countries (company no. 15, to Ukraine) and now the Hungarian location concentrates on R&D with some related production still kept here. Here the evolution of the company resulted in this structure, which differs from all the others. Company no. 15 started out with outsourced production in Hungary, then it acquired its Hungarian partner and located production capacities to Hungary. Later on, production engineering tasks followed production to Hungary. As the next step, certain development activities were also located to Hungary. The reason was partly relocation, partly capacity extension because of increased demand for the products of the firm. The increased competition induced the firm to locate production to an even cheaper location, to Ukraine. At present, a relatively large R&D unit, production engineering unit and production connected to these activities remained in Hungary, with a 50 employee R&D unit, 100 people in the production engineering unit and 80 blue-collar employees in production. The developments in this affiliate seem to be logical for a firm, which is highly sensitive to production costs; however, we could not find another company in that category. In spite of that this latter case may illustrate the dynamism, which to some extent is present in the case of the production-related R&D units, which is more characteristic for companies producing their own brands than for suppliers or service manufacturers. Thus on the basis of the interviews we found that production-related R&D units start out with a narrow mandate, concentrating on sustaining, redesigning, improvements of existing products and processes. In many cases, as the parent company's trust grows gradually together with the successful accomplishment of these simpler tasks, later more and more complex tasks are allocated to the affiliate, which may result in attaining even global responsibilities in certain development areas. This may be the case for companies no. 8, 12, 13, 14, 15 or 20. For example in the case of company no. 12 it was indicated that while the number of engineers in the R&D unit is more or less constant, the share of those, who carries out development tasks is higher and higher. Global responsibility can be reached more quickly if production is located mainly or exclusively to Hungary. In the case of services companies, the interviews also indicated a growing responsibility and number of tasks and related employment in companies no. 3, 10 and 11.

As far as the locations of R&D activities are concerned, production-related units are understandably located to the production sites, while stand-alone units can usually be found in Budapest. Budapest stands out both in terms of the annual number of graduates in engineering, mathematics and sciences and as the economic and cultural center of the country. A few companies (no. 5, 16 and 18) have countryside plants in university towns, in which cases being close to consumers (no. 16) and to knowledge centers (universities, no. 5 and 18) were the main motivating factors.

Relocation in R&D can be very rare, we could find only traces in our sample, it is usually an expansion of R&D activities, which is realized through opening a new unit abroad, usually there is no downsizing or closing down a unit in the home country or in other locations in our sample parallel to opening or

extending one. This is in line with the findings presented in Hall (2010) or Hijzen, Swaim (2007), who found that expansion of the R&D activity abroad, has no employment effect in the home country. Two interviewed managers explicitly said that there were R&D tasks relocated to Hungary, but always new tasks were allocated to the home country unit, thus there was no staff loss there (companies no. 4 and 15). Relocation comes in the picture more in terms of production relocation, where later certain related R&D activities are also transferred to the new production site.

R&D units are usually separated organizationally from production activities. However, certain managers stated that the dividing line is not so strict between the units of production engineers and of development engineers. These units not only help each other and exist in a close cooperation, but in certain cases there is a possibility for engineers to do both R&D and production engineering tasks. This did not seem to be related to the size of the R&D unit or production. That was the case for example for companies no. 3, 7, 13, 14 and 15. For example, in the case of company no. 3, the number of engineers working on R&D tasks is 32, while in terms of the hours they work on it, it is 10.2.

The head of the R&D unit is usually part of top management in the case of stand-alone units, while in the case of R&D units connected to production this is usually not the case (though there were a few exceptions?). This can be explained partly by the larger average size of stand-alone R&D units and their greater importance inside the company network.

The R&D/sales and R&D-staff/total number of employees data are very diverse in the sample. One reason for that is that real “stand-alone” companies have a high ratio, while those, even large-sized R&D units, which are part of a larger organization, have a low ratio. That is also the case for almost all the production-related R&D units and those companies, which are part of a large holding publishing a consolidated balance sheet. The five service-providers, on the other hand, have higher ratios, because in their cases there is usually no related production. Thus these data are misleading when the R&D intensity of the companies are compared. On the other hand, the interviews revealed an increase between 2006 and 2011 in terms of R&D/sales and R&D-staff/all employees in all the interviewed companies, even in those cases, where there was a temporary decrease in the number of R&D employees during the crisis.

As far as the content of the R&D activity is concerned, the companies in the sample do very diverse activities from the point of view of complexity, even inside the two analyzed sectors. There are real global centers for a company, which carry out complex tasks and are responsible for a certain area for the whole multinational company. In certain cases, where production is carried out only in Hungary, certain R&D tasks, which require proximity to production, are done only here, as for example technical maintenance of products. On the other hand, especially in the case of certain production-related R&D units, there are many, which concentrate only on a very small segment of R&D, usually small process or technology development tasks. This is reflected usually in the size of the R&D unit, as in the case of companies no. 19, 7 or 6. However, there is no direct relationship between the size and the complexity of tasks, as the minority foreign-owned company no. 1 has a relatively small R&D unit, but at the same time it is a leading innovator in world comparison in its field. (However, the company relies on a wide network of university-related research centers all over the world, where it outsources R&D tasks.) Similarly, company no. 13 has a relatively small unit, which in its field came up with novelties in worldwide comparison. However, overall, usually the production-related development is further away from R&D, than activities carried out in a stand-alone unit. The content of R&D varies even in the case of the individual companies. For example, company no. 5 indicated that it is assigned full projects as well as smaller tasks, this latter is usually the case when there is probation of a new type of task or R&D area. In company no. 14, only a part of the activities is related to R&D.

As far as the distribution of tasks between the parent company and affiliates is concerned, it seems that real research tasks are usually kept at the parent company (for example companies no. 8, 14 or 15). Company no. 4 indicated that there are certain research tasks, which require proximity to production and are carried out in Hungary.

The level of responsibility varies also to a great extent. Interestingly enough, with the exception of four companies, all others in the sample have global responsibility in at least one area, even if it is a relatively small segment of R&D. This means that these are the leading centers inside the network of the multinational company for that area; new R&D activities in that area are assigned to the Hungarian R&D unit. In the case of production-related units, it is explained by the fact that certain tasks must be close to production and the Hungarian production unit is either the only one or is the largest one. On the other hand, responsibilities may depend on the type of work organization in the network of affiliates inside the multinational company. Delegating certain tasks may be more efficient if responsibilities connected to them are also delegated. This is the case usually when the affiliate already proved to be able to carry out R&D tasks efficiently.

In terms of their independence in deciding research and development directions, the most independent are the two minority foreign-owned units, which are basically independent Hungarian companies. Certain service providers (companies no. 2 and 11) are relatively independent. In the case of company no. 2, the R&D-unit is under the direct control of the parent company and this latter decides about the distribution of new projects, at the same time, it has a large maneuvering room when deciding about local cooperation with universities and companies and the use of local experience in global developments. The role of the parent company is very important in that case in organizing the research and putting the partial research output developed by the individual R&D units together, which underlines the role of fragmentation and the efficiency-seeking type of that investment. The relative independence is also true for stand-alones (4, 10, 11) and the quasi stand-alone R&D unit of company no. 15, partly because it is the only R&D unit outside the home country in Europe for a relatively small-sized multinational company. In these companies, the parent is usually open for ideas, innovations coming from the affiliate. It is also true that the level of independence varies by tasks or projects (company no. 11, 14 or 17). At the same time, production-related units have a low level of independence, with the exception of those, which have global (or European) responsibilities in certain areas, or which, due to good experience, could climb higher in the innovation ladder of their multinational company network, as for example company no. 8 or 12, the developments of which are used in other affiliates. Company no. 8, which is the only production unit, indicated that its parent is also open for ideas for development coming from the Hungarian affiliate. On the other hand, those companies which carry out R&D together with their buyers (e.g. companies no. 6 and 7) are dependent much more on the buyer than on their parents.

The role of the company in the hierarchy of the R&D units in the network of firms inside the multinational company was asked to be evaluated by the interviewed managers. Understandably, the two minority foreign-owned companies have the highest level in this hierarchy – as they themselves are the parent companies. As for the other 18 companies, according their own evaluation of their importance, four put them among the top centers inside their company network. Five others indicated that in at least one area they are the leading R&D centers. On the other hand, especially among the production-related units, there are at least three units evaluated to be at the bottom of the hierarchy.

In terms of the size of the R&D network of the multinational companies, there were only five small ones, where the number of R&D centers remained below five. Two of these are the minority foreign-owned companies, one is a service provider and two are production-related R&D units. In Europe, the number of R&D units is understandably lower, thus the relative position of the Hungarian R&D center is better in 9 cases. All the analyzed companies, except for the two minority foreign-owned ones, have a global reach and a global network of affiliates, including R&D centers, even in the case of the smallest ones (e.g. no. 15). Cooperation exists in all cases between the R&D units worldwide at least in terms of using best practices (e.g. company no. 7) or new developments (e.g. company no. 6) or providing support (company no. 9) and helping each other, except for the two minority foreign-owned companies. Many managers reported frequent personal visits or even longer-term stays at each other among the R&D units. On the other hand, not all companies distribute the various R&D projects among the affiliates in competition. This reflects the different organization of R&D activities in the multinational companies in the sample. In some of them, especially in the larger ones and the

service providers, the R&D units compete for the projects. There are even a few production-related units, where there is competition. For example, in the case of company no. 13, interestingly enough, there are many research areas in the multinational company, and there is a sum designated for certain areas and distributed each year for the R&D units operating in that area. In other cases, for example in the majority of the production-related R&D units, by the nature of the activity (serving the buyer) or by the nature of the distribution of activities, i.e. according to competences, knowledge and capacities, there is no competition. On the other hand, in the case of company no. 4, local knowledge and specialization are the most important factors in the allocation of projects, and lack of competition can be attributed to the lack of parallel capacities inside the R&D network of the multinational company. Similar method for the allocation of projects was reported by company no. 11.

Registration of patents is also less common in production-related units, which can be explained partly by the nature of their R&D activities. However, there are exceptions, for example company no. 19, which in spite of its small size and the nature of the activity (process development connected to a great extent to local production) registered a patent. This is also true for companies no. 13 or 24, while companies 6, 7, 8 and 9 did not register any patents. Here a distinctive factor may be the policy of the parent company. It is also important to note, that the registration of patents is realized in all relevant cases through the parent company, where a specialized department (or at least one specialized employee) deals with these issues. However, in the case of company no. 17, where the number of inventions at the Budapest affiliate is very high, there is an officer located there from the home country, who deals with the patenting issues at the affiliate. In the case of company no. 2, there is a local manager operating in Hungary with a coordinating role concerning patents. This may indicate a higher position of these affiliates in the affiliate hierarchy. In the case of companies no. 4 and 17, it was indicated that the share of the Hungarian affiliate is relatively high in the total number of patents registered by the parent company.

In the overwhelming majority of cases, the R&D output serves the local production in the affiliate, the parent company or other affiliates of the multinational company (17 cases), thus it is not sold to "independent" buyers. The exceptions are the service provider companies (2, 11 and 16). However, in certain cases the R&D output serves directly the buyer, when first-tier suppliers (for example company no. 6) or electronic manufacturing service providers (for example company no. 7) basically collaborate with the buyer in the process of development of the technology or product.

None of the companies acquired R&D results in the form of patents or know-how from other companies. Outsourcing of R&D-related activities is slightly more frequent (14 cases), but none of the companies deem it significant, except for the minority foreign-owned ones. For example, for company no. 18 outsourcing acts as a kind of buffer: it does not have to sack and then reemploy staff when capacity utilization fluctuates. Outsourcing is more occasional in the sample than continuous, with the exception of two service providers (companies 5 and 16), who have strong links and cooperation with a few local SMEs. As an example of occasional outsourcing, for company no. 9 prototypes are done locally. The partners are usually universities and local SMEs, and the activities are testing and development of specific software. Moreover, companies no. 4 and 11 indicated that they outsource to local universities certain tasks with a relatively large value annually.

Trainings for the R&D personnel (and for other workers) are continuous in all the companies in the sample. Besides scientific trainings, there are others (e.g. personal development, language). In the larger companies, the trainings are internally available (through the intranet), and they use outside courses to a limited extent. There are many companies, which use trainings offered by local SMEs (companies 5, 10, 13, 19) or universities (company 16).

Workshops, seminars and conferences are usually attended by the R&D staff (15 companies), there are even own internal workshops (closed for outsiders) organized for example in companies 8 or 16. Company no. 1 and 20 organize even high-level international scientific conferences in the fields they operate (no. 1) or in which they have a global competence (no. 20).

Fairs are attended by the R&D staff from the majority of companies (13), for companies no. 4 and 8 fairs are considered to be an important source of information concerning innovation trends and novelties. Publishing articles in scientific journals are especially important in the case of those companies, which have a very close cooperation with universities. For example in the case of companies no. 4, 5, 12, 17 and 20, leading managers have jobs at universities as well. (In the case of company no. 4 for example the number of such colleagues is as high as 8.) 11 companies indicated that there are colleagues in the R&D staff who published articles. In the majority of cases this is connected to cooperation with universities (for example companies no. 4, 11 or 12). Company no. 1 established its own scientific journal.

In terms of cooperation, 12 companies have close cooperation with universities, and one of them is in the process of establishing such cooperation. During the interviews it has been obvious, that there is cooperation with universities with real content, when the company uses the results of the common projects or uses services offered by the universities. In other instances, the main aim of the cooperation from the point of view of the company is to secure the "supply" of appropriately trained specialists for themselves. We discuss that in more detail in the section dealing with the local impact of R&D units.

In terms of membership in various innovation associations, only seven companies (or their managers) were actively involved in these. Three interviewed managers were among the leaders of these associations, or of the innovation committees of associations. There were five companies, which were members of a cluster. Four of them were highly critical about the functioning of this type of organizations in Hungary.

Locational advantages

Overall, the list of location advantages is relatively short. During the interviews, no instructions or a list of possible factors were given to the interviewed managers. In spite of that, the answers were relatively unanimous. There were eight factors, mentioned at least by two managers. These are the following: previous production (10), knowledge base (9) and costs, especially those of skilled labor (9), the level of education (8), previous personal contacts (3) and availability of skilled engineers (3), previous experience (2) and buyers' requirements (2). In our sample, contrary to the findings of the literature presented in the second chapter, cost considerations are as frequently mentioned as the knowledge factor. The importance of the level of local education however, further strengthens the importance of the local knowledge base. The set of factors differs for the production-related and stand-alone R&D units. Understandably, for all production-related units, the presence of relevant production is the most important locational factor. There is one exception: company no. 12, which was privatized to the foreign owner, for whom the knowledge base accumulated in the R&D of the company, was one of the important attracting factors. For stand-alone units the most important locational factor is usually the knowledge base, except for three cases, where there was previous production and originally the R&D unit was either planned or actually established to support local production, but later either production was relocated or there was a considerable change in the original plans. While costs were mentioned by half of the respondents (the two minority foreign-owned companies are left out of consideration here), it must be noted that in none of the cases was that mentioned on the first place. It was in most of the cases the second most important factor. As one manager put it (company no. 20), in R&D cost is of secondary importance, the trust and reliability factor is much more important. Another manager said (company no. 16) that costs are important, but only if the quality of work is good. At least in the case of two companies, previous professional ties and "strong personalities" were playing an important role in locating R&D activities to Hungary. In the case of companies no. 2 and 4, previous personal ties, in the case of company no. 10, previous good experience in working with the Hungarian company played a role in one of the acquisitions or in setting up a new company. While it was not mentioned explicitly, the home country composition of R&D units shows the importance of geographical closeness (European and inside that, German dominance), which involves also cultural and language proximity. In the case of certain production-related units, buyers' requirements shape the evolution of the R&D activities to a great extent. First, having an R&D unit is a competitive advantage when competing for projects. Second,

R&D activities cover those areas, where the buyer does not have its own capacities. Among home-country push factors, lack of engineers (company no. 4) and lack of informaticiens (company no. 5) were mentioned.

It can be seen that locational advantages are related to the type of the R&D center: stand-alones and production-related units differ in their activities and in the attracting factors as well. However, it is important to note that quality aspects (knowledge) are very important for both, more important than cost advantages. Cost advantages are usually assessed in the light of quality aspects. According to the representative of company no. 14, costs are important, but quality is even more important.

The interviewed managers were also asked about the problems and barriers to the further attraction of FDI in R&D and for their operations and cooperation in Hungary. As for the operation, the overall opinion was that the business environment, especially the taxes (profit and personal) are favorable for an export-oriented company. Criticism was formed mainly on the instability of the regulatory system, the sudden, unexpected changes in regulations, taxes etc. even during the tax year. As for the further attraction of FDI in R&D activities, according to one manager, a certain "saturation-level" was already reached (company no. 4), especially due to the bottleneck caused by the quality and quantity of fresh graduate engineers. However, others were more of the opinion that there is still room for other R&D investments. On the other hand, many company managers complained about the declining level of education in engineering and the lack of language knowledge. According to the representative of a Scandinavian affiliate, while the knowledge of engineers is very good in specific areas, they usually have neither an overall picture, broader thinking nor a market-oriented mentality. Moreover, it is impossible to find technical or engineering assistants with language knowledge. A further problem mentioned was the low mobility of engineers in Hungary (company no. 6 had to set up its laboratory in a larger town instead of the originally planned site close to production and in the case of company no. 20, a few engineers left the firm because of personal reasons: their family did not follow them to the countryside town, thus they commuted or were away from their families during the week). One company complained about the lack of availability of certain services (e.g. testing) and infrastructure for R&D (company no. 15), which thus has to be carried out in Germany. This complaint is reinforced by the fact that company no. 20, in cooperation with the local university and its town, built a laboratory for testing. Cooperation is moreover hindered by the relatively high related administrative burden (company no. 15) and by the relative slowness of universities (companies no. 12 and 15).

Another important difference could be traced between the opinions of the US and German owned companies. For the US investors, Hungary and its region does not seem to be on the map of FDI and R&D, while representatives of the German affiliates thought that further R&D investments could be expected.

Impact on the local economy

There are various channels through which the foreign-owned R&D units can impact upon the local economy. However, the relative importance of these varies to a great extent. The most important one can be to add to the existing level of R&D activities, which is of great importance in Hungary, where in these two sectors, foreign-owned affiliates are responsible for almost all the R&D activities. Connected to that, the R&D units increase considerably the demand for skilled engineers. In that respect, they may have a crowding-out effect, as local companies are unable to pay as high wages as the foreign-owned ones. However, the demand from local companies for such employees is rather limited. According to Edler and Polt (2008) maximization of benefits for the host country is attained, when affiliates bring in foreign technology, their inputs are in majority acquired in the host country and the level of their independence is high.

Backward and forward linkages are either non-existent or very limited in the majority of cases. Even if there are backward local linkages, they exist mainly connected to the production activities. In these cases, there are even efforts made by the company itself to recruit more local suppliers through various supplier programs (8 companies). However, the lack of ability and capacity of local, Hungarian-owned suppliers to supply components or complex products is a main hindering factor.

On the other hand, certain activities (mainly in the electronics sector, mentioned by companies 7 or 8) have a lower supplier-intensity. Company no. 2 for example recently introduced a program in the framework of which it provides "coaching-type" support for small companies, on the basis of which later it may recruit local suppliers. (At present it has none of them.) The exceptions are companies no. 5 and 16, which are dedicated service companies and have strong ties with local SMEs even in R&D. Company no. 5 for example has close supplier contacts with three Hungarian SMEs in R&D. Company no. 16 has five or six such partners and considers itself a kind of integrator company. Among the manufacturing R&D units, companies 12, 13 and 18 have local suppliers even in R&D, though to a limited extent. As it was explicitly mentioned in the case of companies no. 4, 9 and 12, the relatively high share of local suppliers is a result of a dedicated supplier program, carried out either by the affiliate itself or in cooperation with the Hungarian Trade and Development Agency.

On the other hand, it is important to note that almost all companies in the sample have contacts with universities (15 out of 20) and an additional one is in the process of establishing these contacts (no. 19). Moreover, company no. 15 has plans to form such contacts. Four companies in the sample cooperate with research institutes. However, as it was already noted, the content of the cooperation with universities varies to a great extent. In a few cases the aim of the cooperation is to secure the supply of graduates to the company (usually through trainees/apprentices programs). For example, company no. 5 noted that. Moreover, "influencing" the content of university education may also be important (company no. 11, and especially no. 17), even through establishing a dual education system (companies no. 4 or 14). In other cases, the university provides various courses for the company (for example company no. 14). The content of cooperation may be only providing the university with various supplies, e.g. software in the case of company no. 3. On the other hand, there is closer cooperation, with the aim of applying for funds, usually for research activities. Furthermore, another type of cooperation is when the company conducts research and/or development activities together with the university. For example, company no. 2 has strong ties with universities: it finances the research laboratories and infrastructure and assigns various research topics to the universities. In a few cases, there is even outsourcing of certain activities to university departments. Company no. 7 has common development projects with more universities, the results of which are later used in production. The cooperation is in at least four cases (companies 1, 4, 5, 17, 20) established, reinforced and kept going through a personality, who works for both the university and is a top manager at the R&D unit. Dachs et al. (2008) differentiate between three types of embeddedness on the basis of the partner in cooperation. Domestic horizontal embeddedness is the case when the affiliate cooperates mainly with competitors, while in the case of domestic vertical embeddedness, the cooperation partners are suppliers and clients, and embeddedness in the domestic science system means cooperation with universities and research centers. They are not mutually exclusive, and also an affiliate strongly embedded into the intra-company network may have strong links to other domestic economic and non-economic actors. In our sample, the type of the embeddedness is overwhelmingly in the domestic science system. We could find one case of close cooperation with a competitor company (company no. 2), and in at least two cases (companies 6 and 7) close cooperation in R&D with the buyer.

As far as the forward linkages are concerned, as for production, all the companies are highly export-oriented. There are a few exceptions, which have relatively substantial local sales, as for example companies no. 2, 3, 10, 11, 13, 16 and 18. In some cases this concerns mainly local sales to related (e.g. having the same owner) companies, as for example in the case of company no. 3. In other cases this is realized through the parent company, thus it is recorded as exports and then imports, as for example in the case of company no. 10. However, for their R&D, as we could see, in none of the cases do they sell the results of their R&D activities locally. In the overwhelming majority of the cases, these results are used by the affiliate itself or by the multinational company or its other affiliates. They hardly sell the results of their R&D activities embodied even in the local adaptation of their products, as we could find no cases of R&D with the aim of local adaptation, i.e. for adaptation to the Hungarian market.

At least eight of the 20 companies in the sample are active members of local associations, such as AMCHAM, Hungarian chamber of commerce, other bilateral chambers of commerce, sectoral associations. For the companies, these associations provide an informal forum for exchanging ideas, discussing experiences, making themselves more visible for other companies etc. Some of the companies indicated, that their main aim for participating in these associations is to find business partners. Moreover, through these associations, they can express their views about the business environment; exercise some pressure for changing certain detrimental (for them) elements of it. This may be one channel for impacting upon the local economy. As another channel, this type of associations may bring benefits to domestic companies, because they provide a forum where domestic and foreign managers may meet and pass on to each other information and knowledge. (See e.g. Dunning, 1993, p. 470). Trying to find traces of this has been outside the scope of this study.

The role of the existing stock of FDI in attracting further investments is obvious. However, there were only two companies in the sample, which could state with certainty, that there were many partner companies in the home country which followed them to Hungary. The role of this type of impact could not be established specifically for R&D units, but we may suspect that it can be minor in these cases.

The importance of the mobility of skilled personnel within the multinational company was analyzed by Inzelt (2008) in the case of Hungary. In our sample, we found this effect limited in the case of the R&D units. The share of foreign employees permanently staying in Hungary is usually very low. It is more common that employees are "exchanged" for a longer period of time or Hungarian employees take part in foreign trainings, or that there are shorter (a few days or 1-2 weeks) visits to each other among the affiliates and the parent. On the other hand, we could find stronger foreign presence in certain companies at the higher managerial level (head of R&D unit or director). For example, the head of research is of foreign nationality in companies no. 9, 17 and 20. Moreover, in those production-related units, where the main reason for setting up an R&D unit is to serve buyers, there is usually a relatively large presence of engineers and experts arriving from buyers (companies no. 6 and 7).

The mobility of skilled workers is one of the most important channels of local spillovers. As we saw, all interviewed companies offer various trainings to their recruited employees. All of them offer a set of courses, which contain not only "professional", but also language and self-development courses. In that respect, affiliates in the sector seem to deviate from other affiliates, because according to Dunning (1993, p. 372), trainings organized by foreign- owned affiliates are usually narrowly focused on the actual needs of the activity, which the employee carries out. Company no. 20 for example provides one-to-three year training in the home country for engineers recruited in its R&D unit. Some of these highly trained employees may either go to work to local companies, or set up their own companies or go to work to another local affiliate in the sector, partly due to the arising shortage of relevantly trained employees. Thus they could take the knowledge acquired at the R&D unit with them to their new workplaces, thus impacting upon the local economy. What we could find on the basis of the company survey was that there are a very few cases of such employees going to work to a Hungarian-owned company. First of all, all the companies have a relatively low attrition rate. Second, the main direction of the mobility of the skilled employees is another foreign-owned company in Hungary. There were two companies, where employees left for universities, and three managers mentioned that there were cases when employees left for a Hungarian-owned company. There were also cases when employees left for the R&D center of the parent company (for example company no. 8). Moreover, setting up own company based on the knowledge and contacts acquired when working for an R&D unit is also rare: there were two cases mentioned by the interviewed representatives, and one company may have indirect link to university spin-offs.

The local impact of these companies depends also on the extent of their geographical spread in Hungary. We could see that they are either concentrated to Budapest or the production-related units are close to the plants, thus mirroring the FDI-map of Hungary, with "heavyweights" in the Western and North-Eastern parts of the country. As far as their contacts and countryside plants are concerned, the geographical coverage is extended to certain countryside university towns, such as

Debrecen, Győr, Kecskemét, Miskolc, Szeged, Veszprém. Thus their regional impact is wider than in the case of business services investments (UNCTAD, 2004, p. 169), and their contacts are stronger with the countryside. For example, the services company no. 5, besides Budapest, has two countryside plants in Miskolc and Szeged, both large university towns, Miskolc close to various industries, but Szeged located in a relatively backward area with minor industrial activities. Company no. 6, a production-related R&D unit has a test-laboratory in Győr and the development department is transferred to the production unit. Company no. 12 has a Budapest R&D center and production-related units in four countryside towns, mainly in less developed regions of the country.

While there can be more areas where they impact upon the local economy, one more aspect should be emphasized. All these companies operate fully in the white economy and pay a large amount of taxes (even if they received a tax holiday for a longer period of time as an investment incentive). The tax content is especially important in the case of employees, where the higher than average salaries are fully paid and taxed here.

The odd ones out: minority foreign owned companies in the sample

The two minority foreign-owned companies have a professional-financial (Company no. 1) and a financial (Company no. 16) foreign investor. Considering the final and not the immediate investor, it turns out that Company no. 16 is in reality a completely Hungarian-controlled firm. The two companies, in spite of their similarities in terms of ownership structure (minority foreign-owned), size (small), high export/sales ratio (100 % and 90 %, respectively), strong links to universities and innovative nature (a high R&D expenditures/sales ratio), applied a completely different strategy. Company no. 1 can be perceived as a spin-off company, its activity is centered around an invention, which is novel in worldwide comparison, a medical precision instrument. It is a born global company, which was established in 1988 and internationalized almost immediately - partly by various home-country sales problems, in spite of its strong embeddedness into the Hungarian innovation system - through reaching a very high export/sales ratio (100 %) in three years after its foundation and investing abroad already in 1990, in Germany. An affiliate was established there, mainly with the aim of providing marketing services to the parent firm and to help trading its products abroad. The director is the same person for both the Hungarian parent and the German affiliate. Until 2009, it had a minority German owner, a venture capital firm, which it changed in 2011 to an Asian one, first because of problems with the financial owner, and second, because it made successful conquers of the markets in various Asian countries. It is worth mentioning, that this company does not register R&D activities fully, mainly because the administrative burden is too large for such a small company. On the other hand, due to a bad experience, the company is among those with the highest number of registered patents (26+6) in the sample.

Company no. 16, on the other hand, became an independent company only in 2011. Its holding firm had a close contact with a foreign affiliate operating in Hungary since the beginning of the nineties for a longer period of time, which meant a fixed market for the firm. It provides various electronics and automotive services to it, including R&D. This close relationship gave the opportunity to the Hungarian company to conquer new markets, including foreign ones. The highly successful R&D unit then was separated in an independent company, though it is still part of the holding structure. Company no. 16 is active in three main business lines: embedded systems, mobile applications and dedicated software development, all provided for business partners (not for consumers). It grows dynamically; it has an outside Budapest unit as well in a Hungarian countryside university town. It is active abroad as well: it has affiliates in Germany, Romania and Turkey and representative offices in many cities, where it has projects. The overwhelming majority of its activity is R&D (according to the CEO, around 45 % research and 45 % development, the remaining 10 % are maintenance services connected to previous projects), it develops mathematical models and software for various uses. It is obvious that the highly innovative Hungarian controlled firms need the foreign minority owner in the case of the first company to provide financial stability and to help its market access in Asia, while in the case of the second company, presumably improving the image and increasing trust of (potential) foreign buyers can play a role.

In the literature there is one related interesting result in Kokko and Kravtsova (2008). In their regression analysis based on Slovenian, Polish, Hungarian and Estonian firm-level data, they found that among the determinants of innovative capacity in terms of both product and process innovation, one of the two significant firm-level determinants is foreign minority ownership. This is connected to higher innovative capability. Our two cases point to one possible explanation to these interesting results: highly innovative and competitive domestic companies "use" minority foreign ownership for strategic reasons.

Conclusion

Hungary became host to automotive and electronics R&D units of foreign, mainly European multinational companies especially after 2000. R&D activities in these sectors are clearly dominated by foreign-owned companies, and even in services, R&D units serving mainly the automotive and electronics sectors are widely present. The present paper relies on interviews with leading managers of companies in the automotive and electronics sector with an R&D unit in operation in Hungary. 20 company interviews were conducted and given the relatively low number of such centers in Hungary, it could cover around one-fifth of such companies.

The large diversity of the R&D activities carried out by these units is shown. We distinguished two types of R&D units: stand-alone R&D centers and production-related units, and showed how the various factors shape their evolution. As far as the motivation of multinationals in investing R&D activities is concerned, local adaptation-type (home-base exploiting or market-seeking) activities are not present: we could not find cases when the main task of the unit would be local adaptation to the host market. However, adaptations to the larger market (mainly European) by outside European companies can be found. On the other hand, the asset-augmenting or knowledge-seeking motive seems to be more relevant in the case of Hungary, especially in the case of the stand-alone centers. Similarly to the findings of the literature, the efficiency-seeking motive is of secondary importance, it can be evaluated only in connection with the quality of activities. In the case of production-related units, proximity to production is the main motivating factor, however, there is a room for developing from there to a stand-alone unit, for which we could find cases in our sample. Overall, it seems important to build the trust between the parent company and the affiliate through carrying out various R&D tasks and projects successfully and then the affiliate in most of the cases is able to climb higher on the innovation ladder.

The most important locational advantages are connected to the motivations of companies: factors characterizing the knowledge base and education, in the case of production-related units, previous production are the most important. As a second factor, costs, especially those of skilled labor are also important. The local impact of this type of projects is limited, they have little local linkages. Even in the cases where the production unit is more embedded in the local economy, the R&D unit itself has less numerous local relations, except for the high inclination of the R&D units to cooperate with local universities though with varying content. Through this inclination to cooperation, the majority of these units become relatively closely embedded into the local innovation system..

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Annex

Annex Table 1 Characteristics of the interviewed companies

No.	Date of interview	Sector	Size	No. of R&D employees	Location	Foreign share (%)	Nationality of immediate/ final foreign owner	Type of R&D unit
1	04.12.2012	E	S	12	Central Hungary	6	Asian/ Asian (previously German)	connected to production, not separate unit
2	13.12.2012	E (S+)	L	1150	Budapest	100	Swedish/ Swedish	"stand-alone", one separate unit of three
3	14.12.2012	E	L	32 (10.2)	Budapest	100	Austrian/ German	connected to production, separate unit (part of a holding)
4	04.01.2013	A	M	140	Budapest (plus production-related units in Northern Great Plain)	100	German/ German	"stand-alone", data available together with the production unit
5	07.01.2013	E (S+)	L	400	Budapest, (plus units in North Hungary and Southern Great Plain)	92.5	German/ German	"stand-alone" (S)
6	08.01.2013	A	L	30	Western Transdanubia (3 units, one R&D)	99.4	Cypriot/ Asian	connected to production, separate unit
7	09.01.2013	E	L	40	Western Transdanubia (3 units, one with R&D) and Northern Great Plain (1 prod. unit)	99.99	Austrian/ Asian	connected to production, separate unit
8	09.01.2013	E	L	70	Northern Great Plain	100	Dutch/ US	connected to production, separate unit (+)
9	11.01.2013	E	L	60	Central	100	Swiss/	connected to

					Transdanubia (3 units, 1 R&D)		Danish	production, no separate unit (+)
10	14.01.2013	A (S+)	M	125	Budapest	100	Austrian/ Austrian	“stand-alone” (but S)
11	15.01.2013	E (S+)	L	1000	Budapest	100	Dutch/ (European)	“stand-alone” (but S)
12	16.01.2013	E	L	200	Budapest and Northern Great Plain (2 units), Western Transdanubia (2 units)	100	Hungarian/ US	connected to production, separate unit (+) (part of a holding)
13	18.01.2013	E	M	13	Budapest	100	Hungarian/ German	connected to production, separate unit (part of a holding)
14	23.01.2013	A	L	39	Western Transdanubia	100	German/ German	connected to production, separate unit
15	24.01.2013	A	M	50	Central Hungary	100	German/ German	“stand-alone” with connected production
16	31.01.2013	A,E (S)	S	30	Budapest and Northern Great Plain (R&D units)	3	Austrian/ Hungarian	“stand-alone” (holding)
17	31.01.2013	A	L	856	Budapest (prod. units in Northern Hungary)	100	Dutch/ German	“stand-alone”
18	13.02.2013	E	L	225	Central Hungary and Southern Great Plain	100	Hungarian/US	“stand-alone” (part of a holding), with some related production
19	15.02.2013	A	L	5	Northern Great Plain	100	Dutch/ French	connected to production, separate laboratory
20	18.02.2013	A	L	170	Western Transdanubia	100	German/German	connected to production, separate unit

Source: author’s compilation

Annex Table 2 Characteristics of the interviewed companies

No.	Entry mode	Year of establishment in Hungary	Year of est. of R&D	Interviewed manager	Export/sales (%, 2011)	Intra-firm export in % of total export (2011)	R&D/sales (2011, %)	R&D staff/all employees (2011, %)
1	A (G)	1986	1986	Owner	100%	n.a. (high)	n.d.	48%
2	G	1990	1991 (1996)	Vice President	80,84%	91,97%	23.8%	73.7 % (whole company)
3	A (P)	1990 (1994)	(1992)	CEO	24,67% (2012)	63,6%	n.d.	n.d.
4	A (P, R&D:G)	1989	1994	Director Advanced Engineering, Location Leader	96,7%	n.d. (estim.: 73,3%)	9.7%	17.4%
5	G	1994	1994	CTO	99,4%	99,7%	32 %	basically 100 %
6	A(G)	2009 (1993)	2009 (2006)	General Manager	93,0 %	2,1 % (2012)	n.d.	2%
7	G	1994	2008	CEO	98,2%	n.d. (low)	0.05%	0.8% (full time only)
8	G	2002	2004	General Manager	99,7%	~100 %	16.7 %	6.5 %
9	G	1999	2007	R&D Manager	96,4%	~100%	0 (2012-)	0.03%
10	A	2001	2001	Managing Director	100%	100%	~80%	~100%
11	G	2006	2006	Country director and Manager R&D Business Relations	90,9%	100%	52.3%	more than 50%
12	A (P)	2008 (1990)	2008 (1990)	Innovation Manager	98%*	97%*	0.14%*	3.6%*
13	A	1998	2000 (separate unit since 2006)	R&D and Engineering manager	88,1%	n.d. (low)	~1.5 %	2.9%
14	G	1996	2001	Manager, Product	92,7%	100%	~0.1%	~2%

				Development				
15	A	1998	2001	Director of Engineering	92,0%	6,5%	~2%	22%
16	G	2001	2001	executive director	62,8% (~90%, 2012)	n.d. (low)	~90%	~100%
17	G	2000 (1991)	2000	director of one of the R&D units	56,3%	87,7%	~6%	~90%
18	A (P)	2008 (2000)	2008 (2000)	chief technology officer	98%*	97%*	0.14%*	3.6%*
19	A (G)	2011 (1992)	2011 (2006)	HR-manager	99,6 %	40,8%	0.3%	0.01%
20	G	1994	2001	Head of Engine Development	99,6%	~100%	2.5%	4.1%

Source: author's compilation, * data refer to the total holding

Note: entry mode: A – acquisition, G-greenfield; A(P): acquisition connected to privatisation, A(G): acquisition of a former greenfield investment

Annex Table 3 Characteristics of R&D

No.	Level of independence of the R&D unit	R&D content	Global competence?	Patents	Selling R&D results outside the company network	Out-sourcing R&D	Role in the hierarchy of R&D units inside the company network
1	H	medical precision instruments; research and development	yes	altogether 26	no	yes, substantial (tests and experiments, 7 universities in Hungary and 7 abroad and 1	centre

						Hungarian and more foreign hospitals)	
2	M	telecommunications research, software and hardware	yes, in certain areas	around 35-40 annually	yes	yes (universities, affiliates, SMEs)	second in Europe, third in the world
3	L		no				
4	M	electronic systems	yes, in certain areas	yes, more than 1 annually	no	yes, universities	largest size, widest development area, among the top ones
5	L	software and some hardware	in one area	yes, through the parent	no	yes, 2-3 medium-sized Hungarian companies	in one area the only R&D centre, second
6	L-M	development, testing and preparation of measuring devices, serial product validation	when the product to be produced elsewhere is developed here in cooperation with the buyer	no	no	no	European design centre
7	L	production and process development, testing	no	no	no (to buyers incorporated in the product)	yes, from Germany	low, responsibility for local production
8	L-M	development of a test centre, development of new products, redesign	in certain areas	no	no	no	in size: bottom third, but the only one close to production
9	L	production and product development	for certain products	no	no (incorporate in the	Hungarian universities, one foreign-	up and coming, still in the phase of building up the

					product)	owned company	development site
10	M	design, development, durability testing, simulation calculations, software development and engine electronics	in a few areas	1-2 annually	no (to parent)	no	most important in the CEE region, widest competence
11	M-H	telecommunications network related research and development	in a large number of areas	yes, through the parent	yes	yes, software development from SMEs	among the largest ones, but not from the leading centres, for certain products the whole development process here
12	M	three different areas, traditional, new products, adaptation to the European market, related software	in certain areas	yes, through the parent	no (rarely through the parent)	yes, Hungarian universities, a few Hungarian SMEs	1/3 of global R&D staff here, leader in the EMEA region and in its field
13	M	development of new products and technologies	in one area	yes, through the parent	no	yes, software to Hungarian SMEs	the top in one area worldwide
14	L-M	product development, application development, process technology development, system development, testing, prototyping	no	yes, 2010:5, 2011-12:0, 2013: 1-2, through the parent	no	yes, rarely, to Hungarian SMEs (e.g. designing tools)	development distributed according to the size of production, because the Hungarian affiliate represents 20-30 % of sales, relatively important R&D allocated here, but not at the top in the company
15	M-H	product and process development	in three areas	altogether 2	no	occasionally, mainly software and testing	according to size and turnover: top 1, according to the complexity of tasks, 2nd
16	H	embedded systems, mobile computing, dedicated software development	yes	a few in Hungary,	yes	continuously to 5-6 Hungarian SMEs	centre

				protection in Europe			
17	M-H	automotive electronics, car multimedia, gasoline systems, chassis systems and electrical drivers	in certain areas European	60-70 in 3-4 years	no	no	among the largest in size, second-ranked
18	L	image processing software	yes	19 in 2011	no	from 2 local SMEs	up and coming, improving innovation performance, quickly growing in size
19	L	process and technology development	no	1	no (incorporate in the product supplied to buyer)	no	at low level
20	M	product and process development, numerical simulations, virtual analysis, problem solving, testing	in 2-3 areas	yes	no	yes (university)	maybe the first outside the home country

Source: author's compilation

Annex Table 4 Locational advantages for attracting R&D

No.	Number of R&D centres worldwide	Number of R&D centres in Europe	Competition between R&D units	Cooperation between R&D units	Locational advantage 1	Locational advantage 2	Locational advantage3
1	1	1	not relevant	not relevant	not relevant	not relevant	not relevant
2	n.d.	n.d.	yes	yes	personal contacts	level of education (mathematics, science)	availability of skilled engineers
3	numerous	numerous	yes	yes			
4	18	7	no	yes	production site in Hungary	personal contacts, university	availability of skilled engineers
5	2	2	no	yes	good	labour	

					education in relevant fields	costs	
6	6	3	no	yes	relevant production	accumulated knowledge	financial aspects
7	one central innovation centre, production facilities in more than 30 countries, the majority of them with small R&D unit	production facilities in more than 15 countries, the majority of them with small R&D unit	no	limited (with buyers)	proximity to production	closeness to buyers (buyers' requirement)	
8	numerous (at least 7)	at least 3	no	yes	proximity to production	cost advantage (mainly labour cost)	
9	80 companies in 55 countries, numerous R&D centres	n.d.	no	yes	production site	salary level	knowledge in specific areas
10	around 10-15	around 6-10	yes	yes	knowledge	labour costs	common experience/personal link
11	5 leading and numerous smaller	3 leading and numerous smaller	yes	yes	knowledge base	tertiary education of engineers	
12	3 large in the area	1	yes	yes	knowledge base		
13	8 (connected to production-related engineerin	3 (similarly to previous)	yes	yes	knowledge base	previous experience and licensing	

	g)						
14	16	2	no	yes	production site, proximity to production	labour costs relative to the quality of work	
15	4	2	limited	yes	proximity to production (originally)	cost advantages (labour cost	good quality work
16	4	4	no	no	strategic reasons		
17	numerous	numerous	yes	yes	originally close to production site	cost advantages (skilled labour)	knowledge base, cultural proximity, common language, time zone
18	n.d.	n.d.	yes	yes	local knowledge base, education system	local universities , institutes open for collaboration	local high tech production, previous local presence of the company
19	38 R&D centres	more than 20	no	yes	local production	buyers' requirement	
20	17	?	no	yes	local production	well-trained engineers and strong university contacts	cost-benefit (less and less important)

Source: author's compilation

Annex Table 5 Impact on the local economy

No.	Backward linkages	Forward linkages	Cooperation partners in R&D	Local associations	Followers	Skilled personnel from abroad	Mobility of skilled personnel	Helping suppliers
1	limited	no	universities in Hungary and	no	no	no	no	yes

			abroad					
2	no	yes	universities and other firms in Hungary	yes, very active	no	0.6% at present, always at such level	low attrition, mainly to other multinationals in Hungary	no suppliers yet, various programs ("coaching") in place
3	yes, limited, for production	yes	university in Hungary	yes, very active	yes, limited	no	to universities	yes, global value sourcing program
4	yes, substantial, around 30% Hungarian companies, for production	yes, limited, to MNC affiliates in Hungary	three Hungarian universities, one research institute	yes, active	yes, substantial	2% at present, usually at that level	to Germany, to other Hungarian companies (also SMEs), one successful "spin-off"	yes, continuous, managerial type of help, specific supplier program
5	yes, important (SMEs)	limited	universities in Hungary, SMEs	no	no	no	low attrition, mainly to other multinationals in Hungary	yes, especially those with which they already have a business link
6	yes, limited for production	limited	universities, R&D institutes, buyers	only one local	no	very low (3 at present), mainly from the buyers	n..d.	yes, continuous
7	yes, limited (mainly services and some components for production, about 5% SMEs)	very limited	universities, buyers	very active in one association	one	5%, mainly from buyers	no	yes, specific program
8	yes, limited for production	very limited	two Hungarian universitie	yes, very active in various	one	no	3 to the US R&D centre	no

			s	associations (including innovation assoc.)				
9	yes, substantial for production, including Hungarian companies	very limited	two Hungarian universities	one association, not important	no	no, only the head of R&D	no	yes, various programs
10	yes, limited (a few SMEs)	yes, through the parent	no	two associations, not important	no	less than 10 %	15-20 people, to R&D units in foreign- and Hungarian-owned companies	no
11	yes, limited, a few Hungarian university spin-offs and foreign affiliates in Hungary	yes	9 Hungarian and 4 foreign universities	yes, active in two innovation-related associations	no	around 10 %, for 1-2 years	no	no
12	yes, relatively important for R&D as well, including Hungarian SMEs	limited	Hungarian universities	yes, in one active	no	below 10 %	no	yes, substantial programs
13	yes, local SMEs mainly in services	yes	no	no	no	"exchange" of engineers between affiliates, 1-2 per year	no	no
14	yes, for production, though low	no	one Hungarian university	only one	no	"exchange" of engineers, for a few weeks	a few left, for abroad	specific program in place
15	limited (packaging,	no	no	no	(one)	1 at the beginning,	a few, usually	no

	services)					now no	to other affiliates of MNCs in Hungary	
16	yes, first-tier and second tier Hungarian SMEs for R&D as well	yes	many Hungarian universities	no	not relevant	no	low attrition, one quasi-spin-off (the area no longer kept)	yes, very intensive cooperation with first-tier
17	limited for both production and R&D	no	universities, research institute. academy of sciences	in many, active	presumably yes	below 5 %, higher at the managerial level (50%)	low attrition, to other R&D a few	no
18	yes, for production and R&D as well	yes (market leader)	universities, Hungarian SMEs	in one very active	no	below 5%, previously managers were sent here from the centre, now no	very low attrition, a few, to Hungarian SMEs, universities as well	yes
19	yes, for production	yes in 2012, to affiliates of MNCs	organising at present	no	no	yes, often, engineers for 3-4 days	no	yes, specific evaluation system for suppliers
20	yes, for production, for R&D only a test lab	no	Hungarian universities	no	yes, numerous	Hungarian engineers are sent to the centre for 1-2 years' training	no	yes

Source: author's compilation

Questionnaire

I. General characteristics of the company (Hungarian affiliate)

Year of establishment (in Hungary):

Main products/services:

Share of sales connected to the main activity in total sales:

Entry mode:

Number of employees at the end of the first year of operation:

at present:

Nationality of main/controlling owner at present:

Sales (2011):

Export/sales (2011)

Share of external (not intra-company) exports in total (2011):

Main clients/customers of the company:

II. R&D and innovation

1. Do you carry out R&D in Hungary? yes When was the R&D unit established in Hungary or when were R&D activities located here? Was there any significant change in that respect since you came to Hungary (allocating R&D here later, increasing/decreasing R&D capacity)? Where (town(s)) do you carry out R&D in Hungary?

2. Is (has been) the R&D activity registered (for tax reduction purposes or/and at the statistical office)?

3. Are the R&D units organisationally separate from other local units? Is the leader of the R&D unit part of the top management of the affiliate/of the whole multinational company?

4. What was the approximate share of R&D expenditures in sales in 2006 and in 2011? What was the approximate number of R&D employees in 2006 and 2011?

5. Please, briefly describe, what is the R&D activity you carry out in Hungary?

6. How independent is the affiliate to determine the R&D/innovation strategy and the direction/subject of local projects?

7. What are the main results of the R&D activity? Have you registered any patents? Is it registered by the parent company or by the affiliate?

8. Who is the main user of the results of R&D activity carried out in the Hungarian affiliate? Do the results fully or partly serve the parent company or other affiliates?

9. Have you sold any of the results of the R&D carried out in Hungary to independent companies in Hungary or abroad?

10. Have you acquired any R&D results (patents, know how etc.) from another company/institute/university in Hungary or abroad? Have you outsourced R&D activity (or part of it) to any of these?

11. Have you acquired machinery, equipment or software for R&D or innovation activities? (e.g. high tech equipment, ICT hardware or software)

12. Have you carried out innovation in the last 5 years? If yes, which type: product, process/technology, organisational/managerial, marketing? Was this innovation new to the company, to the country (Hungary), to Europe or to the world?

13. If yes, the activity connected to the innovation was carried out by the affiliate itself/in cooperation with another company in the network (parent or affiliate), /in cooperation with another company/in cooperation with a university/research institute/acquired from an independent company /acquired/received from a company in the company network?

14. Did you have trainings for employees in order to make the introduction of the innovation smoother (e.g. for operating new machines, to assimilate new production or management techniques)? Was that training organised by the affiliate or in cooperation with an institute/university/other firm? Are there workshops, seminars, visits to trade fairs etc. organised especially for your R&D personnel? Does the R&D personnel publish scientific articles in specialised journals?

15. If you cooperate in R&D or in the innovation process, who is your main partner? Do you participate in international cooperation/collaboration? (e.g. EU framework programmes) How far away (geographically) are your main partners in R&D cooperation from you? In which stage of the innovation process does this cooperation take place? What is the frequency of cooperation with these partners? What is the form of cooperation (contract, informal, etc.)?

16. Is the company a member of any R&D or innovation networks, associations in Hungary? What was the main aim of joining this network/association? If yes, did you find this membership useful from the point of view of the company's R&D activity? If yes, how?

III. Locational advantages

1. Does the parent company have (other) R&D centres worldwide? How many? When were they established compared to the Hungarian one? Was another unit closed down parallel with the establishment of the Hungarian one? How would you determine the place of the Hungarian R&D unit in the hierarchy of these R&D centres?

2. Is there competition between the units worldwide for R&D projects? Is there cooperation between them? Has there been a change in that respect?

3. What types of R&D activities are internationalised? What is the main reason for internationalising R&D from the point of view of the characteristics of the home country?

4. What is the reason for allocating R&D activities to Hungary or to the Hungarian affiliate? Why was Hungary chosen over other countries of the CEE region (Czech Republic, Poland, Slovakia etc.)?

5. What were those characteristics of the affiliate (relevant production, accumulated knowledge, technological and managerial skills, organisational assets, management with experience and skills etc.), which influenced the decision to establish an R&D unit here or transfer certain R&D activities here?

IV. Impact on the local economy

1. What can be those company-specific assets, which determine the competitiveness of the parent firm and the affiliate?

2. Do you buy products or services embodying high technology level from local firms? Do you outsource certain R&D tasks to local firms, universities or institutes? Do you sell products, services or technology (especially those connected to the results of your R&D activity) to local firms?

3. Is the affiliate company a member of any local associations, organisations, professional or other? Is the company member of a local cluster? How frequent is the involvement of the affiliate in the activity of the given association/organisation/cluster?

4. Are there any companies, which followed the affiliate to Hungary because they had strong supplier ties with the parent company? (e.g. tier-1,-2 etc. suppliers)

5. How many highly skilled research personnel came to Hungary from abroad to work for the affiliate? How long (on average) do they work in Hungary? Are there many former R&D employees, which went to work to local companies/institutes/universities? Do you still have contacts and/or cooperate with them?

6. Did you provide any of your suppliers with technological, organisational, other type of advice in order to help it to perform better/become a supplier?

7. How do you evaluate your relationship with public authorities?

8. In your opinion, what are those elements of the local business environment, which hinder your local cooperation?