Chapter 4
R&D internationalisation and local innovation in the Visegrad Group after the FDI peak

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1. Introduction

One policy objective of the Visegrad group of countries[1] (V4) is to encourage economic growth by enhancing technology transfer and technological learning. Foreign direct investment (FDI) can facilitate the cross-border transfer of a variety of resources, including process and product technology, managerial skills, marketing and distribution knowledge and human capital. It can also result in significant positive *spillovers* to the local economy through linkages with local suppliers, competition, imitation and training. Yet, the V4 has played only a marginal role in attracting foreign research and development (R&D) targeted towards creating new local competences. Still, the region has the advantage of having geographic and cultural proximity to Germany and Austria, as well as having a skilled scientific workforce and relatively lower R&D costs. One noticeable trend is that the internationalisation of R&D activity has increased significantly in all four countries over the past sixteen years.

Decisions on the extent and location of foreign R&D activities of global enterprises can be very complex, often involving the expansion or modification of already existing investment projects. Though multinational companies generally prefer to keep their R&D activities close to their headquarters, they sometimes locate R&D activities and other technical support in their subsidiaries with the intention of adapting existing technologies, resources and products to local market conditions. These asset- (Dunning and Narula 1995), competence-exploiting (Cantwell and Mudambi 2005) or home-base (Kuemmerle 1999) activities mainly reflect local demand conditions, including the size of the home market, the competence of the parent enterprise, as well as regulations, standards, and consumer tastes (Jindra 2012). Multinationals may also locate foreign R&D activities in specific locations with the target of creating new technology and products. These asset-augmenting or competence-creating activities mainly reflect local supply conditions, including whether the multinational company recognises the technological skills of the workforce, the relative cost of high-tech labour, proximity to universities and R&D laboratories and to potential partners.[2]

This chapter considers R&D internationalisation from the perspective of the technology accumulation approach developed by Cantwell (1989), Stephan (2006, 2013) and Jindra (2012). Their approach originates in the dynamic, evolutionary theory of Nelson

1. The V4 is made up of Czechia, Hungary, Poland and Slovakia.

2. Competitive enterprises often follow both strategies simultaneously, suggesting the motives cannot be easily separated. Narula and Zanfei (2005) and Sachwald (2008) suggest that asset-seeking strategies have become more frequent, but that asset-exploiting strategies continue to predominate.

and Winter (1982), considering the importance of technical change in the context of localised technological learning. The idea suggests a cumulative relation between existing location-specific advantages within the host country, decisive for the locational choices of multinational companies. Stephan (2013) distinguishes between the technological role of internal and external networks, stating that internal networks give rise to internal technology transfer between parent and affiliate, while external networks give the foreign investor access to local knowledge and technology. This provides a way to relate the spatially bounded technological capabilities to the internationalisation of R&D and innovative activities.

The second section considers the sourcing of foreign technical knowledge in the V4. Section three provides a review of recent trends in the internationalization of R&D by multinational companies in the V4. Section four then asks who are the major foreign R&D investors in the V4 and from what industries do they come. Here the automotive industry is discussed in more detail. Section five discusses innovative activities from the point of view of whether the company has a foreign head office or not. The rise of global innovation networks is then considered in section six. By way of conclusion, section seven addresses the issue of whether the R&D activities of foreign enterprises in the region are having a significant influence on technological upgrading and innovation-driven growth.

2. Foreign knowledge acquisition and local knowledge creation in the V4

Gross domestic spending on R&D not only leads to the creation of new technologies in the V4, but also improves companies' ability to absorb already existing knowledge and technology. Cohen and Levinthal (1989: 569) observed that companies have to enter a time-consuming and costly process of investing in their capacity to absorb knowledge, or their 'ability to identify, assimilate and exploit knowledge from the environment', if they are to successfully apply the knowledge learned from spillovers. This idea becomes a connecting device between the potential for catching up (technological opportunities) and its realisation (appropriation conditions). Technological opportunities can arise from changing patterns of demand, changes in the size of markets, the product cycle and new developments in science and technology. Realisation of these opportunities will depend on the ability of entrepreneurs to secure profits generated by innovation (Fagerberg *et al.* 2007).

The absorptive capacity (knowledge, skills and experience) of the local affiliate defines the pace of technological accumulation within the global enterprise. Multinational companies can transfer technology directly (internally) to local affiliates under their ownership and control or indirectly (externally) to companies not under their control. They can also encourage technical change and technological learning directly through technology upgrading and indirectly through technology transfers from within their networks to local companies. Spillovers can occur between companies that are vertically integrated with the global enterprise (inter-industry spillovers) or in direct competition with it (intra-industry spillovers). The innovation system, together with

the absorptive capacity of other enterprises, will determine the pace of technical change and technological learning in the region as a whole (Rojec and Knell 2017).

R&D is often seen as a linear sequence of functional activities, but evolutionary models emphasise that innovative activities are the outcome of a dynamic non-linear process. Schumpeter (1934) perceived innovation as part of the economic process itself, with the actions of cost-minimising capitalists generating a tendency toward equilibrium through the search for *global* investment opportunities, and the actions of *local* profit-seeking entrepreneurs engendering disequilibrium through the introduction of new products, markets, production methods and new organisational forms. Increasing market demand also encourages technical change and technological learning as it induces companies to invest and rationalise production. Innovation should not be considered the same as R&D activity, as it does not imply pushing back the frontiers of knowledge, but developing the capability for technological learning and technical change.

The challenge for the V4 is to build the appropriate or relevant technological and organisational capabilities needed to carry out specific tasks and assimilate new knowledge. Building technological capabilities is a cumulative, path-dependent activity that generates technical change, investment in new capacity and ultimately growth. It is also a complex and diverse activity that involves interaction between users and producers, and between companies and other organisations, engendering different patterns of technological accumulation and innovation depending on the learning structure. The incentive structures underlying the institutional arrangements support and sustain the rate and direction of technological learning, providing an important influence shaping public policy. Appropriate technology and innovation policy can improve the absorptive capacity of local companies by opening up access to foreign knowledge and through R&D incentives and various forms of public support intended to speed up local knowledge creation (Lee 2013).

Most competences acquired before 1990 became obsolete immediately after the economic collapse of Eastern Europe, meaning that new ones had to be acquired (Pavitt 1997). With only a tenuous connection between innovation, diffusion and productivity gains under central planning, institutional change was required to put the economies on a new path of economic growth. The transition from central planning to a market-oriented economy proved to be a formidable challenge for the V4 countries, especially when considering the twin issues of technical change and technological learning. Over the past 25 years, the V4 has played only a marginal role in attracting foreign R&D aimed at creating new local competences. The challenge for the V4 is to shape and create new technological opportunities and market landscapes.

Upgrading technology in the V4 to EU levels necessarily involves learning to use and improve technologies that already exist in the relatively more advanced industrial economies, and not by pushing the knowledge frontier further.[3] Learning-by-doing,

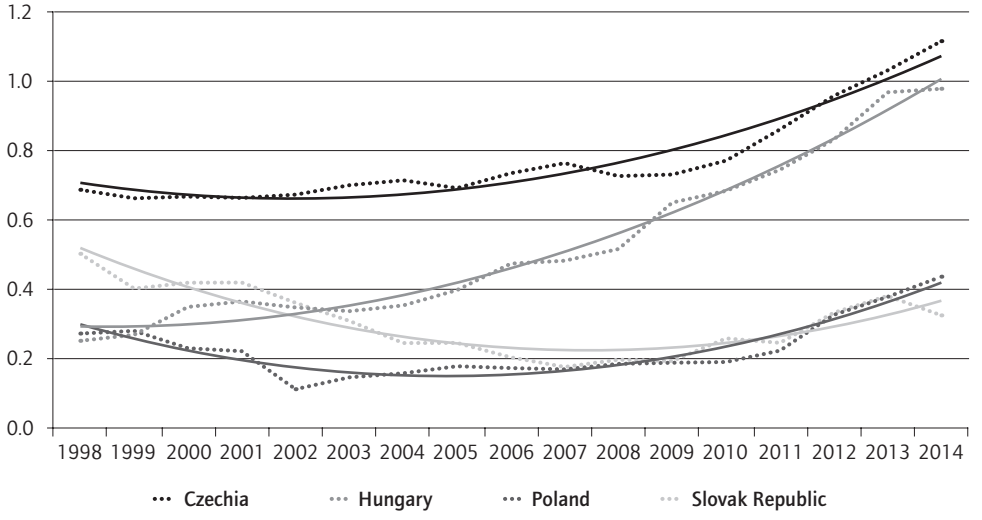
3. Catching-up can also be percieved as moving up the value chain ladder. The V4 is deeply integrated in global or European value chains.

learning-by-using and learning-by-failing involve building the capability to master, appropriate, and improve already existing knowledge (Lall 2000). Countries that have invested heavily in the formation of skills and R&D capabilities appear to be capable of catching up, while those that have not made such investment are falling further behind (Lee 2013). A mission-oriented approach to R&D and innovation policy could put the V4 countries onto a path of economic growth, but this involves bold, risk-taking actions by both private and public-sector entrepreneurs (Mazzucato 2015).

Total R&D spending in 2015 as a share of GDP (R&D intensity) was still comparably low in the countries within the group, although significantly up on 2005. Czechia and Hungary (1.9% and 1.4% respectively) had moved closer to the EU average (2%) by 2015, though still far away from the EU2020 target of 3%. Slovakia and Poland had lower values (1.2 and 1.0%) but still higher than other CEE new member states (Eurostat 2017).

Figure 1 illustrates the evolution of business enterprise R&D spending (total BERD) as a percentage of GDP (BERD intensity) in the V4. Compared with 2005, Czechia and Hungary had seen significant increases in BERD intensity (1.1% and 1% respectively) by 2015. Poland and Slovakia on the other hand did not show much progress and had a BERD intensity of just around 0.4% in 2015. All V4 countries received significant help from European structural and investment funds, which also appear in the statistics as inward BERD (see also the chapter by Ferry in this publication).

Figure 1 **BERD intensity in the V4, 1998-2014**



Source: OECD Main Science and Technology Indicators, 2017

3. R&D Internationalisation and the V4

R&D activities have become increasingly internationalised over the past 60 years. Though multinational companies have been carrying out R&D activities abroad for many years, the trend accelerated significantly in the mid-1990s (Israel 1998).[4] Within 10 years, R&D expenditure of foreign affiliates worldwide more than doubled, from US$29bn in 1993 to US$67bn in 2002 (UNCTAD, 2005). Similar statistics from the OECD (2008) show that R&D under the control of foreign companies more than doubled from US$37bn in 1995 to more than US$83bn in 2005 in the OECD countries. Moreover, the share of corporate R&D spent outside the home country by Western European multinationals almost doubled from 26 to 44%, while the share spent by North American multinationals increased from 23 to 32% over the same period. There is a clear global trend of multinational companies increasingly locating R&D activities outside their home country. Statistics on R&D internationalisation have also improved in recent years (OECD 2015).[5] Most European countries now collect information from domestically-owned enterprises and foreign-owned subsidiaries about their total business enterprise research and development (BERD) on a bi-annual basis. Inward BERD represents expenditures of foreign-owned affiliates in the reporting country, while domestic BERD refers to expenditures of domestically-owned affiliates in the reporting country[6]. Sectoral data are generally available at NACE (revision 2) two-digit level. The quality and availability of inward BERD data is reasonably good for the manufacturing sector, but not for service industries.

More than half of the total €4.4bn BERD activity in the V4 took place in the manufacturing sector. R&D activity by foreign enterprises is important for all four V4 countries. In 2013, foreign enterprises accounted for over 60% of total BERD in manufacturing, or about €1.35bn. Czechia and Hungry each accounted for more than €600m of inward BERD in manufacturing, Poland for about half of that, while Slovakia was estimated to have about €100m. By contrast, domestic enterprises carrying out R&D activities in the manufacturing sector spent less than €600m in the entire V4 in the same year. While there is no data for service industries in Poland and Slovakia, inward BERD in the Czech service sector makes up about one third of total inward BERD, and about 60% in the Hungarian service sector.

Figure 2 illustrates the intensity of R&D internationalisation over time. The trend line shows that R&D internationalisation (share of foreign BERD in total BERD) has increased quite significantly over the past 16 years in all four V4 countries; the largest increases were observed in Poland and Slovakia, but there were also noticeable increases in Hungary and Czechia. Considerable variation was observed in the statistics in all four countries, ranging from as low as 10% in Poland in 2001 to over 80% in Slovakia in

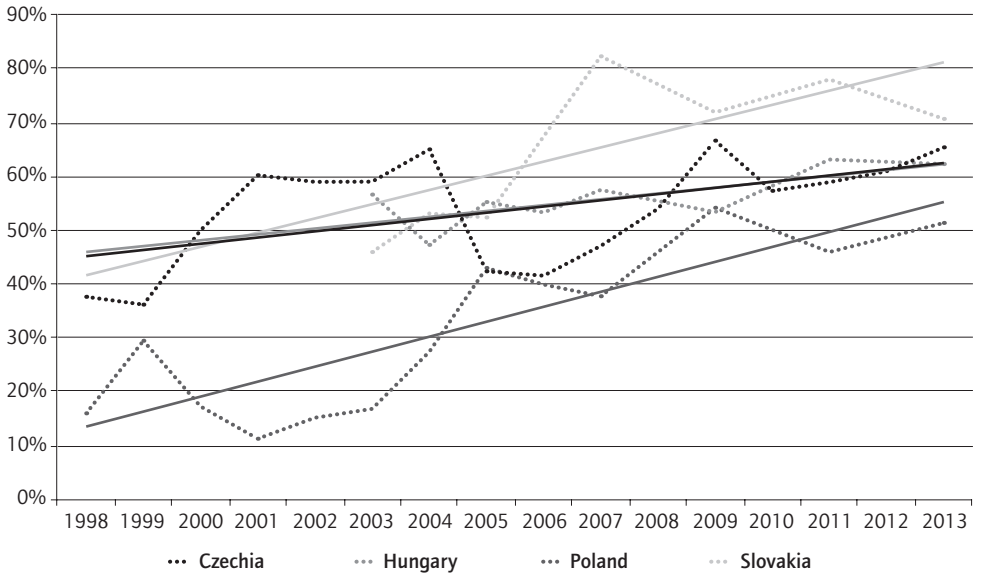
4. Thomas Edison is often credited with the creation of the first industrial research laboratory in Menlo Park, New Jersey, which included several scientists who had migrated from other countries, especially Germany. The laboratory became a model for other institutes and enterprises to duplicate in the late nineteenth century, but became most notably a leading source of new industries and technologies. Another example is IBM's research laboratory located in Switzerland since 1956.

5. The Frascati Manual (2015) provides 'the guidelines for collecting and reporting data on research and experimental development'.

6. In line with the terminology of the European Commission, this chapter will use the term 'inward BERD' for business R&D spending by foreign-owned affiliates (also referred to as 'foreign BERD')

2007. R&D internationalisation generally appears highest in small countries, as is the case with the V4 where Slovakia has the highest share and Poland the lowest. The other side of the coin is that there were very few domestic companies in the V4 engaging in any significant R&D activity. By contrast, the larger European countries, such as Germany and France, have a much lower share of R&D internationalisation, as business R&D is mainly driven by domestic companies.

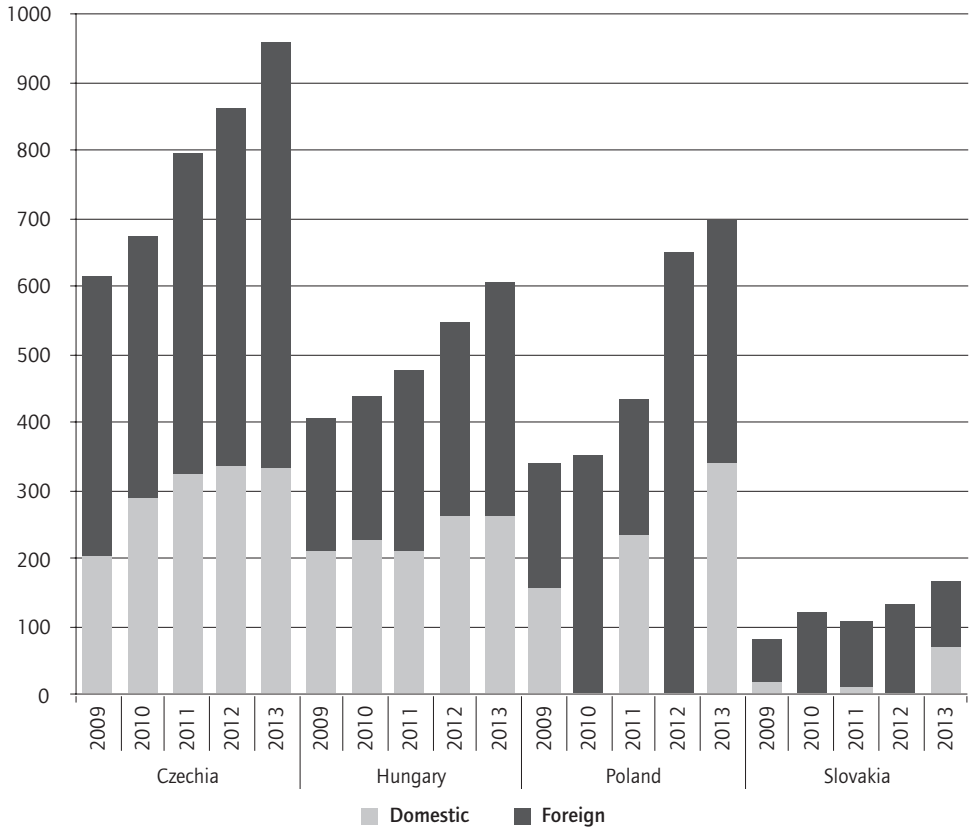
Figure 2 **Share of R&D by foreign affiliates (inward BERD) in total BERD in the V4 (%)**



Source: own calculation based on Iversen *et al.*, 2017

Growth of inward BERD has been very strong in the V4 since 2009. Figure 3 confirms how R&D internationalisation has evolved, showing business R&D activity in the manufacturing industries broken down into its domestic and foreign components between 2009 and 2013. There appears to have been little or no growth in domestic R&D activity from 2009 to 2013 in all four countries, except in Poland where it increased significantly. However, inward BERD increased significantly in all countries over the same period. Inward BERD can have both positive and negative effects. Inward R&D-related FDI can increase technology accumulation in the V4 but can also result in a downsizing of indigenous R&D capacity, a crowding-out of the labour market, and a loss of technical competences (Piscitello and Santangelo 2011).

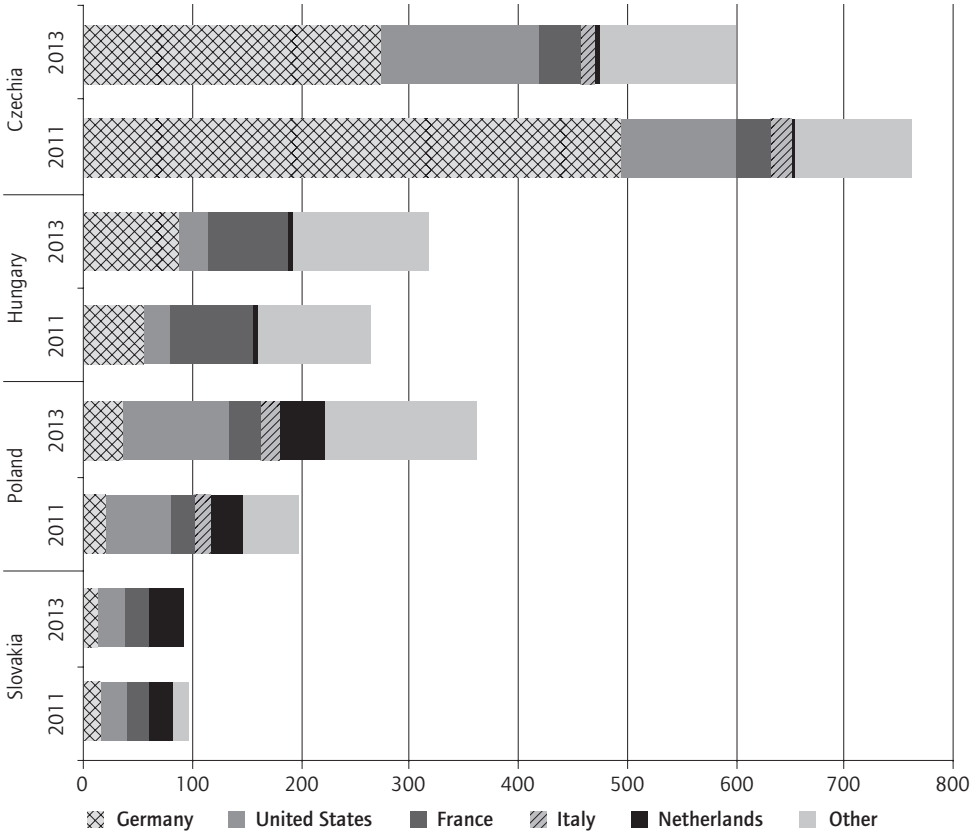
Figure 3 **Domestic and foreign BERD in manufacturing at constant 2010 prices in millions of Euros**



Note: for Poland and Slovakia values for 2010 and 2012 show total BERD.
Source: own calculation based on Iversen *et al.*, 2017

Figure 4 shows that Germany and the United States were the largest foreign investors in R&D activity in the V4 industrial and construction sectors. Germany was the main source of inward BERD flowing into Hungary and Czechia. In the early 2010s, German companies accounted for more than half of inward BERD in these sectors in Czechia and for about a third in Hungary. US-based companies also made significant investments in Czechia, while companies based in France and in Sweden made notable investments in Hungary. Poland experienced a very large jump in R&D funding from 2011 to 2013, mainly because of R&D activity carried out by US-based companies. R&D activity financed by foreign companies increased by 75% over the two-year period, while domestic investment increased at a much lower rate. And although the size of R&D investments in Slovakia was low when compared with the other countries in the group, R&D internationalisation was the highest. Companies based in the Netherlands, Germany, France and the United States invested in R&D in Slovakia during 2013.

Figure 4 **Inward BERD in industry and construction, by country of origin, millions of Euros**



Source: Eurostat and Iversen *et al.*, 2017

The connection between inward BERD and productivity highlights some of the important issues within the V4. Table 1 shows apparent labour productivity[7], BERD intensity (share of BERD in value added) and the share of R&D employment for 2009, 2011 and 2013. Apparent labour productivity of foreign enterprises appears to be twice as high as that of domestic ones in the V4, though at levels significantly lower than in Germany. A similar pattern is observed for BERD intensity and the share of R&D employment, though the differences are not so great. Compared to domestic BERD, inward BERD is significantly higher in Czechia and Slovakia (although Slovakia has low levels in both), while in Poland the shares are more balanced, with relatively low BERD spending. The data for Hungary indicates that R&D intensity is more domestic-oriented and that the share of R&D employment is higher in multinationals.

7. Apparent labour productivity is gross value added per person employed, expressed in thousands of Euros.

Table 1 **Apparent labour productivity (in thousand EUR) and BERD intensity (%) in manufacturing, 2009, 2011, and 2013**

		Apparent labour productivity			Share of BERD in value added			Share of R&D employment		
		2009	2011	2013	2009	2011	2013	2009	2011	2013
Germany	*Domestic*	*52.1*	*64.5*	*64.6*	*11.7*	*9.8*	*10.6*	*3.7*	*3.5*	*3.4*
	Inward	*82.8*	*89.2*	*82.5*	*9.4*	*10.4*	*12.5*	*6.0*	*7.4*	*7.8*
Czechia	Domestic	15.8	18.5	18.3	2.2	2.7	2.5	0.9	1.1	1.1
	Inward	30.0	36.0	37.2	3.5	4.1	3.3	1.5	1.6	1.9
Hungary	Domestic	16.1	18.0	17.3	2.9	2.4	3.2	1.1	1.4	1.7
	Inward	32.2	39.2	39.4	2.1	2.1	2.5	1.3	1.6	1.9
Poland	Domestic	15.7	19.2	20.7	0.7	0.9	1.1	0.5	0.6	0.7
	Inward	32.7	37.1	35.5	0.9	0.8	1.4	0.5	0.8	1.0
Slovakia	Domestic	13.1	15.7	15.6	1.1	0.7	:	0.4	0.3	:
	Inward	19.6	28.5	31.8	1.6	1.5	:	0.4	0.7	:

Source: Eurostat

An alternative way to measure the number of announced greenfield R&D FDI projects and related design activities is by source and destination. Announced greenfield FDI projects include information about R&D activities, including design, development and testing that originate in (are funded by) one country but are carried out in another. The fDi Markets database (Financial Times Ltd) provides an alternative, but complementary picture of the internationalisation of R&D activity, with its data covering a sample of 3,480 announced FDI projects in high to medium-high technology-based industries from 2010 to 2015. It differs from the BERD data in its source in that it includes reported projects focused on R&D and/or design. Table 2 contains a matrix of announced greenfield R&D FDI projects, by source (originating) country (or region) by row, and the destination (receiving) country (region) by column, from the beginning of 2010 to the end of 2015.[8] The table shows that the vast majority of R&D projects going to Central Eastern Europe were financed by Western Europe and the United States. To be more precise, 13 projects were financed by the V4, but located outside the region, whereas 137 projects were financed by foreign sources (mainly located in Europe and the United States), but located inside the V4 during this period.

8. The matrix resembles a transport-planning problem and is presented here as a square matrix. UNCTAD (2016) presents similar statistics in Annex table 7, but presents them in terms of the world as destination and the world as source (investor).

Table 2 **Number of announced greenfield R&D FDI projects, by source and destination, 2010-2015**

	W Europe	E Europe	USA+	E Asia	Other	*Total*
W Europe	344	140	235	209	418	***1346***
E Europe	6	6	2	2	3	***19***
USA+	412	109	72	255	545	***1393***
E Asia	114	18	105	100	127	***464***
Other	80	20	54	24	80	***258***
Total	**956**	**293**	**468**	**590**	**1173**	**3480**

Source: own calculation based on based on information from the Financial Times Ltd, fDi Markets (www.fDimarkets.com) and Iversen *et al.*, 2017

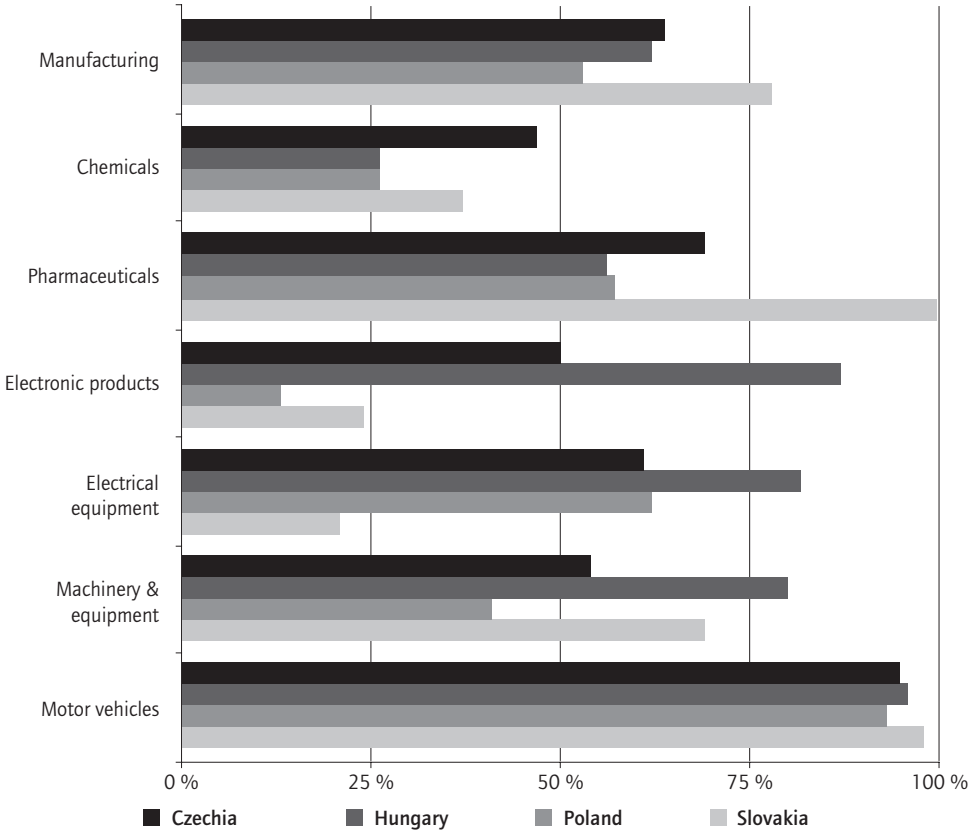
4. The share of foreign investors in business R&D in the main V4 industries, with a focus on the automotive industry

The internationalisation of business R&D is largely shaped by the industries or sectors in which it takes place.[9] Company heterogeneity and behaviour have an important influence on the industrial structure and on both domestic and foreign research and development. UNCTAD (2005) estimated more than 10 years ago that almost 60% of the R&D expenditures of the 700 largest R&D-performing multinationals took place in three industries (IT hardware, automotive, pharmaceuticals/biotech), with a further 20% invested in another three industries (electronics/electrical equipment, chemicals and IT software). Since then the main trends have remained stable, with the same industries tending still to be the most internationalised ones in terms of outward R&D. Pharmaceuticals take the lead (share of foreign R&D of almost 40%), followed by automotive, IT hardware and electronics (30%).

More than half of the R&D activity carried out by Visegrad enterprises is of foreign origin. Figure 5 shows inward BERD as a percentage of total BERD in six relatively more R&D-intensive industries in 2013. There is considerable variation across the industries and countries, as one would expect. More than 90% of R&D activity in motor vehicles is attributable to foreign enterprises in all four V4 countries, while the figure for pharmaceuticals is at least 50%. Figure 6 shows the distribution of total BERD in the V4, by type of ownership in main manufacturing branches. R&D investment in the motor vehicle sector makes up more than a quarter of total BERD, while another quarter is attributed to electrical and electronic products, and machinery and equipment.

9. Pavitt and Patel (1999) observed that a company's competitive advantage 'is often directly related to that of its home country and as such is strongly shaped by that country's industrial specialisations and national innovation systems, including its accumulated research and labour force skills.'

Figure 5 **Inward BERD as a percentage of total BERD, by selected industry, 2013**



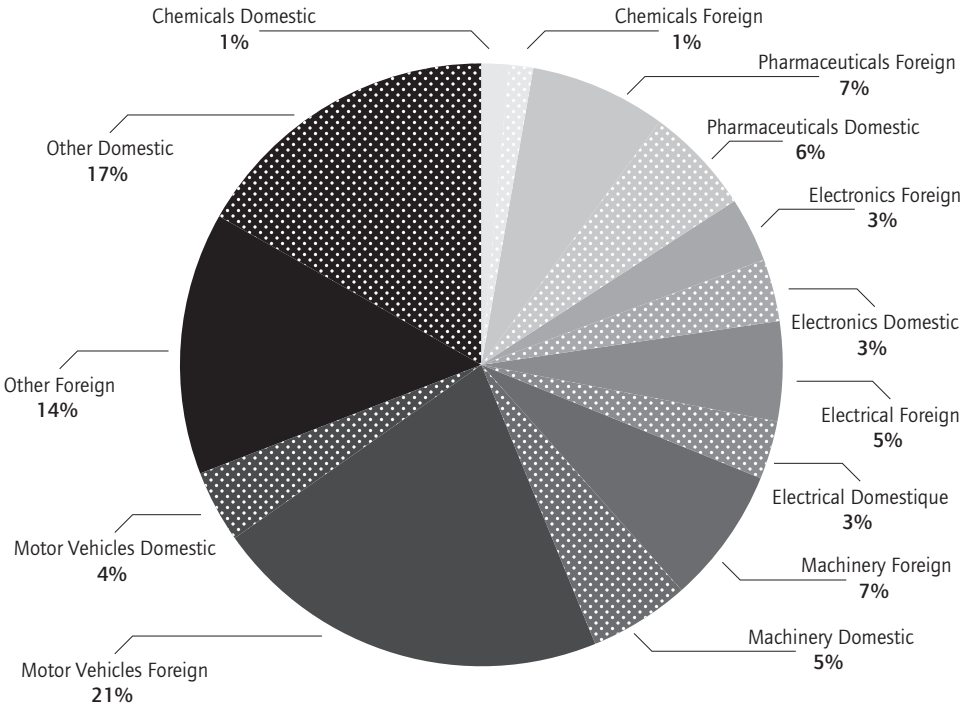
Source: Eurostat and Iversen *et al.*, 2017

This section focuses on the automotive industry. The industry, including the manufacture of parts and accessories for motor vehicles, is classified as a medium-high technology industry on the basis of its R&D intensity. It is a highly internationalised industry with a substantial flow of foreign direct investment from Western Europe (mainly Germany) to Central and Eastern Europe (mainly the V4 countries). R&D internationalisation follows a predominantly demand-driven strategy, as the industry tends to adapt products to satisfy customers' preferences, road and climatic conditions, and governmental regulations in foreign markets (UNCTAD 2005).

R&D activity in the European automotive industry has more than doubled in the past 16 years, accounting for about one-quarter of all European R&D activities in 2015. Activity is highly concentrated on Germany which accounts for almost two-thirds of total European automotive R&D. Germany relies on extensive cross-border R&D networks, in particular to Western Europe (France, the Netherlands, Switzerland and Austria) and also to the United States and Japan (see also Figure 9 on innovation networks), but not so much to the V4 countries, though its R&D activities there increased in the last decade. BERD activity within the industry is dominated by large multinational companies. The

Volkswagen group spent more than €13.6bn Euros on R&D activities in 2015, the most of any global multinational enterprise, and twice as much as it spent in 2010. A member of the Volkswagen group, Škoda Auto invested an estimated €400m in R&D facilities worth in 2014, the most significant such investment in the V4 in the last decade.

Figure 6 **Total BERD in the Visegrad Group, by ownership and industry, 2013**



Source: Eurostat and Iversen *et al*., 2017

One of the conditions of Škoda's sale to VW was the continuation of Škoda's in-house R&D (Pavlínek 2012; 2017). The Czech government played an active role in providing investment incentives for the development of a new Škoda R&D centre, which was opened in 2008. Here, the Volkswagen group adapts existing technologies and design engineering of the upper bodies of its cars to local market conditions, taking into account regulations, standards and consumer tastes. There also appear to be some competence-creating activities, as the Volkswagen group was able to make use of certain technological skills within the workforce and the proximity to the parent firm. Ultimately, Volkswagen was able to significantly lower the cost of in-house R&D by hiring experienced engineers and designers at a wage rate lower than in Germany.

Table 3 shows apparent labour productivity, the share of BERD in value added and the share of R&D employment for Germany and the V4. Apparent labour productivity of automotive production is much higher in Germany than in the V4 countries, while the share of BERD in value added is on average nearly ten times higher than in the V4, as is the share of BERD in value added and the share of R&D employment. In Germany,

the productivity of domestic enterprises in the sector is higher than that of foreign ones, while we see the opposite in the V4 countries. These figures illustrate that R&D intensity remains very low in the V4 automotive industry, while the productivity gap with Germany remains persistently high. The data also suggests that there has been limited technological upgrading in the V4 automotive industry. While apparent labour productivity in the V4 automotive industry improved, the share of BERD in value added did not change in the period examined, and even decreased in Czechia (though the country still has the highest of the V4 countries).

Table 3 **Labour productivity and BERD intensity in the automotive industry**

		Apparent labour productivity			% of BERD in value added			% of R&D employment		
		2009	2011	2013	2009	2011	2013	2009	2011	2013
Germany	Domestic	:	103.2	105.4	:	23.5	27.6	9.2	10.5	10.1
	Inward	58.7	71.0	:	29.8	21.8	:	11.9	9.8	11.7
Czechia	Domestic	14.6	16.6	18.9	4.7	3.3	2.7	1.7	1.6	1.7
	Inward	32.0	42.6	43.1	7.8	8.7	4.6	2.5	2.3	2.6
Hungary	Domestic	12.5	16.6	17.6	1.6	1.9	1.8	1.3	2.2	2.6
	Inward	38.0	51.9	48.1	2.4	1.7	2.5	1.7	1.9	2.1
Poland	Domestic	16.6	19.2	19.9	0.4	1.1	1.3	0.6	1.3	1.6
	Inward	30.4	36.8	36.3	2.5	0.9	2.7	0.4	0.7	1.7
Slovakia	Domestic	11.8	15.0	24.7	0.3	0.2	0.7	0.1	0.1	0.4
	Inward	23.7	32.0	36.6	2.3	2.7	2.1	0.3	1.0	1.3

Note: apparent labour productivity in thousand EUR/worker/year.
Source: Eurostat and Iversen et al., 2017

5. Innovation in foreign-owned enterprises

Business enterprise R&D activities do not accurately describe the innovation process. Technological capabilities are also reflected by a company's ability to introduce higher quality products, cost-saving processes, and improved organisational and managerial processes. Such capabilities are often not captured in statistics measuring R&D activities, and indeed R&D surveys and innovation surveys are often carried out by very different people within an enterprise. Furthermore, foreign direct investment, joint ventures, strategic alliances, technology licensing, subcontracting and embodied technology transfer all play an important role in the innovation process.

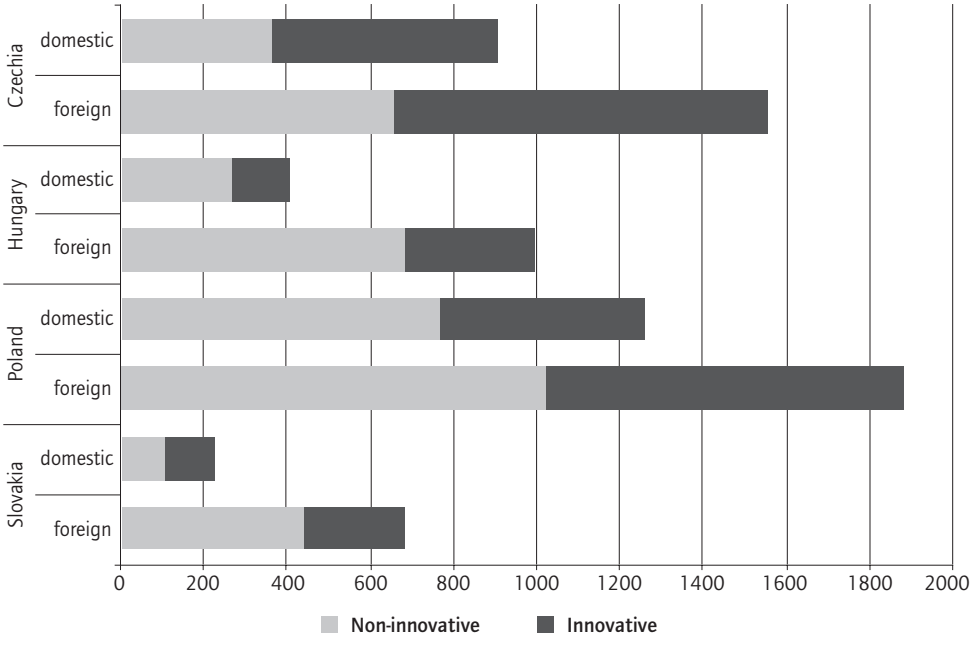
The Community Innovation Survey (CIS-2014) is one of the best ways to measure innovation.[10] It draws on Schumpeter's distinction between five kinds of innovation:

10. The Community Innovation Survey provides information on knowledge inputs going into the innovation process, including R&D expenditures within the company, collaboration with other companies and organizations, and R&D acquired outside the company, all of which are relevant for analyzing R&D internationalisation. The survey is based on the so-called Oslo Manual (2005) which provides guidelines for creating new input and output indicators that capture the innovation process and for composing survey questionnaires. Originally issued in 1992, the manual has been revised three times, with a fourth revision planned for next year.

new products, new production methods, new markets, new sources of supply and new forms of organisation. The survey identifies whether an enterprise is a member of an enterprise group and whether it is foreign. This means that each enterprise within the group can serve different markets, as with national or regional subsidiaries, or serve different product markets. An enterprise group is an association of enterprises under common ownership and controlled by the group head or parent. The CIS-2014 identifies all enterprises that are part of an enterprise group and enterprises groups that have a foreign head office. Here we only look at those with head offices located abroad.

Figure 7 shows the number of domestic and foreign enterprises in the V4 countries, classifying them as innovative or non-innovative. An innovative enterprise is considered one that introduced new or significantly improved goods or services or a new or significantly improved production process, distribution method, or supporting activity between 2012 and 2014. A non-innovative enterprise would include enterprises that either do not innovate or *only* introduce new organisational and marketing innovations. The data confirms that enterprises with a head office abroad tend to be more innovative than domestic ones. Czechia appears the most innovative of the V4 countries, followed in turn by Poland, Hungary and Slovakia if we consider the absolute number of innovative firms that are part of a global enterprise group. When considering the share of innovative firms within each category, foreign enterprises in Czechia and Poland perform rather well, as do Czech and Slovak ones in the domestic category.

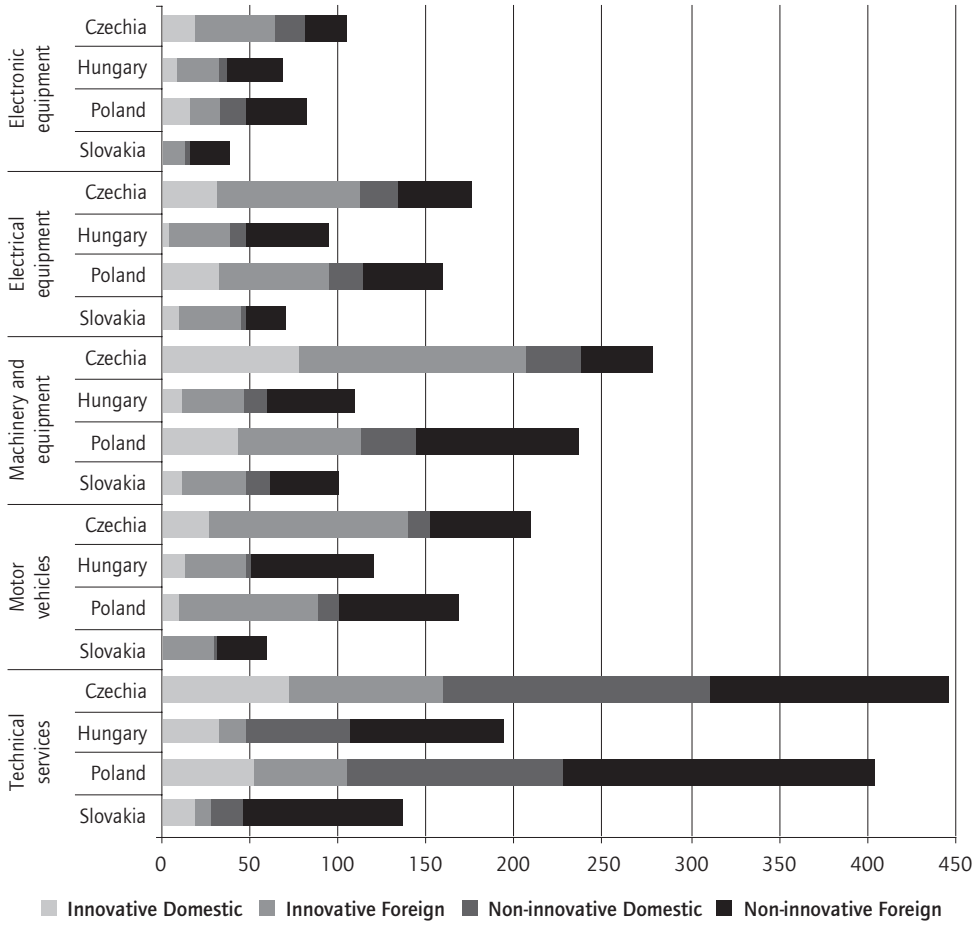
Figure 7 **The number of innovative and non-innovative enterprises that are part of a global enterprise group, 2014**



Source: own calculations based on The Community Innovation Survey (CIS), 2014

Figure 8 shows the number of innovative and non-innovative enterprises included in the CIS-2014 that are part of a global enterprise group by industry and illustrates the distribution according to form of ownership. The grey bars show innovative domestic and foreign enterprises, while the black ones show their non-innovative counterparts. As before, there is considerable variation across industries and countries. One visible pattern is that Czech enterprises appear more innovative than their regional counterparts, but this might be due to certain factors related to the questionnaire or its interpretation. In line with the BERD statistics, the automotive and machinery and equipment sectors appear most active in innovation, as does the electronic and electrical equipment sector, though it is a bit smaller.

Figure 8 **Share of innovative companies that are part of a global enterprise group, 2014**



Source: own calculations based on The Community Innovation Survey (CIS), 2014

The data also includes software and computer services, defined as computer programming, information services, software publishing and related activities. They are part of the Knowledge-Intensive Business Services (KIBS) and generally considered

to be high-tech based on their R&D intensity. However, in the V4, KIBS appear to be smaller enterprises that are less innovation-active. We have few statistics on inward BERD for the V4, except for Czechia. This data indicates that inward BERD accounted for just under half of total BERD from 2009 to 2013 in computer services.

6. The rise of global innovation networks in the Visegrad region

Innovation collaboration between companies and other organisations is essential for the creation, transfer and absorption of new knowledge and ultimately economic growth. Collaboration is important because it reduces the risk and complexity involved in the development of new products and processes by spreading it among several partners with agreed complementary aims. Collaboration is a strategic choice for local and global partners, and companies most often want to be in a *global innovation network*. When strongly embedded in the local social environment, they tend to cooperate with partners in their proximity, provided they have the necessary complementary resources. If these complementary resources do not exist locally, companies are more likely to collaborate with foreign partners. Foreign-owned subsidiaries are not free to choose a collaboration partner, as they tend to have more restrictions than domestically-owned companies. Foreign-owned subsidiaries also have the advantage of being able to tap foreign sources of technological knowledge through other subsidiaries in the group and parents abroad.

The Oslo Manual (2005) also provides the guidelines for measuring collaboration between companies located in different regions and countries. Table 4 provides data from the 2012 Community Innovation Survey showing the innovation collaboration activities of enterprises located in the V4 with domestic and foreign enterprises. Collaboration agreements typically have multiple partners, which means that regional totals do not add up to the number of total collaborations. The vast majority of collaborations occur between individual enterprises, or enterprise groups and organisations within the same country, which is generally the case when collaboration partners include upstream suppliers, downstream customers, competitors, the government and universities and other research institutes. About half of the collaborations involve other European partners, while about 10% of partners come from the United States and nearly 10% from China or India.

Table 4 **Innovation collaboration in the Visegrad region, 2014**

	Any type of collaboration	National	Europe	United States	China or India	Others
Czechia	2,534	2,140	1,277	288	205	207
Hungary	1,032	920	472	96	83	60
Poland	2,616	2,311	1,137	230	155	217
Slovakia	752	600	546	97	91	87

Source: The Community Innovation Survey (CIS), 2014

Freeman (1991), Powell and Grodal (2005) and others have shown that own R&D activity is positively correlated with the intensity of networking and that it positively affects a company's ability to exploit the opportunities arising from innovation cooperation. R&D and innovative activities are becoming globalised for several reasons. Companies tend to internationalise certain activities at earlier stages of their life cycle because of global competition and specialisation as well as the increasing costs of R&D and other innovative activities. The trend towards innovation globalisation is also part of a general tendency of companies to source technology externally and to collaborate with other companies, universities and public research organisations, in addition to investing internally in R&D and innovation activities (Powell & Ginnaella 2010). Data also suggests that companies that collaborate with international partners also collaborate with domestic and European partners (Knell and Shrolec 2008).

Social network analysis can be used to illustrate the spatial structure of international R&D networks. This describes networked structures in terms of nodes or actors within the network and the relationships or interactions that connect them. In our case, each node corresponds to the inward BERD of an individual country whereas each connection corresponds to the total flows between any two countries. Germany appears as the central node in Figure 9, with extensive interaction between it and its neighbours France, the Netherlands, Switzerland and Austria. This observation confirms the analysis of Scherngell (2014) that almost all European R&D activity is located in the centre of Europe, leaving very little in the periphery. Stehrer and Stöllinger (2015) suggest that European manufacturing is becoming increasingly concentrated around a Central European manufacturing core, centred in Germany, but including Austria and the V4. A more recent update by Dachs *et al.* (2014) that includes 2013 data, however, indicates that the V4 has become more integrated into the R&D network.

The main rationale behind innovation globalisation is to gain access to local markets and to specialised knowledge located in different countries and regions. Since knowledge is not evenly distributed across countries and regions, companies create links 'between specialised knowledge development nodes located in places which are increasingly more geographically dispersed' (Herstad *et al.*, 2008). Innovation requires access to the global pool of knowledge where 'companies increasingly adopt ecosystems of innovation which link networks of people, institutions (universities, government agencies, etc.), and other companies in different countries to solve problems and find ideas' (OECD 2008: 31). Herstad *et al.* (2008) also suggest that international collaboration encourages innovation in enterprises, especially in small economies such as those found in the V4. Yet, the globalisation of R&D and other innovative activities requires substantial resources, and access to global innovation networks by small and medium-sized enterprises might be constrained by the high costs and complexity involved. Likewise, collaboration strategies hold most promise for sectors characterised by highly competitive markets with short product life cycles and where much explicit knowledge is required, external interfaces are important and positive externalities are created (OECD 2008b).

Figure 9 **European innovation networks**

Source: Iversen *et al.*, 2017

7. What policy actions are needed to promote business R&D and innovation in the V4?

Technical change and technological learning are essential for the V4 to get much closer to the knowledge frontier. Inward BERD is important for transferring new knowledge and technology to the V4, though it needs to be noted that most global BERD activities take place in multinational enterprises located in the most advanced economies. The presence of foreign subsidiaries with R&D activities should strengthen the absorptive capacity of local enterprises in the V4. As this capacity strengthens, policies should be aimed at facilitating the diffusion of new innovations throughout the economy. Potential spillovers can occur both directly through linkages in the local economy, as well as indirectly through the labour market and competitive pressure. Policy initiatives should promote R&D cooperation and a collaborative innovative environment that ties local enterprises together with other private and public players. Foreign direct investment coupled with an effective R&D and innovation policy can close the technology gap between V4 economies and the advanced EU economies by upgrading the region's technology. The main challenge is to build the appropriate or relevant technological and organisational capabilities needed to carry out specific tasks and assimilate new knowledge within the V4.

R&D activity continued to internationalise over the past 16 years in all four V4 countries, despite the financial crisis in 2008. This trend does not however imply the globalisation

of R&D activity, as it was mainly other European countries which provided most of the inward BERD in the manufacturing industries, strongly suggesting that geographical proximity is important to the region. However, total BERD intensity remained fairly low until after the crisis and the introduction of the Europe 2020 strategy. The goal here was to invest Structural Funds more efficiently by strengthening research, technological development and innovation (R&I target) as well as information and communication technologies (ICT target), a strategy later to become known as the smart specialisation strategy (Foray, 2015).

There is considerable heterogeneity across the different industries in the V4, in terms of both the intensity of R&D internationalisation over time and the relative importance of the respective industry. The automotive industry remains very important for the V4 and is highly integrated with Germany. While the industry accounts for about a quarter of all EU R&D activity, two-third of this is attributable to Germany. The V4 region has relatively little inward BERD in the sector, and much of this is attributable to Volkswagen's investment in Skoda, aimed at adapting existing technologies already available in the Volkswagen group and local design engineering. There are further examples of investments in automotive R&D activities by other enterprises, as the relatively high growth rate of foreign R&D activities indicates. On a positive note, foreign investment in ICT activities, including software development, has been strong in the last few years, with statistics from Czechia and Hungary suggesting that inward BERD in the KIBS has more than doubled since the financial crisis.

Funding of business R&D has been increasingly sourced from abroad since the financial crisis. Companies increasingly collaborate in R&D and innovation activities both within and across national borders, and multinational enterprises rely more and more on their subsidiaries for technical knowledge. Such collaboration networks often contain both large multinational enterprises that attempt to direct and control the global innovation network and smaller enterprises and research groups that evolve in a more self-organizing way, guided by the needs of network members. Policies should be directed toward local enterprises and their ability to collaborate with other domestic companies, universities and public research organizations.

Foreign enterprises located in the region tend to be a bit more innovative than domestic ones. A similar trend appears in the statistics of apparent labour productivity, but the results are mixed when it comes to the share of BERD in value added. Czechia appears to be the most innovative country in the region, though statistics are not strictly comparable. The V4 countries should strengthen investment in innovation and promote product and process upgrading by improving their absorptive capacity and policy governance (Fagerberg *et al.*, 2007). They must recognize internal and external sources of information and knowledge and then apply these in the innovation process. As companies develop their indigenous R&D capability, they will gradually follow an asset-seeking strategy rather than only following an asset-exploiting one.

The V4 should adopt a mission-oriented approach to innovation policy (Mazzucato 2013). Such policies emphasise problem-specific societal challenges involving many different players. Policy interventions are not to be seen as market failures, but as a

market-creating process that includes public-private partnerships and facilitates the development of larger and higher- risk projects. Many breakthrough technologies, such as the Internet, biotechnology, nanotechnology and green technology required risk-taking and bold entrepreneurial action by public organisations. The V4 countries should encourage industry clusters in knowledge-intensive industries and increase industry–university collaborations and support for start-ups. Moreover, they need to increase their private and public investment in R&D, regardless of whether the funding comes from domestic or international sources.

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