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Foreign direct R&D investment in Central Europe: where do we stand?

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Abstract

This article questions the nature of the foreign direct R&D investments in Central Europe. Do the affiliates of the multinationals still undertake adaptive R&D? Have they recently engaged in innovative R&D activities in their Central European affiliates? We assess the nature of the R&D activities of the multinationals in Central Europe in three steps. In a first step we use the OECD database on foreign direct R&D expenditure and personnel to compare the foreign affiliates' R&D intensity with the indigenous firms' R&D intensity. We find few differences between the two families of firms. In a second step we use patents granted to foreigners in Central Europe as a variable proxy to assess the evolution of innovative R&D activities in Central Europe. We find that the patenting activities of foreigners rose with the increase of their R&D investments in Central Europe. We also suggest that the Central European affiliates still have a marginal position in the patenting strategy of the multinationals. In a third step we focus on the patent data of the foreign affiliates in the Czech Republic – the Central European leader as regards of foreign direct R&D investments –, in the major foreign direct R&D sectors – electronics, electrical equipment, machinery and motor vehicles –. We build a sample made of the ten multinationals representing the most active R&D investors in the country and assess the recent evolution of their patenting activity. We suggest that, (a) even these major R&D investors still only marginally apply for patents in their Czech affiliates; (b) there is no under-evaluation of the innovation activity of the Czech affiliates due to a geographical separation of inventions – in the Czech Republic – and patent location – in Western Europe; (c) the researchers working in the Czech affiliates are still not sufficiently oriented towards innovation activities to be integrated in the patenting-oriented international teams built by the multinationals. Foreign direct R&D investments in Central Europe remain mostly production supportive and associated with the international exploitation of technology produced in the Western headquarters and affiliates. Despite the strong engagement of the Czech government towards foreign direct R&D, real innovative R&D increases very slowly.

Keywords: business R&D, multinationals, Central Europe, innovative R&D, patents.

1. Introduction

Multinationals hold a central position in the world for R&D activities (UNCTAD 2005). Although there has been much debate among scholars on the extent and pace of multinationals' internationalization of R&D activities, the literature provides evidence that internationalization of R&D is a growing phenomenon which started in the 1990s (Gerybadze and Reger 1999) and grew in the 2000s (UNCTAD 2005). The location abroad of R&D activities changed the spatial organization of the multinationals and the comparative advantages of the nations in many industries (Gassmann and von Zedtwitz 1999, Kuemmerle 1999, Le Bas and Sierra 2002). Recent research also detects a wider geographical dispersion of R&D activities owing to the emergence of new actors, such as China, in the world economy (Filippaios et al. 2009). Despite a wider world dispersion of R&D activities, the important R&D activities of multinationals – basic research and applied research – still remain highly concentrated in a few leading OECD countries (Patel and Vega 1999, Bergek and Berggren 2004). When multinationals locate R&D activities abroad they mainly choose other leading OECD countries (Guellec and van Pottelsberghe de la Potterie 2001). The extant literature focuses *de facto* mainly on foreign direct R&D investments in OECD countries (e.g. Guellec and van Pottelsberghe de la Potterie 2001). The literature focusing on foreign direct R&D activities in developing and (post)-transition countries remains extremely scarce. The lack of studies can be explained by the fact that multinationals traditionally locate little R&D activity in developing and (post)-transition countries and when they do, they tend to engage in routine R&D activities (Amsden et al. 2001). However, several Asian emerging countries have recently succeeded in attracting important R&D activities and some multinationals have located more sophisticated R&D activities in non-OECD countries (UNCTAD 2005).

Numerous studies and reports have stressed the relocation of production activities of multinationals from developed countries, mainly the core European countries, to the new member states of the European Union (e.g. Pavlinek 2004). The transfer to Central and Eastern Europe of numerous production activities has led to a new European economic geography in the automotive or electronics industries (Rojec and Damijan 2008). Since the late 1990s, the location of activities by multinationals in Central and Eastern Europe no longer exclusively concerns plants but also concerns R&D investments. In the last decade, scholars have detected an increase in the R&D activities of the foreign affiliates of multinationals located in Central Europe (Kalotay 2005, Lengyel and Cadil 2009, Sass 2013).¹ Since the late 2000s, there has even been a growing concern in the European science and technology debates about the risk of the erosion of technological competencies in the home countries when multinationals relocate their R&D activities from the core European countries to the Central European periphery (Dachs et al. 2014). Despite the increasing role played by the multinationals in the R&D of the Central European countries, studies remain rare. Pavlinek and Zenka's (2010) and Pavlinek's (2012) work on the internationalization of R&D in the automotive industry is one of the few exceptions.

The Central European countries possess four main advantages that might lead to an increasing capture of foreign direct R&D investments. Firstly, short geographical distance reduces the cost of the exchange of knowledge for the multinationals located in Western Europe with their affiliates in Central Europe (on the important role of spatial proximity in the exchange of knowledge, see Jaffe et al. 1993, Almeida and Kogut 1999). Secondly, in the centrally planned economies, business R&D was undertaken in a handful of large firms. During the transition period many large-sized firms were acquired by foreign investors, who often decided to keep the R&D laboratories, and even sometimes to transform them into

¹ In this article Central Europe refers to the Czech Republic, Hungary, Poland, the Slovak Republic and Slovenia.

specialized R&D centers (UNCTAD 2005). Thirdly, the wage gap between research personnel in Western and in Central Europe is wider than the gap in the case of blue-collar production workers (Szalavetz 2012). Fourthly, since the mid-2000s the open-door policies aiming at attracting manufacturing plants have progressively been complemented by more targeted policies among which the policies aiming at attracting R&D centers – mainly by actively providing the foreign investor with financial and fiscal incentives – have taken up a prominent position (Rugraff 2008, Antaloczy et al. 2011, Guimon 2013).²

The extant literature provides increasing evidence of product and process upgrading in the affiliates of multinationals located in Central Europe (e.g. Domanski and Gwosdz 2009, Jürgens and Krzywdzinski 2009), but little is still known about the R&D activities of foreign affiliates. This paper aims at filling this gap by analyzing the recent evolution of the location by multinationals of R&D activities in Central Europe. The paper questions two opposite hypotheses:

Hypothesis 1. *The multinationals locate R&D activities in Central Europe relatively similar to those undertaken in the Western headquarters and affiliates. The Central European affiliates of multinationals progressively become R&D rivals of the Western affiliates. There is a real risk concerning the relocation of R&D activities from the West to the East as well as a danger of the erosion of the technological competencies in the home markets.*

Hypothesis 2. *The multinationals locate R&D activities in Central Europe different to those in the Western headquarters and affiliates. The Central European affiliates of multinationals remain specialized in adaptive R&D. The Western headquarters and affiliates continue to undertake basic research and applied research whereas the Central European affiliates mainly undertake incremental developments. The Central European affiliates remain poorly positioned in the internal division of R&D activities by the multinationals.*

The two opposite hypotheses refer basically to the motives of foreign direct R&D investments. The economic theory and extant literature suggest that the location abroad of R&D activities is encouraged by three broad factors: the necessity to adapt technologies to the local demand, the possibility of reducing costs and the opportunity to benefit from ‘reverse spillovers’. The three motives of internationalization correspond to a large extent to the dual typology adopted in the international business literature: ‘asset-seeking R&D investment’ versus ‘asset-exploiting R&D investment’. The former is related to the growing significance of increasing existing assets by absorbing and acquiring technological spillovers from agglomerative effects in the host countries (Dunning and Narula 1995). ‘Asset-exploiting R&D investment’ is associated with a multinational’s need to invest in R&D affiliates abroad in order to exploit the existing competitive advantages (e.g. by adapting the technologies to the local demand) in conjunction with the location-specific advantages of the host country (e.g. low labor costs) (Dunning and Narula 1995).

Methodologically, the determination of the dominant motives can be observed directly by survey-based research and indirectly by statistics on R&D expenditure/personnel and patent applications. In this paper, we chose to combine the three approaches. Our methodology presents the advantage of combining a static approach which benchmarks the R&D performance of the foreign affiliates in Central Europe and a dynamic assessment of their patenting activity.

The remainder of the paper is organized as follows: the next section presents the previous literature and the conceptual framework. Section 3 provides an overview of the R&D activities of the foreign affiliates in Central Europe. Section 4 describes the methodology. Section 5 proposes a discussion of the empirical results. Section 6 concludes the paper.

² On the effectiveness of financial and fiscal incentives in attracting R&D activities by foreign affiliates, see (Hall and Van Reenen 2000).

2. Background

Three main factors tend to encourage the concentration of the R&D activities, mainly in the home country of the multinational: scale economies in innovation, agglomeration economies and the risk of dissipation of trade secrets (Kumar 1996). Foreign direct R&D investment is also encouraged by three broad factors: the necessity to adapt technologies to the local demand, the possibility of reducing costs and the opportunity to benefit from 'reverse spillovers' (Kumar 1996). 'Traditional spillovers' from foreign direct investment are positive externalities from the presence of multinationals on the host economy (Blomström and Kokko 1998). However, multinationals may also benefit when investing abroad from positive externalities coming from domestic firms and other local institutions (e.g. universities, research institutions). These 'reverse spillovers' mainly appear when the multinationals can connect to national/regional innovation systems or to high-level clusters in a host country (Driffield and Love 2003). Since the most dynamic world clusters remain concentrated in developed countries, multinationals only very rarely locate R&D facilities in developing and (post)-transition countries to benefit from innovative activities by local actors. Developing and (post)-transition countries mainly attract foreign direct R&D investment for adaptation and cost reasons. Academic studies of the determinants of the localization of R&D activities tend to confirm that adaptive R&D investments and cost-reducing R&D investments are important location factors of R&D facilities in developing countries (Reddy 1997, Sun et al. 2006). Besides the three major factors of concentration/internationalization of R&D, the firm's decision depends on additional determinants related to the firm's characteristics (e.g. size, age, mode of entry into the foreign market, organization), related to the industry (e.g. R&D intensity, rivalry) and related to the host country (e.g. proximity, size of the local market, protection of intellectual property rights, local technological capability, tax and incentive policies towards foreign direct R&D). The economic literature fails to find indisputable relationships between firm/industry/market characteristics and the decision to internationalize R&D activities. Foreign direct R&D investment is a heterogeneous process with considerable variation in the nature and activities across industrial sectors and technology fields (Florida 1997).

Intellectual property rights provide a good example of the heterogeneity of the process in R&D investment. One may suspect the presence of a positive relationship between the strength of the intellectual property regime and foreign direct R&D investment in a host country. As expected, Kumar (1996) found that the strength of the intellectual property regime positively affected the US multinationals decision to locate R&D activities in developed countries. However, Kumar's study (1996) also suggested that the strength of the protection did not deter US multinationals from investing in R&D activities in developing countries. The author also detected strong variations across industries in the effect of property rights on the location decision of foreign direct R&D investment.

The effect of the size of the multinational on foreign direct R&D decision provides a second example of the difficulty of finding reliable determinants for the internationalization of R&D. R&D expenditure is highly concentrated among the largest world companies: in 2004, the 700 multinationals spending most on R&D accounted for almost half of the world R&D expenditure (UNCTAD 2005). However, the concentration of R&D spending among a limited number of multinationals is insufficient to prove the existence of a positive relationship between the size of the firms and their R&D investment abroad. Pearce (1989) suggested rather an inverted U-shaped relationship between foreign direct R&D investment and the firm size.

The three motives for the internationalization of R&D activities correspond to a large extent to the dual typology adopted in the international business literature: ‘asset-seeking R&D investment’ *versus* ‘asset-exploiting R&D investment’ (Dunning and Narula 1995). ‘Asset-seeking R&D’ – or ‘home-base augmenting R&D’ (Kuemmerle 1996) – is related to the growing significance of augmenting existing assets by absorbing and acquiring technological spillovers from agglomerative effects in specific sectors and specific firms (Kuemmerle 1999, Patel and Vega 1999). ‘Asset-exploiting R&D’ – or ‘home-base exploiting activity’ (Kuemmerle 1996) – is associated with the multinationals’ need to invest in R&D affiliates abroad in order to exploit their knowledge base. However, the typology remains to a large extent theoretical. Indeed, Criscuolo et al. (2005) suggest that most multinationals undertake both adaptive and innovative R&D activities simultaneously in developed countries

Owing to the complex nature of innovation and innovation systems, business R&D remain less internationalized than other dimensions of corporate activities such as production activities (Pavitt 2001). The innovative activities of the multinationals are significantly influenced by their home country’s national system of innovation (Pavitt and Patel 1999). Basic research and related training remain localized in the home country because they depend on person-embodied and institution-embodied tacit knowledge rather than information-based codified knowledge (Pavitt and Patel 1999). Overseas R&D affiliates often develop expertise complementary to the core competence of the multinational. In a great majority of cases, multinationals locate their activities abroad in technological fields in which they are strong at home (Le Bas and Sierra 2002). In many industries, internationalization concerns mainly routine R&D, whereas basic R&D is embedded in a small number of OECD home countries (Patel and Vega 1999, Bergek and Berggren 2004). In the automotive industry for example, the centers of excellence remain located in a limited number of clusters in Europe, the U.S. and Japan (Sturgeon et al. 2008). Some authors even consider that the adoption of the organization related to modular production increased the degree of R&D concentration in the European core automotive clusters in the 2000s (Sturgeon et al. 2008).

Although the firms’ R&D activities are less internationalized than other activities, Dunning and Lundan (2009) recently identified three new trends in the internationalization of R&D activities. Firstly, a notable increase in the level of internationalization; secondly, a much stronger role for foreign affiliates in the knowledge-creating activities of multinationals; and thirdly a wider geographic dispersal of their innovative activities. Numerous studies have acknowledged the rapidly increasing internationalization of technological activities, mainly in the form of foreign direct investment in R&D by large international companies (Gassmann and von Zedtwitz 1999, Kuemmerle 1999, Le Bas and Sierra 2002, Song et al. 2011). The literature clearly shows a recent increase in the internationalization of R&D activities combined with a wider geographical dispersion owing to the emergence of new actors, such as China, in the world economy (Filippaios et al. 2009). The empirical literature also detects an increasing role of foreign affiliates in the knowledge-creating activities of multinationals. Filippaios et al. (2009) stressed the increasing importance of the technological affiliates of the world’s 100 largest food and beverage multinationals by the end of the 1990s. Kuemmerle (1999) found that an increasing proportion of foreign affiliates of multinationals evolved beyond a marginal local adaptation of technology. In addition to ‘asset-exploiting affiliates’, a new type of ‘asset/competence-augmenting affiliates’ has emerged, which contributes to the creation of new processes, products and technologies that are used throughout the world by other foreign affiliates and even re-imported to the parent headquarters.

Affiliates with a strong innovation potential are endowed with specific competencies. Creative researchers and R&D personnel represent an important location-specific competency. Creative researchers and engineers are often integrated into international R&D teams which provide a greater potential for the cross-fertilization of technologies and access

to location-specific competencies (Criscuolo and Narula 2007). The integration of researchers and engineers active in an affiliate into the regional/international network of R&D units signals their innovation-augmenting potential onto the multinational as a whole (Ambos and Schlegelmilch 2004).

Finally, academic research detects a great deal of heterogeneity among the affiliates of multinationals in terms of R&D. Affiliates which strongly contribute to the innovation of the multinational are endowed with capabilities associated with knowledge absorption and utilization (Phene and Almeida 2008) and succeed in the identification of an opportunity, subsequent negotiations with the headquarters and finally, the commitment of resources to a new initiative by the headquarters (Birkinshaw 1997). On the other hand, affiliates with relatively weak capabilities remain strictly controlled by the parent headquarters (Hobday and Rush 2007). In this kind of affiliate non-routine engineering decision making is decided at the headquarters and the affiliate has little autonomy. Most of the time, the R&D personnel is specialized in adaptive R&D.

3. Overview of foreign direct R&D investment in Central Europe

3.1 Role in business R&D

The multinationals have progressively increased their R&D implication in Central Europe since the beginning of the 1990s (UNCTAD 2005:148). The foreign R&D presence expanded through the acquisition of large firms such as Skoda in the Czech Republic or Tungsram in Hungary. The newcomers have increased the R&D orientation of firms which used to carry out R&D. R&D also expanded through greenfield projects in the manufacturing industry when the multinationals located R&D activities and laboratories to adapt products to local or regional needs. The foreign affiliates multiplied their annual R&D expenditure by 3.2 between 2001 and 2009 in the Czech Republic, by two between 2004 and 2010 in Hungary, by 5.4 in Poland (2001-2009) and by 1.5 between 2000 and 2007 in Slovakia (OECD database 2014). In a survey carried out in 1999 on a sample of firms in Hungary, Kalotay and Hunya (2000) found that firms that were bought by foreigners following privatization deals increased their R&D expenditure by 13.6% two years after they were bought.

Table 1 shows that by the end of the 2000s, the foreign affiliates employed 16,484 R&D persons in the manufacturing sector and spent roughly USD1.5 billion in R&D in Central Europe. Foreign direct R&D dominates the manufacturing industry. The foreign affiliates represented 55.7% of the R&D expenditure and 42.9% of the R&D personnel in 2009. Slovenia excepted, the foreign affiliates' role in R&D is much more important in Central Europe than in Western Europe (OECD, 2014). Foreign direct R&D investment is particularly strong in the Czech Republic, which is the Central European country that attracted the most R&D activities. In 2009, almost half of the Central European foreign affiliates' personnel and expenditure were located in the Czech Republic. However, the Czech domination is to a large extent due to Skoda's important R&D activities located in the country. The R&D expenditure of Skoda amounted to roughly USD 300 million in 2009 (Skoda annual report 2010:2).

Table 1. Foreign direct R&D investment in the manufacturing industry in Central Europe, 2009 (in USD million and percentage)

	Czech Republic	Hungary	Poland	Slovak Republic	Slovenia	Total
Foreign direct R&D personnel	7484	3942	3127	848	1083	16,484

Foreign direct R&D expenditure, USD million	731.3	274.0	260.6	88.7	162.0	1516.6
Share of foreign direct R&D personnel in business R&D personnel, %	53.3	48.4	32.0	58.0	21.3	42.9
Share of foreign direct R&D expenditure in business R&D expenditure, %	67.8	53.4	54.3	72.4	33.8	55.7

Sources: Author's calculations based on OECD database (2014) and World Bank annual exchange rates.

3.2 Sectors of foreign direct R&D investment

The contribution of the foreign affiliates to R&D is very unevenly distributed across the sectors in Central Europe. Unsurprisingly, high-technology industries (pharmaceuticals, computer, electronic and optical) and medium-high technology industries (electrical equipment and automotive) are particularly focused on R&D. Foreign direct R&D investment is related to the presence of manufacturing plants in the host countries. Since foreign direct investments went predominantly to a limited number of industries belonging to high-technology and medium-high technology industries, a handful of sectors are concerned with the R&D expenditure/personnel. Table 2 highlights the sectors which attracted the predominant share of foreign direct R&D investments in the Czech and Slovak Republics, Hungary and Poland. In 2009, the foreign direct R&D expenditure in the motor vehicle industry in the four countries counted for over a quarter of the foreign direct R&D manufacturing expenditure and for over four fifths of the host countries' motor vehicle R&D expenditure.

The Czech leadership in business R&D is due to a large extent to the central position of the automotive industry in the economy: in 2009, the manufacture of motor vehicles accounted for more than half of the foreign direct R&D. Skoda alone accounted for two thirds of the R&D expenditure in the Czech motor vehicle industry and two fifths of the foreign direct R&D expenditure. Figures on business R&D in Central Europe remain therefore volatile since they may be strongly impacted by the R&D investment or disinvestment decisions of a limited number of large firms. Besides the automotive industry, two other sectors attracted foreign direct R&D activities: pharmaceuticals (in the Czech Republic, Hungary and Poland) and electronics (in the four countries). One can also detect national patterns: machinery and equipment, and motor vehicles in the Czech Republic; pharmaceuticals, electronics and motor vehicles in Hungary. In Poland and the Slovak Republic, where foreign affiliates poorly invested in R&D, the motor vehicles industry generated a predominant share of foreign direct R&D activities (Table 2).

Table 2. Major manufacturing sectors of foreign direct R&D investment in Central Europe(a), 2009

ISIC Revision 4 (Division) (b)	Share of foreign direct R&D in total business R&D		
	25-50 %	50-75 %	+ 75 %
R&D personnel	CZ 26*, 27*, 28** H 21***, 28** PL 19**, 20*, 21**, 27**	CZ 21* H 26***, 27** PL 10*, 29***	CZ 29*** H 29***

R&D expenditure	SK 25* CZ 26, 28* H 21*** PL 19**, 21*, 28*, 30*	SK 27**, 28** CZ 27 H 28* PL 27* SK 22**, 27*	SK 22**, 24*, 29** CZ 21*, 29*** H 26**, 27*, 29*** PL 10***, 29*** SK 24*, 29***
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Total of the four Central European countries	Pharmaceuticals (21)	Electronics and electrical equipment (26-27)	Motor vehicle (29)
R&D personnel share of foreign direct R&D in total business R&D	43.7 (c)	40.3	84.6
Share of sectoral foreign direct R&D in total foreign direct R&D	11.1 (c)	17.9	27.4

Notes: The table only contains information on the ISIC two digit divisions (10 to 33) for which the share of foreign direct R&D in total business R&D exceeds 25 % and for which the share of foreign direct R&D of the sector (or ISIC division) in total foreign direct R&D exceeds 5 %.

(a) Information for Slovenia is confidential; (b) ISIC Revision 4 can be consulted in Appendix 1; (c) Information for the Slovak Republic is confidential.

* 5 % < Share of sectoral foreign direct R&D in total foreign direct R&D < 10 %; ** 10 % < Share of sectoral foreign direct R&D in total foreign direct R&D < 20 %; *** Share of sectoral foreign direct R&D in total foreign direct R&D > 20 %.

Sources: Author's calculations based on OECD database (2014) and World Bank annual exchange rates.

3.3 Foreign direct R&D intensity

In the Innovation Union Scoreboard, the European Union member states are classified in four performance groups based on their average innovation performance (European Commission, 2014). The summary innovation index takes into account eight dimensions when benchmarking the innovation activity of the member states. Based on this summary measurement, Denmark, Finland, Germany and Sweden are considered as 'innovation leaders' with innovative performance well above that of the EU average. The 'innovation followers' gather together most of the other Western European countries and one Central European country, Slovenia. Their performance is above or close to the EU average. The Czech Republic, Hungary, Poland and the Slovak Republic belong to the third group of 'moderate innovators' with innovation performance below that of the EU average. The fourth group gathers together the 'modest innovator' countries. When one focuses more specifically on the business R&D investment, which is one of the eight dimensions, the classification of the Central European countries is the same as in the global measurement (European Commission 2014:15). However, the Innovation Union Scoreboard does not distinguish between the R&D activity of indigenous firms and the foreign affiliates of multinationals. Table 3 focuses exclusively on foreign direct R&D investment and measures their R&D intensity by using three ratios: *ratio 1*: R&D expenditure-person employed; *ratio 2*: R&D expenditure-turnover; *ratio 3*: R&D personnel-person employed.

'Innovation leader' countries, such as Germany, are endowed with indigenous firms actively investing in R&D. These countries also attract affiliates of multinationals which are strongly R&D-oriented (Table 3). Compared to the 'innovation leaders' group of countries, the foreign direct R&D intensity in Central Europe remains low by the end of the 2000s. In

Central Europe, foreign direct R&D expenditure per person employed remains fifteen times lower than in Germany. The share of intra-mural R&D in turnover is five times lower and the R&D personnel proportion in total personnel is seven times lower. Interestingly, the difference also remains important with Spain which also belongs to the ‘moderate innovators’ group. In 2009, the foreign direct R&D expenditure-turnover ratio was almost four times lower and the R&D personnel share more than two times lower in the Czech Republic than in Spain.

Table 3. Intensity of foreign direct R&D in the manufacturing industry, in Central Europe, Germany and Spain, 2009

	R&D expenditure/number of persons employed, USD	Intra-mural R&D expenditure/total turnover, %	Number of R&D personnel/ number of persons employed, %
Czech Republic	1471	0.72	1.51
Hungary	928	0.40	1.34
Poland	414	0.21	0.49
Slovak Republic	435	0.19	0.42
Slovenia	4329	1.88	2.89
Central Europe	912	0.48	0.99
Germany	14,261	2.60	6.97
Spain	4176	0.77	3.53

Note: Germany belongs to the ‘innovation leaders’ whereas Spain is, like the Central European countries (Slovenia excepted), a ‘moderate innovator’.

Sources: Author’s calculations based on OECD database (2014) and World Bank annual exchange rates.

Finally, the three tables demonstrate that: firstly, multinationals have increased their R&D implication in Central Europe. Secondly, they are the dominant actors in the business R&D in the manufacturing industry. Thirdly, the foreign direct R&D investment is concentrated in a small number of industries, mainly pharmaceuticals, electronics and automotive. Fourthly, the activity of the foreign affiliates is, globally, of low R&D intensity.

In the next section we present the methodology used to discriminate between the two hypotheses presented in the introduction of the article.

4. Methodology

It is very difficult to measure business R&D activities (Freeman and Soete 2009). Firms, mainly small- and medium-sized firms, often develop informal innovation activities that are hard to estimate and may be invisible in the innovation surveys (Altenburg et al. 2008). Activities that are a by-product of learning-by-doing processes also remain unrecorded, although those activities are often very relevant in developing and (post)-transition countries. The delimitation of R&D activities is also very complex. Some researchers consider that prototyping and testing are separate elements of R&D, whereas others consider that they are central elements of the activity of R&D (Cohen et al. 2009). R&D remains an accounting category which includes activities of differing importance. Moreover, the declarations made by multinationals to the authorities concerning their R&D activities are influenced by the host state incentive and fiscal policies towards business R&D (Sass 2013).

The available empirical evidence on foreign direct R&D investment consists of three types of data: survey-based studies, statistics on R&D expenditure/personnel and patent applications. In this paper, we chose to combine the three approaches. Our methodology presents the advantage of combining a static approach which benchmarks the R&D performance of the foreign affiliates in Central Europe and a dynamic assessment of their patenting activity.

Our methodology is based on three steps:

Step 1. We use the OECD statistics database, Section ‘activity of multinationals’ to benchmark the R&D intensity of the foreign direct R&D investments in Hungary and the Czech Republic with the R&D intensity of the indigenous firms (OECD 2014). This comparison provides an initial assessment of the nature of the R&D undertaken in Central Europe. The R&D intensity indicators provide a picture of the R&D situation by the end of the 2000s. However, information regarding the evolution of the foreign direct R&D investments over the last twenty years is not available in the OECD data.

Step 2. In order to overcome this difficulty we work on patent data.³ ‘A *patent is a document issued by an authorized government agency, granting the right to exclude anyone else from the production or use of a specific new device, apparatus or process for a stated number of years*’ (Griliches 1998:288). The invention must be non-trivial (would not appear obvious to a skilled practitioner), useful (has a potential commercial value) and novel to be ‘patentable’. **Because patents result from the firm’s investments in basic research and applied development, patent data can be considered as a relatively good proxy of the firm’s genuine inventive activity.**⁴ We use the OECD patent database to assess the global evolution of the patenting activity of the foreigners in Central Europe between 1990 and 2010.

Step 3. We then work on patent data to detect the possible emergence of a process of upgrading of the R&D activities organized by foreign affiliates in the Czech Republic, the leading Central European country regarding foreign direct R&D investments. We use the AMADEUS database of the Bureau Van Dijk which contains patenting and ownership information of firms in Western and Central Europe to detect the emergence of innovative R&D in the Czech Republic, as well as the potential transfer of innovative activities from Western Europe to the Czech Republic.

We took the information of the foreign direct R&D centers/activities delivered by the Czech investment agency (Czechinvest 2013, 2014a, 2014b) and crossed this information with the information released by the multinationals (annual reports, newsletters, etc.). We constituted a sample of ten multinationals with the following characteristics:

- a) They own at least one Czech affiliate;
- b) They belong to the electronics-electrical-machinery-automotive sectors (ISIC 26 to 29); these sectors have attracted the bulk of the foreign direct R&D investments;

³ The idea of using patent to assess the R&D activities of firms and the process of innovation and technical change goes back to Schmookler (1966) and Pakes and Griliches (1980). Since the end of the 1990s, a large strand of the literature has used patent statistics to analyze the internationalization of business R&D (Guellec and van Pottelsberghe de la Potterie 2000, Cohen et al. 2009, Narula and Guimon 2010). Regardless of the patent office (national or international), five main types of information are available in the patent document: the names and postal addresses of the inventor(s); the organization to which the patent property right was assigned and the legal address of the patentee; a detailed technological classification of the invention; the patentee’s specific claims regarding what the invention can do that could not be done before; and citations that indicate previously existing knowledge, embodied in prior patents or other publications, upon which the patent builds.

⁴ We are aware that patent data does not uncover the total innovative activity of foreign affiliates in Central Europe. Some R&D activities do not appear in the patent data because multinationals choose not to apply for a patent (on the motives explaining why a firm may choose not to apply for a patent, see Cohen et al. 2000). However, these strategies only marginally impact our study.

c) The Czech affiliate(s) employ(s) more than 50 R&D personnel: we eliminated the Czech affiliates that only marginally invested in R&D activities and have a poor patenting potential;

d) The affiliates were created/acquired before 2008. The technological capabilities of the R&D centers and their embeddedness in the local scientific and engineering communities only develop progressively (Song et al. 2011). The headquarters are also often more reluctant at the beginning of the activity to confer important tasks and functions to their foreign affiliates, mainly when the activities are of strategic importance for the multinational (Birkinshaw 1997);

(e) The affiliates belong to active patenting multinationals. In order to avoid a bias owing to the presence in the sample of firms that never apply for patents, we only took into consideration affiliates that belong to multinationals that deploy patenting activities in Western Europe.⁵ All the firms in our sample regularly apply for patents in Western Europe and have located R&D activities in the Czech Republic.

We then used three proxy variables of innovative R&D:

- *Proxy 1* is composed of *Proxy 1a* and *Proxy 1b*:
 - o *Proxy 1a*. The patents granted to the Czech affiliates – of the ten multinationals in our sample – compared to the patents granted to the headquarters and affiliates in the home country of the ten multinationals.
 - o *Proxy 1b*. The patents granted to the Czech affiliates compared to the patents granted to the other Western affiliates (outside the home country of the multinationals).⁶

The evaluation of the two proxy variables was done over two recent periods of three years, 2008 to 2010 *versus* 2011 to 2013. A significant increase in the patenting share by the Czech affiliates of multinationals would provide support to our Hypothesis 1: the R&D activities of multinationals in the Czech Republic progressively move from adaptive R&D to innovative R&D.

Since it is difficult for authorities to detect the patentee when several affiliates participate in the development of a patent, the geographical separation of R&D and patent location is relatively easy to implement. There can be a geographical separation between the inventor (e.g. a researcher working in the Czech Republic) and the applicant (e.g. an affiliate in Western Europe or the headquarters) creating a misevaluation of the innovative activities in the Czech Republic. The project risk can also be supported by a different affiliate from the one hosting the R&D activity. Karkinsky and Riedel (2012) suggest that multinationals have an incentive to locate their patents at affiliates with a relatively small corporate tax rate and

⁵ The sectoral reports of Czechinvest contain lists of numerous foreign direct ‘selected R&D investments’ and ‘selected technology centers’ (e.g. a list of 46 ‘selected automotive R&D investments and technology centers’ in Czechinvest 2014a). In reality, the majority of the multinationals only possess a small testing and development department which adapts the production to local needs. ON semiconductor and Freescale Semiconductor both have development centers of approximately 100 employees in Roznov. However these multinationals do not actively apply for patents in Western European countries and correlatively in the Czech Republic. The two multinationals therefore do not belong to our sample of firms.

⁶ Basic R&D remains concentrated in the home market of the multinationals and/or the most dynamic clusters in the more advanced countries (Sturgeon et al. 2008). Since innovative R&D is less intense in the Western affiliates of the multinationals – mainly those which are not located in dynamic clusters – a transfer of R&D activities to Central Europe is more probable than from the headquarters to Central Europe.

find that the location of the inventor and the applicant location differ in roughly 10% of the cases.

- *Proxy 2* assesses the geographical separation of inventions and patent location. It is composed of *Proxy 2a* and *Proxy 2b*:
 - o *Proxy 2a*. Czech patent location with foreign inventors between 2008 and 2013. This evaluation aims at detecting the existence of a process of patenting by the Czech affiliates of inventions made abroad.
 - o *Proxy 2b*. Foreign patent location with Czech inventors in 2013. In order to avoid an under-evaluation of the innovative R&D of the Czech affiliates, we assess patents located in Western Europe that come from the activity of researcher(s) in the Czech Republic.

Because creative researchers/inventors boost the R&D efficiency of a multinational as a whole, an increase in the participation of the Czech inventors in international R&D teams could therefore be considered as an indicator of the emergence of innovative R&D capacities in the Czech Republic. A significant increase in the participation of inventors from the Czech Republic to regional/global R&D networks in multinationals would provide support to our *Hypothesis 1*. The third proxy variable focuses on the international cooperation of researchers (at least two researchers coming from two different countries):

- *Proxy 3*. Presence of at least one Czech inventor among the international teams in the patents granted to the Western European affiliates and headquarters of the multinationals. Should we find few Czech inventors working in international teams, it would suggest that the Czech R&D is, in 2013, insufficiently innovative to be integrated in the R&D networks of the multinationals.

5. Empirical results

Do the Central European affiliates of multinationals progressively become rivals in the field of R&D for the Western affiliates (Hypothesis 1) or do the Central European affiliates of multinationals remain specialized in adaptive R&D (Hypothesis 2)?

In this section, we firstly compare the R&D intensity of the foreign affiliates and the indigenous firms in the major sectors of R&D investment of the multinationals. We then assess the foreign direct patenting activity in Central Europe. We finally study the patenting activity of the multinationals' R&D affiliates in the Czech electronics, electrical, machinery and automotive industries.

5.1 Foreign affiliates' versus indigenous firms' R&D intensity

Our analysis is limited to the two countries, – the Czech Republic and Hungary –, and the three industries, – pharmaceuticals, electronics and motor vehicles –, that attracted the dominant share of foreign direct R&D activities in Central Europe. Table 4 displays two types of indicators: the first category of indicators measures the R&D intensity of foreign affiliates *versus* indigenous firms in terms of R&D expenditure and R&D personnel. The second indicator assesses the difference in size of the two groups of firms.

Three main features must be taken into consideration to correctly benchmark the R&D intensity of the foreign affiliates:

Firstly, it is widely accepted in the literature that multinationals possess R&D advantages over non-multinationals (Caves 1982) and that they invest more in R&D than non-multinationals (Dunning 1993). Multinationals also tend to be important in industries with a

high level of R&D relative to sales (Markusen 1995). One may therefore expect multinationals to invest more in R&D than indigenous firms active in the same industry.

Secondly, the literature shows that multinationals are larger than non-multinationals (Dunning 1993). Owing to their advantage in size and their competitive advantage in R&D-intensive activities, multinationals should be more R&D-oriented than indigenous firms in general, but also more R&D-oriented than indigenous firms active in the same industry as the multinationals.

Thirdly, the literature also suggests that the Central European firms are poorly involved in genuinely innovative activities (European Commission 2014). Their R&D expenditure and patenting activities remain weak and they severely lack the capabilities to develop creative activities. The Central European firms remain mainly locked in imitation (and not creation) and specialized in non-R&D activities such as testing and standards. The current business R&D situation goes back to the central planning and transition periods. Hanson and Pavitt (1987) demonstrated that the systems of innovation worked according to completely different models in the Eastern and Western world. The authors explained the poor business research and innovation performance of Eastern Europe by the central planning of innovative activities. An artificial separation between scientific research – mainly carried out by the Academy of Science – and industrial research carried out by branch R&D organizations, was responsible for an absence of inter-organizational learning and of in-house R&D. Innovation was limited to routine tasks in production firms. In the transition period a large part of the inherited R&D structures collapsed, mainly organizations engaged in applied R&D (Radosevic 1997). The empirical literature detected a path-dependency in the ‘style’ of innovation in the Eastern firms throughout the 1990s and 2000s. The inherited R&D structures explained the poor R&D performance of the indigenous firms in Eastern Europe (Radosevic 1997, Högselius 2005, Kapil et al. 2011). Owing to the poor innovation intensity of indigenous firms in Central Europe, one may expect the foreign affiliates to outperform the R&D of the indigenous firms.

Table 4 delivers mixed results. The ratio of R&D personnel in total persons employed is higher for foreign affiliates than for indigenous firms in the Czech and Hungarian manufacturing industry, but the ratio is lower in the pharmaceutical industry and in the computer, electronic, optical industry in both countries. Indigenous manufactures of pharmaceuticals and manufactures of computer, electronic and optical products also spend more in R&D (Intra-mural R&D expenditure/total turnover) than the foreign affiliates. In the electronics industry the difference between the two groups of firms is very important: the indigenous firms spend respectively twelve times and seven times more intramurally in R&D than the foreign affiliates. Only in the motor vehicle industry do the foreign affiliates outperform the indigenous firms.

These figures must be compared, firstly, to the R&D intensity in Germany and Spain of the two groups of firms and, secondly, to the average size of the firms. The higher R&D intensity of indigenous firms compared to the foreign affiliates does not mean that a new indigenous R&D dynamic in the Central European major industries is emerging, but clearly signals the low R&D commitment of the multinationals in Central Europe. Indeed, the indigenous firms producing computer, electronic and optical products remain roughly three times in the Czech Republic and six times in Hungary less R&D intensive (in terms of intra-mural R&D expenditure/total turnover) than in Germany. On the other hand, the gap between the foreign direct R&D investment in Germany *versus* in the Czech Republic and Hungary is huge. The gap is the widest for electronics R&D spending (as a share of the total turnover) of the foreign affiliates in Germany and in Central Europe: they spend respectively fifty four times and thirty six times more in Germany than in the Czech Republic and Hungary. In Spain (which also belongs to the EU-group of ‘moderate innovators’) the foreign affiliates employ a much

higher number of R&D personnel and spend more in R&D than in the Central European countries. The comparison between the Czech Republic, Hungary and Spain also clearly stress the unique position of the pharmaceuticals in Hungary and motor vehicles in the Czech Republic. These two industries represent exceptions in the Central European business R&D: foreign affiliates are much more R&D-oriented than in comparable ‘moderate investor’ countries.⁷

The two former industries excepted, the poor R&D investment of the foreign affiliates in Central Europe is all the more evident when one compares the average size of the foreign affiliates with the indigenous firms. Foreign affiliates are, on average, much larger than indigenous firms (Table 4). Basically large-sized firms, and mainly multinationals, used to invest more in R&D than non-multinationals. However, despite their advantage in size, foreign affiliates spend less in R&D in pharmaceuticals and electronics than locally-owned firms. Even in the motor vehicle industry, large foreign-owned firms only investment a little bit more than smaller-scaled local firms. In Hungary, the automotive foreign affiliates are on average twelve times larger than the automotive indigenous firms. However the former R&D expenditure (in total turnover) is only slightly higher than the expenditure of the latter.

Table 4. Comparison of the R&D intensity of foreign affiliates *versus* indigenous firms in the Czech Republic, Hungary and Germany, 2009

ISIC, Rev.4	Number of R&D personnel/ number of persons employed, %		Intra-mural R&D expenditure/total turnover, %		Number of persons employed/number of firms, persons	
	foreign affiliates	indigenous firms	foreign affiliates	indigenous firms	foreign affiliates	indigenous firms
Czech Republic						
Manufacturing	1.5	0.9	0.7	0.6	117.9	4.7
Pharmaceuticals	4.7	7.2	3.7	4.2	277.1	25.9
Computer, electronic and optical products	2.0	6.5	0.3	3.6	178.1	4.0
Motor Vehicles	2.5	1.7	1.4	1.3	457.6	22.6
Hungary						
Manufacturing	1.3	1.1	0.4	0.7	125.9	7.3
Pharmaceuticals	15.9	14.1	6.9	8.6	317.9	145.4
Computer, electronic and optical products	1.8	3.6	0.2	1.5	344.9	5.6
Motor Vehicles	1.7	1.3	0.5	0.4	406.8	33.1
Germany						
Manufacturing	7.0	3.6	2.6	2.5	228.9	32.2

⁷ Additional information on foreign direct R&D investments in the Hungarian manufacture of pharmaceuticals can be found in Lengyel and Cadil (2009) and for the Czech motor industry in Pavlinek (2012).

Pharmaceuticals	16.1	16.6	10.2	9.3	568.6	99.3
Computer, electronic and optical products	21.7	15.1	10.8	9.3	149.3	30.8
Motor Vehicles	13.5	11.3	4.3	5.2	627.1	283.6
<hr/>						
Spain						
Manufacturing	3.5	2.5	0.8	0.8	209.3	9.3
Pharmaceuticals	8.2	16.7	3.0	6.0	426.3	73.3
Computer, electronic and optical products	9.7	13.7	2.1	5.0	136.8	10.9
Motor Vehicles	2.9	3.9	0.5	1.5	533.8	30.0

Source: Author's calculations based on OECD database.

The comparison of the foreign affiliates' *versus* indigenous firms' R&D intensity provides a first indication that Central European R&D is mostly production supportive and associated with the international exploitation of technology produced in the home country of the multinationals.

5.2 Foreigners' patenting in Central Europe

Hypothesis 1 *versus* Hypothesis 2 was further questioned by working on the patents granted by the European Patent Office (EPO) and the US Patent and Trademark Office (USPTO) to foreigners in Central Europe. The bulk of the foreign ownership corresponds to patents granted to the foreign affiliates of multinationals engaged in R&D activities.

The patenting activity of foreigners rose with the increase of their R&D investments: foreign ownership of domestic invention increased tenfold in Central Europe between 1990 and 2010 (Table 5). In 2010, 654 patents were granted to foreigners in Central Europe *versus* 60 in 1990. However, Central Europe still holds a marginal position in the patenting strategy of the multinationals: in 2010, patents granted to the foreigners in Central Europe represented only 3.27% of the totality of the patents granted to foreigners across Europe. The marginal position of Central Europe is all the more evident, when one compares its position with Spain or Germany. In 2010, patents granted to foreign investors in the five Central European countries was equivalent to the patents granted to the same actors in Spain, and represented one tenth of the patents granted to foreign investors in Germany.

Table 5. Foreign ownership of domestic invention, 1990-2010

	1990	1994	1998	2002	2006	2010
<hr/>						
Number of patents granted to foreigners						
Total EU-20**	7851	10,260	17,595	24 ,519	33,318	20,018
Central European countries, of which:	60	123	232	380	585	654

Czech Republic	13	27	66	101	183	168
Hungary	24	36	64	126	170	204
Poland	23	38	63	87	140	212
Slovak Republic	0	5	16	20	48	26
Slovenia	0	17	23	46	44	44
<hr/>						
% in total EU-20**						
Czech Republic	0.17	0.26	0.38	0.41	0.55	0.84
Hungary	0.31	0.35	0.36	0.51	0.51	1.02
Poland	0.29	0.37	0.36	0.35	0.42	1.06
Slovak Republic	0	0.05	0.09	0.08	0.14	0.13
Slovenia	0	0.17	0.13	0.19	0.13	0.22
Central European countries	0.76	1.20	1.32	1.55	1.76	3.27

Notes: * Patents granted by the EPO and the USPTO; ** EU-15 + Central Europe.

Source: Author's calculations based on OECD database.

The low patenting activity of the affiliates in Central Europe is a result to a large extent of their moderate investments in R&D activities. The existence of a strong relationship between R&D and patenting is rather well documented in the literature (e.g. Hall et al., 1986). Table 6 stresses this relationship in the OECD-countries for the foreign affiliates of multinationals: there is a strong positive relationship between R&D expenses and R&D personnel of foreign affiliates and their patents (See R-square in table 6).

Table 6. Relationship between R&D and patents of foreign affiliates of multinationals in OECD countries, 2009

	R&D expenditure and patents	R&D personnel and patents	R&D expenditure and R&D personnel
R-square	0.95	0.98	0.91
N	13	13	13

Source: Author's calculations based on OECD database.

Relatively poor R&D investments by foreign affiliates in Central Europe explain its peripheral position in the patenting activity of multinationals. One could therefore expect an increase in the patents granted with higher expenditure in R&D. However, patenting not only depends on the quantitative level of R&D expenditure in a country, but also on the patent-R&D ratio (Kortum 1993). The patent-R&D ratio is linked to the motives for internationalization of the R&D activities. Since 'asset-exploiting R&D investments' are adaptive R&D investments and cost-reducing R&D they tend to have a low patent-R&D ratio. On the other hand, the patent-R&D ratio of 'asset-seeking R&D investments' should be

higher because this type of R&D investment contributes to the creation of new processes, products and technologies.

We calculated in Table 7 the patent-R&D ratio of the foreign affiliates in Central Europe. Interestingly, the Central European R&D leader, the Czech Republic, has low patent-R&D ratios compared to Hungary and Poland. In 2009, one million dollar worth of foreign affiliates' R&D produced 0.27 patents in the Czech Republic (0.66 in Hungary); in the foreign affiliates 37.4 persons (21.8 in Hungary) produced one patent. Because the production of patents varies widely across industries the sectoral orientation of foreign direct R&D investment plays an important role in the patent-R&D ratios. The higher patent-R&D ratio of Hungary compared to the Czech Republic may therefore be explained by the strong foreign affiliates' R&D investments in the Hungarian pharmaceutical sector – which is the world's most active patenting sector –. Because foreign R&D investments in the Polish, Slovak and Slovene industries remain limited, their patent-R&D ratios are difficult to interpret.

The Czech Republic – the country which attracted the dominant share of foreign R&D among the Central European countries –, is also the least efficient country regarding the production of patents. In the second half of the 2000s, the Czech Republic received two thirds of the foreign affiliates' R&D directed to Central Europe, but represented only one third of the patents granted to the foreigners. Table 7 tends therefore to further accredit the Hypothesis 2: *the Czech affiliates of multinationals remain specialized in adaptive R&D. The Czech affiliates mainly undertake incremental developments.* This result shows that the multinationals' priority regarding R&D is to develop 'asset-exploiting R&D'. When foreign affiliates invest in R&D in the Czech Republic they do it mainly in adaptive developments. Basic research and applied development remain very limited. That is why the foreigners rarely invest in the Czech Republic and rarely apply for patents.

Table 7. Patent-R&D ratios of foreign affiliates in Central Europe, 2009

	Number of patents	R&D expenditure, USD million	R&D personnel	Patents/ R&D expenditure, USD million	R&D personnel/patent, persons
Czech Republic	200	731.3	7484	0.27	37.4
Hungary	181	274	3952	0.66	21.8
Poland	208	260.6	3127	0.80	15.0
Slovak Republic	35	88.7	848	0.39	24.2
Slovenia	38	162	1083	0.23	28.5
Spain	591	1294	11,516	0.45	19.5
Germany	6251	14,285	73,546	0.43	11.8

Note: Patents granted by the EPO and the USPTO.

Source: Author' calculations based on OECD database.

5.3 Patents and inventors in the Czech foreign affiliates of multinationals

Table 5 demonstrates that the patents granted to foreigners in the Czech Republic have increased between 1990 and 2010. Table 5 also shows that foreigners still apply poorly for

patents in the Czech Republic. However, the former section presents three limitations that need to be tackled. Firstly, the evaluation is based on patents only granted by the European Patent Office (EPO) and the US Patent and Trademark Office (USPTO). Statistics may change when taking into consideration patents granted by national patent organizations, mainly the Czech Industrial Property Office and the German Patent Office. Secondly, the former evaluation concerns the whole of the Czech economy. However, the foreign direct R&D investments are concentrated on four main manufacturing sectors (see table 2). In these sectors, the patenting activities of the foreign affiliates may have increased in a recent period, suggesting the emergence of a new sectoral pattern of innovative R&D activities. Thirdly, the upgrading of foreign direct R&D activities takes time. The detection of the emergence of innovative activities must give the affiliates time to develop innovative activities.

We worked on patent data of the major foreign R&D investors in the Czech manufactures of electronics (ISIC 26), electrical equipment (ISIC 27), machinery and equipment (ISIC 28) and motor vehicles (ISIC 29). Our sample is constituted of the affiliates of multinationals responding to the five conditions defined in the methodological section.

The three proxy variables of innovative R&D are presented in table 8 (the detailed characteristics as well as the variables for each of the ten multinationals can be consulted in Appendix 2). We examined a sample of 2799 patents granted in 2013 in Europe to the ten multinationals. This sample represented 15% of the 18,559 patents granted in 2013 in Europe to the ten multinationals.

Proxy 1a

In our sample, the number of patents granted to the Czech foreign affiliates increased by 71% between 2008-2010 and 2011-2013. The number of patents as well as their variation is strongly influenced by Skoda's patenting activity. Between 2008 and 2013, Volkswagen's affiliate Skoda patented more in the Czech Republic than the nine other top foreign direct R&D investors together. Skoda's position in the patenting activities is absolutely unique in the Czech Republic and in Central Europe. However, even with Skoda, the Czech patent share remains extremely low in the patenting activity of the multinationals. Patents continue to be predominantly assigned to the headquarters and a small number of affiliates in the home country of the multinationals. The German automotive multinationals – seven out of the ten multinationals in our sample – still concentrate their innovative R&D and their patent applications on a small number of entities located in Germany. For example, in 2013 almost all of the patents granted to the Bosch automotive division were attributed to the headquarters in Stuttgart and roughly nine tenth came from the research activity of personnel working in Germany.⁸ In 2013, almost all of the patents granted to the Siemens automotive division were also attributed to one affiliate – located in Berlin – and nine tenth of the patents resulted from the research activity of personnel working in Germany.

Proxy 1b

The gap between the Czech affiliates and the Western affiliates (outside the home country of the multinational) is narrower than the gap between the Czech affiliates and the headquarters in the home country of the multinationals. Over the 2010-2013 period, patents granted to the Czech affiliates represented 2.5% – 5.5% with Skoda – of the patents granted to Western affiliates. The ratio remains relatively low considering that the multinationals in our sample have been the most active R&D investors in the Czech Republic. Moreover, the *proxy 1b* decreased over the two periods suggesting the absence of relocation of innovative R&D

⁸ German teams or international teams with people working in Germany.

activities from Western affiliates (outside the home country of the multinationals) to the Czech Republic.

Proxy 2a

Over the 2008-2013 period, 280 patents were granted to the Czech affiliates of the ten multinationals and only 2.1% of these patents came from the invention of personnel working outside the Czech Republic. This result suggests that there was little geographical separation of inventions – coming from abroad – and patent location to the Czech Republic. This figure is low compared to the ratio related to the geographical separation of inventions and patent location. Indeed, globally in Europe in 2013, we detected a geographical separation of inventions and patent location in 8.4% of the patents granted to the ten multinationals. Our result is in line with Karkinsky and Riedel’s (2012) study which found a separation in roughly 10% of the cases.

Proxy 2b

The reverse process – location of patents in Western Europe of inventions made in the Czech Republic – is very rare (0.06% of the cases in 2013) suggesting that the estimation of the innovative R&D done in the Czech Republic clearly reflects the real state of the country’s R&D activity. There is clearly no under-estimation of the innovative activity in the Czech Republic due to the declaration by Western affiliates of patents coming from innovative R&D undertaken in the Czech Republic. *Proxies 1a* and *1b* represent good evaluations of the position of the Czech R&D in the European division of the R&D activities of the multinationals.

Proxy 3

In our sample of firms, patents with inventors from different countries remain far fewer than patents with inventors from one country. In 2013, 87.6% of the patents resulted either from the activity of one single person or a team constituted of people working in the same country. 12.4% of the patents came from the collaboration between inventors working in different countries. *Proxy 3* aims at assessing the connection of the Czech R&D personnel to international R&D teams. The patenting activity of the Czech affiliates of the multinationals might remain low although some Czech researchers actively participate in intra-multinational R&D networks and patent creations. However, our research suggests that the Czech research personnel working in the Czech affiliates of the multinationals remain marginally present in the international teams. In 2013, the Czech research personnel were only represented in 1% of the international teams which were the inventors for patents. In only one company out of the ten multinationals, did the Czech researchers actively contribute in 2013 to patents located in the Western headquarters. The R&D undertaken in the Czech affiliates is still insufficiently oriented towards innovation to allow the Czech engineers and researchers to actively contribute to the R&D activities of the multinationals and to be actively integrated into intra-multinationals R&D programs.

Table 8. Patents and inventors of the ten major foreign direct R&D investors in the Czech Republic (in ISIC 26-29)

Proxy 1	Patents granted to the Czech affiliates of the ten multinationals
Proxy 1a	Patents granted to Czech affiliates compared to patents granted to headquarters and affiliates in the home country of the multinationals, %

	Period 2008-2010	105/34,356 = 0.3%
	Period 2011-2013	175/49,014 = 0.4%
Proxy 1b	Patents granted to Czech affiliates compared to patents granted to Western affiliates of the multinationals (outside the home country), %	
	Period 2008-2010	105/1322 = 7.9 %
	Period 2011-2013	175/3154 = 5.5%
	Without Skoda:	
	Period 2008-2010	3.4%
	Period 2011-2013	2.5%
<hr/>		
Proxy 2	Geographical separation of inventions and patent location of the ten multinationals	
Proxy 2a	Czech patent location with foreign inventors (no Czech inventor), 2008-2013, %	6/280 = 2.1%
Proxy 2b	Foreign patent location with Czech inventors (all the inventors are Czech), 2013, %	10/18,559 = 0.06%*
<hr/>		
Proxy 3	Participation of Czech inventor(s) in international teams of the ten multinationals	
	Participation of Czech inventor(s) in international teams in patents located in Western Europe, 2013, %	22/2305= 0.95%*

Note: *confidence interval of 10% at the 99% confidence level.

Our methodology was the following: firstly, we listed the European affiliates/headquarters of each of the ten multinationals to which patents were granted in 2013. Secondly, we examined all the patents of the affiliates/headquarters with a small number of patents (less than 150 patents in 2013). Thirdly, we calculated the sample size needed for affiliates with a large number of patents (more than 150 in 2013) for a confidence interval of 10 % at the 99% confidence level. Fourthly, we examined the patents picked out at random to assess the proxy variable for each affiliate of each multinational. Fifthly, we summarized the information for each multinational (see Appendix 2) and then for the ten multinationals.

Source: Author's calculations based on the Amadeus database (see Appendix 2).

Finally, our analysis fails to detect a process of transfer of innovative R&D from Western Europe to the Czech Republic in a recent period. The Czech Republic has become a major hub in the European car and components production. The location of large-scale manufacturing plants by leading automobile manufacturers (Volkswagen-Skoda, Hyundai, Toyota-PSA Peugeot Citroën) has attracted a vast number of global component suppliers which have established plenty of plants across the country (Czechinvest, 2013, 2014a, 2014b). With 2880 R&D personnel and an intra-mural R&D expenditure of USD 400 million in 2009, the foreign-owned automotive sector in the Czech Republic is the most active in R&D in Central Europe. However, Skoda excepted, the patenting activity of the Czech automotive affiliates remains a marginal phenomenon. Hyundai, Peugeot-Citroën (PSA) and Toyota did

not have any patenting activity at all although they located production facilities in the country in the mid-2000s. Major global automotive suppliers such as Bosch, Lear, Faurecia, Denso, Behr, Valeo, each owns several production facilities in the Czech Republic (e.g. five for the Bosch Group) but still do not apply for patents, suggesting the absence of real innovative activities. The automotive manufacturers and component suppliers still come to the Czech Republic for production reasons and not to promote their innovation potential by taking advantage of local competencies and ‘reverse spillovers’.

Only very few Czech R&D centers have been transformed by multinationals into regional ‘centers of excellence’ or ‘flagship R&D centers’. Basic R&D is almost totally absent from the R&D centers, even in the R&D centers considered to be important by the multinationals. Most of the time, they are either design centers or development and testing centers. Four multinationals consider that their Czech R&D center has taken up a prominent position in their European R&D organization: the ‘global R&D center’⁹ of Honeywell in Brno, the ‘flagship R&D center’¹⁰ of Visteon in Novy Jicin, the two ‘global development centers’ of Siemens in Prague and Ostrava and Skoda’s ‘development center’ in Cesana near Mlada Boleslav. Skoda states that ‘*with the facility in Cesana, [it] has the third-largest development center within the Volkswagen Group and one of the most modern ones in the entire automobile industry*’.¹¹ Yet, only Skoda is engaged in innovative R&D. In the Czech Honeywell and Visteon R&D centers – although considered as important R&D affiliates by the multinationals –, the patenting activity remains marginal. Over the 2008-2013 period only seven patents were granted to the Czech affiliate of Honeywell and none to Visteon’s affiliates.

The Czech affiliates’ position in the R&D organization of global players can be exemplified by the case of the German multinational Siemens. In 2013, the company possessed seven factories with integrated development departments and two ‘global development centers’ in the Czech Republic (Siemens, 2014). The development center in Prague is one of the 176 main R&D locations in the world. In 2013, the Czech affiliates employed 9700 people, and among them 540 were involved in R&D. Although the multinational belongs to the most active R&D companies in the country, it remains clearly specialized in production: the Czech affiliates employed 2.7% of Siemens’ world staff, but only 1.8% of the world R&D personnel. The main occupation of R&D personnel in the Czech affiliates can be assessed by studying Siemens’ patent applications. In 2011, Siemens was the world leader regarding patent applications to the European Patent Office and was positioned at the tenth position among the owners by the US Patent and Trademark Office. Siemens applied in Europe for over 4700 patents in 2013 (Appendix 2). However, the Czech affiliates’ patenting activity remains totally marginal: during the period 2008-2013 only 26 patents were granted to Czech affiliates and there was even a strong decline between the 2008-2010 and 2011-2013 periods. The 540 people engaged in R&D activities do not participate to the Siemens international teams for patents (see proxy 3 in Appendix 2). The Czech R&D remains oriented towards design, testing and various adaptive activities. Siemens did not engage in innovative activities in the Czech Republic, despite the opening of so-called ‘global development centers’.

⁹ downloaded on 10 September 2014 from:

<http://honeywell.jobs.cz/working-at-honeywell/honeywell-in-czech-republic/en/>

¹⁰ downloaded on 10 September 2014 from <http://www.hvccglobal.com/en/company/network>

¹¹ downloaded on 10 September 2014 from <http://www.skoda.fr/actualites/2012-09-25-engine-testing-center>

6. Conclusion

This article questions the nature of the foreign direct R&D investments in Central Europe. We test two opposite hypotheses.

Hypothesis 1 states that, after an initial period devoted to the location in Central Europe of production facilities and production-related R&D – mainly for cost reasons – the multinationals have recently engaged in a new generation of R&D investments. This new generation of foreign direct investments undertakes innovative activities and no longer only incremental developments. Foreign direct R&D takes more and more the form of ‘asset-seeking R&D investment’ aiming at augmenting the existing multinational’s assets by absorbing and acquiring technological ‘reverse spillovers’.

In **Hypothesis 2**, the creation of production facilities remains the major determinant of the investments in Central Europe. Foreign direct R&D investments aim at facilitating the production by adapting it to the local conditions. Multinationals possess an innovative advantage that they want to exploit in the host country. In this hypothesis, the division of R&D activities between on the one hand the headquarters and Western affiliates of the multinationals, and on the other hand, the Central European affiliates remains strict. The former continue to host the major R&D centers specialized in basic research and applied research whereas the latter undertake incremental developments when needed for production reasons or required by the customers.

The two hypotheses are assessed in three steps. In the first step, we use OECD data on foreign direct R&D expenditure and personnel, to compare the foreign affiliates’ R&D intensity with the indigenous firms’ R&D intensity. With the presence of multinationals belonging to the major players in world industries one would expect a significant difference in the R&D investments of the two categories of actors. However, the analysis suggests little difference between the foreign-owned and indigenous companies providing a first indication that Central European foreign direct R&D is mostly production supportive and associated with the international exploitation of technology produced in the home country of the multinationals.

R&D data does not provide information on the nature of the R&D activities of the firms. Patent data does. Indeed, patents result from innovative R&D. We therefore use, in a second step, patents granted to foreign affiliates in Central Europe as a proxy variable of innovative R&D to assess the evolution of innovative R&D activities in Central Europe. An increase in patents granted to the foreign affiliates of multinationals in Central Europe would be the sign of the emergence of innovative R&D. We find that the patenting activity of foreigners rose with the increase of their R&D investments in Central Europe between 1990 and 2010. But we also demonstrate that the Central European affiliates still have a marginal position in the patenting strategy of the multinationals.

In a third step, we focus on the patent data of the foreign affiliates in the Czech Republic – the Central European leader regarding foreign direct R&D investment –, in the major foreign direct R&D sectors – electronics, electrical equipment, machinery and motor vehicles –. We build a sample made of the ten foreign multinationals representing the most active R&D investors in the four sectors in the Czech Republic and assess their recent patenting activity. We find that, with the notable exception of Skoda-Volkswagen, even these major R&D investors (regarding R&D employees and R&D expenditure) still only marginally apply for patents in their Czech affiliates. We also show that there is no under-evaluation of the innovation activity of the Czech affiliates due to a geographical separation of inventions – in the Czech Republic – and patent location – in Western Europe –. We finally demonstrate that the researchers working in the Czech affiliates are still not sufficiently oriented towards

innovation activities to be integrated in the patenting-oriented international teams built by the multinationals.

All these results suggest that in the middle of the 2010s, foreign direct R&D investments in Central Europe remain mostly production supportive and associated with international exploitation of technology produced on a national basis. Even the multinationals that announced – in annual reports, newsletters, etc. – the location of so-called ‘regional flagship R&D centers’ still today only rarely apply for patents. Finally, our study is in line with Pavlinek’s (2012) former work suggesting that routine R&D activities dominate in the R&D activities of the automotive multinationals in Central Europe. We demonstrate that this phenomenon is not limited to the automotive industry and we detect no recent shift in the R&D strategy of the multinationals towards an acceleration of the location in Central Europe of innovative R&D. Our evaluation based on objective information – patents –, completes existing field research which assesses the nature of the R&D activities of affiliates by subjective information delivered by the staff of the multinational (e.g. Sass 2013).

The extant literature detects an increase in the internationalization of R&D activities towards emerging economies. Some studies also stress the increasing role played by foreign affiliates, located in emerging markets, in the R&D innovative activities of multinationals. Our study highlights the increase of foreign direct R&D investments in Central Europe, but does not find a shift towards innovative R&D activities. Even global players who have located numerous production affiliates in Central Europe for more than a decade still carry out few innovative R&D activities.

Our results question the efficiency of the governmental R&D policies in Central Europe. In the Czech Republic, but also in Hungary, policies aiming at attracting foreign direct investments – in the 1990s – and foreign direct R&D activities – since the 2000s – have been the pillars of the government’s economic strategy (Guimon 2013). Most of the policy actions – e.g. the Czech supplier development program, the Czech cluster program, the Czech R&D cooperation program – were launched to facilitate the foreign direct R&D activities. Generous incentives were devoted for a couple of years to the attraction of this type of foreign investors. Moreover, since the Czech Republic’s entry into the European Union in 2004 a large share of the structural funds received from the EU has been used to provide incentives and to support foreign direct R&D activities (Guimon 2013:4). The Czech policy succeeded in attracting R&D by multinational firms and in transforming the country into the major destination among the new EU-members of foreign direct R&D activities. However, despite the strong commitment of the Czech government to foreign direct R&D, real innovative R&D increases very slowly. This situation offers few opportunities of transfer of advanced technology to indigenous firms which still fail to catch up on the innovation performance of the firms of the core European Union countries. The tools and methods of the Czech industrial and innovation policies need therefore, at least, to be re-assessed.

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Appendix 1. Excerpts of ISIC, Revision 4

Division	Description
10	Manufacture of food products
19	Manufacture of coke and refined petroleum products
20	Manufacture of chemicals and chemical products
21	Manufacture of pharmaceuticals, medicinal, chemical and botanical products
22	Manufacture of rubber and plastics products
24	Manufacture of basic metals
25	Manufacture of fabricated metal products, except machinery and equipment
26	Manufacture of computer, electronic and optical products
27	Manufacture of electrical equipment
28	Manufacture of machinery and equipment, n.e.c.
29	Manufacture of motor vehicles, trailers and semi-trailers
30	Manufacture of other transport equipment

Appendix 2. Main foreign direct R&D centers/departments in the Czech Republic (in ISIC 26-29): patents and inventors

Multinational	Country of origin	Type of R&D activity	Location	Date of creation of the R&D facility	Number of R&D personnel, 2013	Proxy 1a		Proxy 1b		Proxy 2a	Proxy 2b	Proxy 3	Separation invention/patent
						2008-2010	2011-2013	2008-2010	2011-2013	2008-2013	2013	2013	2013
Bosch Auto	Germany	Dev. and tech. center	Ceske Budejovice	2005	300	0/10,058	0/15,760	0/19	0/9	-	1/6250	1/1000	770/6250
Continental	Germany	Dev. center	Ostrava	1993(a)	160	0/2421	3/3120	0/96	3/271	0/3	0/1340	0/126	77/1340
Hella	Germany	Dev. dep.	Mohelnice	1992(a)	340	5/535	3/508	5/5	3/1	0/8	0/187	0/7	0/187
Magna	Canada	Product dev. center	Liberec	2000(a)	+ 50	0/- (b)	27/-(b)	0/401	27/558	0/27	0/202	0/13	6/202
Rieter	Switzerland	Design center	Usti nad Orlici	2003	+ 50	34/143	37/132	34/49	37/75	1/71	2/65	10/15	24/65
Siemens Auto	Germany	Dev. and testing centers	Letohrad Prague Ostrava	2007	540(c)	0/10,399	2/15,788	0/312	2/1573	0/2	0/4762	0/795	524/4762
TRW	Germany	Tech. support center	Dacice	2006	+ 50	1/328	1/229	1/32	1/98	0/2	0/151	1/2	0/151
Valeo	France	Tech. and dev. center	Prague	2002	70	2/974	4/1606	2/279	0/444	0/6	0/1011	3/78	49/1011
ZF	Germany	Dev. center	Plzen	2007	150	0/2248	0/3033	0/26	0/38	-	7/1157	7/66	58/1157
VW (Skoda)	Germany	Tech. dev. department	Mlada Boleslav	1992(a)	1800	63/7250 (d)	98/8838 (d)	63/103 (e)	98/87 (e)	5/161	0/3434 (f)	0/203 (f)	57/3434
TOTAL						105/34,356 = 0.3%	175/49,014 = 0.4%	105/1322 = 7.9%	175/3154 = 5.5%	6/280 = 2.1%	10/18,559 = 0.06%	22/2305 = 1.0%	1565/18,559 = 8.4%

Notes: Proxy 2a, proxy 2b and proxy 3: confidence interval of 10% at confidence level of 99% for Bosch, Continental, Siemens, Valeo, ZF and VW. All the patents granted in 2013 were evaluated for Hella, Magna, Rieter and TRW.

Total number of patents analyzed: 2799, which represented 15.1 % of the patents granted in 2013 in Europe to the ten companies. In details, we assessed 202 patents granted to Bosch (out of 6250 patents), 382 to Continental (out of 1340), 187 to Hella, 202 to Magna, 65 to Rieter, 265 to Siemens (out of 4762), 777 to Valeo (out of 1011), 264 to ZF (out of 1157) and 304 to VW (out of 3434).

(a) date of creation of the affiliate; (b) information in the Amadeus database is limited to Europe; (c) 540 employees involved in R&D in eight affiliates in the Czech Republic; (d) patents granted to Skoda compared to the patents granted to the Volkswagen and Audi headquarters/affiliates in Germany; (e) patents granted to Skoda compared to the patents granted to the Seat headquarters in Spain; (f) Seat excluded, because the address of inventors is unavailable.

Sources: Amadeus database; Czechinvest; information released by the multinationals (various years).