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Mothers and Daughters: Heterogeneity of German direct investments in the Czech Republic

Evidence from the IAB-ReLOC survey

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Abstract

The aim of the paper is to assess the heterogeneity of German affiliates in the Czech Republic and their mother companies in Germany. Applying cluster analysis to firm-level data from the unique IAB-ReLOC survey, we identify four main groups of firms that partition the sample by broad sectoral lines and technological intensity of their operation. More specifically, the principal clusters can be interpreted as: i) High-tech industrial firms; ii) Low-tech industrial firms; iii) High-tech service providers; and iv) Low-tech service providers. The classification is examined more closely by location, ownership and industry of the firms and in the framework of a probit model. The main result is that there is a significant technological gap between the mothers and their cross-border daughters in industry that cannot be found in the service sector. From this follow implications for technological upgrading on both sides of the border, which are discussed in the concluding section of the paper.

Zusammenfassung

Das Ziel des Papiers ist es, die Heterogenität der deutschen Tochtergesellschaften in der Tschechischen Republik und ihrer Mutterunternehmen in Deutschland zu beurteilen. Wir verwenden Methoden der Cluster-Analyse um vier Hauptgruppen der Unternehmen aus der vom IAB durchgeführten ReLOC-Befragung zu identifizieren. Die Aufteilung erfolgt dabei entlang klarer sektoraler Linien und entsprechend dem Niveau der Technologieintensität. Die Unternehmen können in folgende Clustergruppen unterschieden werden: i) High-tech-Industrieunternehmen; ii) Low-tech-Industrieunternehmen; iii) High-tech-Dienstleister; und iv) Low-tech-Dienstleister. Mit Hilfe eines Probit-Modells untersuchen wir die Klassifizierung detaillierter unter Berücksichtigung des Standortes, der Eigentumsverhältnisse und der Branche der Unternehmen. Als Hauptergebnis ergibt sich, dass eine signifikante technologische Lücke zwischen den deutschen Mutterunternehmen und den tschechischen Tochterunternehmen in der Industrie, nicht aber im Dienstleistungssektor zu finden ist. Daraus ergeben sich Folgen für technologische Anpassungen auf beiden Seiten der Grenze, die im abschließenden Teil der Arbeit diskutiert werden.

JEL classification: D21, L16, F23, O23

Keywords: Multination corporations, foreign affiliate, heterogeneity, cluster analysis, Germany, Czech Republic

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1 Introduction

Multinational corporations (MNCs) are important actors in knowledge diffusion across national borders through imports of knowledge embodied in capital goods, licensing of foreign technology and the application of their organizational and marketing know-how worldwide. Besides facilitating diffusion of knowledge, MNCs are also increasingly important players in the generation of new knowledge abroad. A sizeable part of private research and development (R&D) activity is in fact concentrated in large MNCs, which are dominant players in their home-based innovation systems as well as enhancing technological capabilities through direct investment in host countries (Keller 2010; Narula 2003; Narula/Zanfei 2004). It is the latter aspect of international business activity that is the main focus of this paper.

Much has been written on the possibility that the diffusion of knowledge through foreign direct investment offers an avenue for various spillover effects between foreign affiliates and the host economy (Blomström/Kokko 1998). Despite strong theoretical reasons to expect spillovers, however, the empirical evidence is mixed at best. While there is strong support for direct technology transfer from the parent to the foreign affiliate in the literature, the evidence for technology spilling over to the host country is rare, and in fact crowding out of non-affiliated firms is often detected (Fagerberg/Srholec/Verspagen 2010; Görg/Greenaway 2004). In order to improve our understanding of the potential for these knowledge flows and the impact of foreign direct investment on technological upgrading we need more direct evidence on activities performed by MNCs both in their home and host countries.

This paper aims to contribute to this literature using evidence on a large sample of firms obtained from the original IAB-ReLOC survey, which provides rich individual data on technological activities of German affiliates in the Czech Republic, their mother companies in Germany and control groups of other firms in the respective countries. The paper is organized as follows. In Section 2, we briefly survey the literature on this topic and discuss the existing evidence. Section 3 presents the data collection survey and provides a short descriptive overview of the dataset. Section 4 contains results of cluster analysis on the base of selected questions about technology, education and skill intensity of the firms. Section 5 presents results of a probit model. Section 6 pulls the strands together.

2 Theory, concepts and existing evidence

The literature on foreign direct investment expects technologically advanced activities to be concentrated near the headquarters of the firm. The idea that firms invest abroad to take advantage of technology developed in their home base is the core thesis of the "eclectic paradigm" (Dunning 1988) and it is also the assumption underlying international diffusion of technology in earlier versions of the product cycle theory (Vernon 1966). The purpose of advanced activities, such as R&D, in affiliates is assumed to be limited to facilitating the implementation of technology developed in the home base. The transfer of technology is viewed as one directional to the host country, in order to improve the utilization of technology developed elsewhere.

Nevertheless, dispersion winds for location of technologically advanced activities are in place as well. The traditional perspective has been challenged by the argument that the technological bases of MNCs are increasingly not limited to any single country, but rather emerge from a variety of sources on a global scale (Kogut/Zander 1993). The tacit and "sticky" nature of knowledge implies that it is less costly (or otherwise impossible) to transfer some aspects of knowledge within a firms' ownership boundaries rather than through market transactions. Since geographical and cultural proximity might be necessary for sharing knowledge, foreign firms attempt to narrow this distance by "organizational" proximity. Furthermore, firms need to nurture a diversified knowledge base in order to prevent themselves from being locked into a narrow (location-specific) technology path (Cohen/Levinthal 1990). Firms therefore invest abroad to tap into specific technology competencies embedded in foreign locations (Cantwell 1995).

The former reasons for venturing into technology investments abroad have been dubbed an asset (or home base) exploiting motive, while the latter has been labeled as an asset (or home base) augmenting motive (Dunning/Narula 1995; Kuemmerle 1997, 1999; Narula/Zanfei 2004). Consequently, a typology of three generic strategies of foreign affiliates in terms of technology development may be defined as follows (see also Balcet/Evangelista 2004; Le Bas/Sierra 2002):

Imitative strategy: The affiliate develops no internal R&D capabilities. Innovation activity is fully based on application of existing foreign technology, which requires no additional expenditure on R&D in the host country in order to be used effectively. Most innovation expenditure is spent on arms-length purchase of technology in the form of rights to use externally developed inventions, licenses, trademarks or software, on the acquisition of technology embodied in capital goods and on training of local labor to employ the "ready-to-use" foreign technology. The affiliate aims at exploiting non-technological comparative advantages of the host country such as cheap labor, low transport costs to the final market, or flexible regulations. If any R&D is necessary, it is carried out by the parent, and the solution is communicated only to the affiliate.

Adaptive strategy: The affiliate maintains modest R&D capabilities in order to adjust foreign technology to preferences of local customers or host country regulations. The main objective of R&D is to facilitate smooth exploitation of technological advantages created abroad. The direction of technology transfer is only from the parent to the affiliate with very limited or no contribution of local R&D to further development of the core technology. The local R&D activity is a mere extension of efforts undertaken outside of the host country, which implies purchase of technology from abroad and a limited patenting record of the affiliate (or only local patents). The regional market-seeking motive is the key distinctive feature of the adaptive strategy, so the focus of the affiliate is on market introduction of new products.

Augmenting strategy: The affiliate is deeply engaged in internal R&D activity and has an extensive patenting record. The local R&D activity contributes to the core technology of the foreign owners, so that the affiliate still complements its research by acquisition of R&D from the parent. However, the direction of technology flows is essentially both ways: from parent to the affiliate and vice versa. The main objective is to develop new technologies at the global frontier.

The augmenting motive requires the foreign innovation system to offer certain location-specific technology content, which foreign firms seek to internalize. A pool of highly educated labor, specialized suppliers and state-of-the-art scientific infrastructure strongly supports the localization of affiliates following this strategy. One has to bear in mind, moreover, that establishing an R&D unit in a foreign location requires considerable time, costs and effort, but once deeply embedded in the host country research system, it is less costly to maintain. Thus, investment into R&D tends to be "sticky" in locations where sophisticated innovation systems are already in place, and considerable path dependency – and inertia – in their localization should be expected (Gertler/Wolfe/Garkut 2000; Narula 2002; Narula/Zanfei 2004). Even if firms develop networks of R&D units in multiple locations, the importance of location-specific factors suggests that most of it tends to be highly concentrated in space (Cantwell/Iammarino 1998; Verspagen/Schoenmakers 2004).

Apart from agglomeration effects, the clustering tendency of foreign investment into R&D is further reinforced by the increased fragmentation of value chains across the globe (Arndt/Kierzkowski 2001). As a consequence of gradual liberalization of investment and trade on the one hand and rapid progress in ICT and transport technologies on the other hand during the last two decades, individual phases of value chains can be increasingly separated from each other (in space or ownership or both), which allows firms to focus on exploiting the core elements of their competitive advantage and outsourcing the rest. The flip side is that certain fragments of value chains demanding high skills and advanced technology, such as R&D activity, increasingly gravitate towards different areas compared with fragments intensive on other endowments, such as manufacturing activity.

A latecomer country needs to reach a certain minimum threshold of location-specific factors, which has to offer similar conditions to the frontrunner countries, in order to attract foreign affiliates pursuing the core technology-augmenting strategies (Narula/Zanfei 2004). Indeed, this is extremely difficult to achieve with limited resources and other location-specific disadvantages that most of the latecomer countries face. The path-dependent nature of technologically advanced activities is clearly fortunate for regions on the frontier, while the deepening fragmentation further undermines the advantages of those coming from behind to attract the technology-intensive fragments of value chains. A key matter of concern for countries that currently find themselves somewhat in the middle ground between the technology frontier and most of the developing world, such as the Czech Republic – in the Central Europe on the border between highly developed countries of former Western bloc and much less developed countries of the former Communist bloc – is whether the adjustment path is likely to be towards increasing engagement of foreign affiliates in R&D and other technologically advanced activities or whether technology will tend to be increasingly sourced from abroad.

In the existing empirical research on R&D in foreign affiliates both of these expectations are recognized. A typical conclusion of the early literature in this vein has been that the adaptive focus is predominant among foreign affiliates. However, more recent evidence suggests that the core technology augmenting motive shows an increasing trend (Almeida 1996; Archibugi/Michie 1995; Cantwell 1995; Cantwell/Noonan 2002; Dunning/Narula 1995; Florida 1997; Kuemmerle 1999; Odagiri/Yasuda 1996; Patel/Vega 1999; Pearce/Papanastassiou 1999; Zander 1997). On the one hand, a plausible explanation is that tighter global competition encourages firms to engage more in adaptive strategies to customize products to local needs. On the other hand, however, the increasing specialization and complexity of technological development also increases the pressure to search for knowledge outside of the home base to keep pace with foreign competition.

Yet, there is evidence that the internationalization of R&D activities does not keep pace with internalization of manufacturing. Le Bas/Sierra (2002) confirm that different innovation strategies can be detected in patent data, but the augmenting motive is frequent mainly in the technologically most advanced regions. There seems to be a trend for manufacturing activities to spread to countries rather far behind the technology frontier, while the technologically most advanced segments of value chains remain concentrated and cluster even more in certain areas. The ultimate outcome is that even though foreign direct investment into R&D is growing over time, most of it remains concentrated in the home countries of the largest MNCs – within the triadic or a broader OECD area. In a broader regional context, the path-dependent nature of R&D localization seems to prevail, which is reflected in the increasing technological lead of the frontier countries and it poses substantial challenges for technological upgrading in the latecomers (Fagerberg/Srholec 2008; Fagerberg/Srholec/Knell 2007).

Access to firm-level data from the so-called Community Innovation Surveys (CIS), which are now commonly available for research purposes in many countries, opened the avenue for researchers to classify behavior of firms in terms of technology with the help of multivariate analysis. Studies based on data from early vintages of the CIS questionnaire, for example Cesaratto/Mangano (1993), de Jong/Marsili (2006), Hollenstein (1996, 2003) and Leiponen/Drejer (2007), showed that besides the traditional idea about “science-based” innovation, many firms rely on “market-oriented” and “process, production, supplier-driven” strategies. Using evidence on organizational and marketing changes from the fourth round of CIS, Frenz/Lambert (2009) added what they call “wider innovating” mode. Jensen et al. (2007), based on the Danish DISKO survey, highlighted two types of learning in firms labeled as “science, technology and innovation” and “doing, using and interacting” modes. Still, the literature using large firm-level datasets of foreign affiliates in this respect is very thin. And the existing literature has been primarily concerned with evidence from developed countries.

3 Overview of the dataset

Germany and the Czech Republic are suitable countries for the purpose of this study for many reasons. This accommodates the increasing significance of the Czech Republic for foreign direct investments by German firms and vice versa. The Czech Republic is the one country in Eastern Europe which attracted the highest primary and secondary German direct investments, ranking ahead of target countries like Brazil, Russia, India, or China. Germany and the Czech Republic share a long border (over 800 km/500 miles) with each other. At the same time there is a marked wage costs differential between the two neighbouring countries.

The empirical analysis is based on an innovative micro dataset from the IAB-ReLOC survey; the acronym stands for “Research on Locational and Organizational Change”. For the purposes of the survey we pursue a reference group approach. The starting point is firms with offshoring activities, i.e. firms which carry out their activities in-house abroad. For this group, we observe both the German and the Czech business units. This covers horizontal direct investments, which mainly serve market development, and vertical direct investments, with the dominating motive of cost savings. These firms are then compared to a control group of companies without foreign affiliates (in Germany) and without foreign ownership (in the Czech Republic). Hence there are four survey groups:

T_CZ: Treatment group in the Czech Republic: German affiliates; firms registered and having operations in the Czech Republic, which are affiliates of German companies. By combining information on ownership from the Creditinfo database, the Čekia database, the German-Czech Chamber of Industry and Commerce and the Czech Business register 3,875 relevant survey participants have been identified.[1] If there were two or more German affiliates which had the same residence and owner, only one, randomly drawn, had been included in the survey. After this reduction 3,651 affiliates had been selected for the survey. Moreover, based on information collected in the survey, we are able to distinguish the mode of entry:

– T_CZ1: Greenfield affiliates having German owners from the outset;

[1] As a basic principle we only considered firms which were either legally connected to a German company itself or where there was a legal connection between a company in the Czech Republic and its owner in Germany. Therefore, not all of the 5,700 Czech firms with German owners were relevant to the survey, because about half of them were not directly owned by a German firm but by one or more German private individuals. Only firms with a German owner who also owned at least one German firm were included in the sample. However, the database remains larger in comparison with other studies. For example, the Amadeus database of Bureau van Dijk, which is often used for research purposes, contained in its February 2011 edition only 1,150 Czech companies with German owners.

– T_CZ2: Merger & Acquisition (M&A) affiliates acquired by German owners at some point during their lifetime.

C_CZ: Control group in the Czech Republic: Firms registered and operating in the Czech Republic, which are purely Czech-owned; they neither have a direct nor an indirect foreign owner. Thus, Czech companies which did not have foreign owners but where other Czech firms with foreign owners held shares in them were also excluded. The "foreign" criterion is defined according to the legal place of residence or permanent residency of the physical person. The information concerning the existence of a foreign owner was obtained from the Creditinfo database and additionally verified with each company before conducting an interview.

T_DE: Treatment group in Germany: German mothers; firms registered and operating in Germany with an affiliate in the Czech Republic. The starting point is the owners of the 3,875 companies in the Czech treatment group. Of these companies, 3,274 had verifiably their domicile in Germany. The German treatment group is smaller than the Czech treatment group because some German owners were involved with more than one Czech company.

C_DE: Control group in Germany: Firms registered and operating in Germany, which did not have a foreign affiliate. This information was derived from the database of a partner of the Survey Institute, Heins + Partner, and additionally verified with each company before conducting an interview.

The data were collected via personal interviews conducted by a professional agency using written questionnaires. The total population of both mother and affiliate groups was included in the survey (T_CZ and T_DE), whereas stratified sampling by industry and number of employees of the two control groups (C_CZ and C_DE) was conducted to yield a better comparability of the groups within each country, which resulted in the net number of planned cases of 850 in the Czech control group and 1,285 in the German control group.[2]

The main survey was conducted by TNS Infratest Sozialforschung in Germany and by TNS AISA in the Czech Republic. The fieldwork took place from September 2010 to May 2011. Excluding companies which were identified as liquidated, not reachable, or did not exhibit the characteristics of the respective group when contacted, the response rates were 14.9% in the Czech treatment group, 12.9% in the Czech control group, 18.5% in the German treatment group and 19.1% in the German control group.

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[2] The gross sample for each control group was adjusted to the treatment group of the associated country. Hence the gross sample of the German control group has a similar dispersion of industry and firm size characteristics to the sample of the German mother companies. And in the same way, the gross sample of the Czech control group is similar to the sample of the German affiliates.

After omitting firms that did not respond and observations with missing data, we have at our disposal a sample of 350 German affiliates in the Czech Republic (T_CZ), of which 264 greenfield (T_CZ1) and 86 M&A (T_CZ2) affiliates, 662 firms in the Czech control group (C_CZ), 364 German mother companies in Germany (T_DE) and 1,065 firms in the German control group (C_DE). For all four survey groups the questionnaires were divided into the following thematic blocks: (a) EU enlargement to the East, (b) employment, (c) foreign involvement, (d) corporate policy and development, (e) investments and innovations, (f) wages and salaries, (g) company activities and (h) further company characteristics. In the following, we only describe the information selected for the purpose of this study.

Size of the firm is measured by the total headcount of employees, excluding agency and other external workers, registered in June 2010. Age of the firm refers to the number of years since the firm has been established, hence started operation in the respective country. Industry is identified using the self-reported principal activity of the firm, the structure of which broadly corresponds to 2-digit level of the Statistical Classification of Economic Activities (NACE, rev. 2). On the base of this information, we derive a broad sectoral dummy variable with the value 1 for firms classified in industry and with the value 0 for firms operating in the service sector. Industrial firms include the categories 05-39 and service firms the categories 41-96 of NACE, rev. 2.

Besides the traditional information on the industrial classification, firms further identified how they perceive their position in the value chain, which provides us with insight about the primary activity of the firm from a different angle. Firms were asked to classify themselves on a seven-point scale ranging from 1 for activities at the beginning of the chain, such as the extraction of basic materials, to 7 representing the final stage, when the product (or service) is delivered to the consumer; with the total value added increasing in a snowball manner along the route. Hence, we are able to see how far the firm operates from the final user.

Structural patterns like these are relevant, but even more important is to have information on resources of firms directly devoted to search, absorption and generation of new technology. R&D is the traditional and for a long time the only seriously considered data in this domain. Firms were asked to identify whether R&D belongs to major business functions conducted by the company, which can be perhaps interpreted as the presence of an internal R&D department. From this follows a dummy variable with the value 1 for firms that answered affirmatively and with the value 0 otherwise. The purpose of this variable is to capture a general commitment of the firm to R&D activity.

Yet the technological level of the firm is about much more than just spending on R&D, so that we need to keep an eye on much broader variables, too. For this purpose the data on educational attainment (or qualification) of employees, which represent a rough proxy of human capital, come handy. More specifically, the respondents were asked to classify their labor force into three broad categories as follows: i) Low educated labor, which refers to employees conducting simple activities not requiring specialized education/training; ii) Medium educated labor, referring to employees conducting qualified work, for which vocational education or equivalent specialized training and job experience is required; and iii) Highly educated labor, which refers to employees conducting qualified work, for which tertiary education is necessary.

To provide an even more comprehensive picture, the firms were asked to evaluate the skill requirements of the tasks actually performed by the employees. More precisely, they indicated the percentage share of different kinds of tasks in the process, in which the main product or service is produced. The shares of the five task categories sum up to 100 percent: i) Repetitive manual tasks, which refer to manual work consisting of simple repetitive operations, for example packaging, sorting, copy making, etc.; ii) Diverse manual tasks, which refer to manual work not consisting of simple repetitive operations only but also including operations that require reactions to changes of the working conditions, for example maintenance of transport equipment, driving cars, serving in restaurants, etc.; iii) Repetitive non-manual tasks, which consist of simple repetitive operations, for example proofreading, measurement, bookkeeping, etc.; iv) Interactive tasks, which do not consist of simple repetitive operations, for example negotiating, consultancy or lecturing; and v) Analytical tasks, which refer to operations that are not repetitive and require innovative solutions and independent thinking of the employee, such as research, evaluation, planning.

Finally, the respondents were asked to evaluate the technological level of their company in terms of the physical equipment, i.e. production lines, machinery, tools, etc. in comparison to other firms in the same industry. The seven-point Likert scale ranges from -3 for absolutely obsolete, 0 for the average level, to +3 labeling state-of-the-art technology. Indeed, this variable gives us an invaluable insight about the perceived technological position of the firm vis-à-vis direct competitors, and hence hints on the underlying business strategy within the industry, i.e. whether the firm is a technology leader or rather a follower, and whether the firm competes on quality or rather on low costs.

Table 1 provides descriptive statistics of the variables by location and ownership of the firms. More than two-thirds of the MNC mothers but only about every fourth to fifth affiliate engage in R&D. However, this does not seem to match the average educational attainment of their employees, as the greenfield affiliates surprisingly come out with by far the highest share of the top category. This can be perhaps attributed to the well-known fact that diploma counts do not satisfactorily measure qualitative differences. Admittedly, the task complexity variables are more informative in this respect. But the MNC mothers clearly dominate in terms of the technological level of their equipment, they are positioned significantly more upstream the value chain and they are in line with expectations much larger than the rest of the sample. More detailed discussion of these differences is presented in the next section.

Table 1
Descriptive statistics by location and ownership of the firms (in %)

Location	Czech Republic			Germany		Total
Ownership	Greenfield affiliate (T_CZ1)	M&A affiliate (T_CZ2)	Control group (C_CZ)	MNC mother (T_DE)	Control group (C_DE)	
Sector:						
Industrial activity	56.1	70.9	47.9	56.0	40.4	47.5
Value chain position:						
1: Upstream	1.1	0.0	0.8	0.8	1.7	1.2
2	2.3	1.2	2.4	4.4	3.5	3.1
3	7.2	9.3	5.0	9.6	5.7	6.4
4: Middle	18.2	7.0	13.6	27.2	16.3	17.1
5	23.1	29.1	18.9	25.3	18.9	20.6
6	23.1	24.4	20.2	20.1	21.6	21.3
7: Downstream	25.0	29.1	39.1	12.6	32.3	30.3
Intramural R&D activity:						
R&D engagement	18.6	26.7	23.3	67.3	28.5	31.7
Education attainment of employees:						
Low educated labor	20.4	23.5	18.2	21.3	22.3	20.9
Medium educated labor	46.9	57.4	58.8	60.5	67.3	61.4
Highly educated labor	32.7	19.1	23.0	18.2	10.4	17.7
Task complexity:						
Repetitive manual tasks	31.4	39.3	25.2	25.5	29.0	28.1
Diverse manual tasks	20.0	27.9	33.9	20.5	26.5	27.0
Repetitive non-manual tasks	12.8	13.6	14.1	16.3	13.1	13.8
Interactive tasks	19.0	10.5	14.9	20.8	18.7	17.7
Analytical task	16.9	8.7	11.9	16.9	12.7	13.4
Technological level of equipment:						
-3: Absolutely obsolete	1.9	2.3	0.9	0.3	0.7	0.9
-2	6.4	2.3	3.0	1.6	1.7	2.6
-1	6.1	10.5	7.1	4.1	4.5	5.5
0: Average	32.6	23.3	28.4	14.6	12.2	19.5
1	23.5	23.3	29.5	22.3	21.5	24.0
2	19.3	33.7	24.6	42.3	41.6	34.4
3: State-of-the-art	10.2	4.7	6.5	14.8	17.8	13.0
Structural characteristics:						
Number of employees	60.5	131.6	62.7	264.8	155.5	135.5
Age	12.8	17.3	16.3	45.3	46.8	33.6
Number of observations	264	86	662	364	1,065	2,441

Source: Own calculations using the IAB-ReLOC survey

4 Cluster analysis

In the first step, we cluster firms according to the types of business activity performed. Using various multivariate methods of analysis to study the behavior of firms can be traced back at least to the early seventies (Blackman/Seligman/Sogliero 1973; Rothwell et al. 1974). More recently, as already noted above, these methods have been for example used to identify patterns of how firms innovate (Srholec/Verspagen 2012). It is not the purpose of this paper to provide a general overview of these methods, for more details on the cluster analysis see for example Everitt/Landau/Leese (2001), but we need to explain the clustering procedure on the base on which we choose to sort out the firms.

Cluster analysis is an exploratory tool which divides similar units into groups, so that the degree of association between the units is maximal if they belong to the same group and as small as possible otherwise. Many clustering procedures have been developed over the years. K-means clustering is a type of procedure, in which the number of clusters is pre-determined, i.e. the researcher specifies at the outset that she wants to identify a certain number of distinct groups. But this is not suitable for our purposes, because we do not know ex-ante the number of clusters. Another family of methods is the hierarchical clustering, which we prefer for our purpose; more specifically the method of complete linkage, because setting the actual number of clusters is not required beforehand.

Since our dataset includes binary variables, we use the so-called Gower's dissimilarity coefficient in the clustering procedure, which is suitable for a mix of binary, ordinal and continuous data (Stata 2009a). Calinski-Harabasz pseudo-F and the Duda-Hart Je(2)/Je(1) stopping rules are used to determine the number of clusters (Calinski/Harabasz 1974; Duda/Hart/Stork 2001). Four or three clusters appear as the most viable solution. Also this partitioning of the data is consistent with the dendrogram. After inspecting the results more closely, we have chosen to retain four clusters, because in our view this solution most credibly represents the underlying characteristics of the sample.[3]

Table 2 presents characteristics of the four principal clusters in terms of the average scores on the variables taken into account, i.e. the firm's principal activity, value chain position, engagement in R&D, education of employees, prevailing task complexity and technological level of the equipment. Hence, we interpret them as the generic types of firms, their basic taxonomy, which represents the underlying structure of the population. The main dividing line runs on the one hand between principally industrial and service firms and on the other hand between firms that score high and low on the technology, human capital and skill variables. From this follows the distinction of high- versus low-tech categories of firms operating in industry and services, respectively:

[3] Since the categories of education attainment on the one hand and task complexity on the other hand represent linear combinations of each other, i.e. they add together to equal 100%, we exclude the most frequent categories of "Medium educated labor" and "Repetitive manual tasks" from the clustering procedure.

Cluster (1): High-tech industrial producers

The first cluster identifies industrial firms, each of which conducts R&D activity, and which maintain more highly educated labor, require a higher share of employees performing interactive and analytical tasks and furnish themselves with technologically more advanced equipment, as compared to firms classified in the low-tech industrial category. All in all this earns them the status of the "High-tech industry" category.

Cluster (2): Low-tech industrial producers

The second group marks industrial firms on the opposite side of the technological spectrum, which do not engage in R&D, have a less educated workforce, specialize in manual work, especially in the most rudimentary repetitive tasks, and use more technologically outdated equipment than any of the retained groups, hence this is the "Low-tech industry" cluster.

Cluster (3): High-tech service providers

The third cluster lumps together advanced service firms, which have by far the best education attainment of labor, tasks complexity portfolio and technological credentials of their equipment; they even outclass in these characteristics the high-tech industrial firms by a large margin. Hence, this group is the real boon of technology and hence clearly deserves the "High-tech services" rubric.

Cluster (4): Low-tech service providers

Finally, there is the fourth group, which includes the remaining service firms. This group constitutes the mirror image of the previous category, so that the label of "Low-tech services" fits rather well.

Table 2
Results of the cluster analysis (proportions of firms and average scores on the underlying variables)

Variable	Cluster 1 High-tech industry	Cluster 2 Low-tech industry	Cluster 3 High-tech services	Cluster 4 Low-tech services	Total
Industrial activity	1.00	1.00	0.00	0.00	0.48
Value chain position	4.98	5.31	5.08	5.97	5.38
R&D engagement	1.00	0.00	0.38	0.00	0.32
Low educated labor	23.86	25.77	6.80	25.25	20.90
Medium educated labor	61.52	62.67	54.33	65.65	61.42
Highly educated labor	14.62	11.56	38.87	9.10	17.69
Repetitive manual tasks	34.16	41.46	10.69	25.60	28.08
Diverse manual tasks	26.17	30.14	18.02	31.71	26.95
Repetitive non-manual tasks	14.48	11.32	14.85	14.54	13.81
Interactive tasks	12.53	8.88	28.73	20.68	17.73
Analytical tasks	12.66	8.21	27.72	7.47	13.42
Technical level of equipment	1.32	0.87	1.57	1.06	1.19
Number of observations	567	593	550	731	2,441

Source: Own calculations using the IAB-ReLOC survey

Also the value chain position fits this interpretation. As can be expected, firms classified in industry consider themselves more upstream than in services, if one compares the respective high- and low-tech clusters with each other, because many more service firms operate closer to the final customer by nature of their business. But it is interesting to see that there is a difference by the cluster solution within sectors too. Low-tech firms are considerably more downstream, which probably reflects the fact that value chain segments that are particularly demanding on advanced inputs, such as strategic planning, market analysis, prototype testing, product design and by that matter R&D itself, come first in the value chain, and hence firms comprising these initial stages appear more technology-intensive than those specialized in segments down the route, such as components manufacturing, assembling or distribution to the final customer.

Another outcome that needs to be clarified is that less than half of the firms classified in the high-tech services category report to be engaged in R&D. But there are many jobs, which either do not meet the formal criteria of what is considered to be R&D, even though they are closely related to it, such as all sorts of educational, measuring and testing services, or oscillate at the borderline of what should (or not) be included, such as those in the domain of consultancy, software development and market research (OECD 2002). Hence, there can be a downward measurement bias in the R&D question, especially in the service sector. Moreover, firms increasingly obtain R&D inputs externally in technology markets (Arora/Fosfuri/Gambardella 2001), so they do not necessarily need to harbor a department devoted for this purpose in-house, in order to get access to this kind of resources.

All of the clusters are frequently populated, none of them dominates in terms of the number of observations, none of them represents a mere residual category, which confirms that each of the groups has a merit in its own right. If we retain several more clusters, there start appearing mixed groups of firms in industry and services. But this involves partitioning the sample into too many groups, some of which are sparsely populated, and hence difficult to work with empirically. So there seem to be pockets of firms that given the characteristics taken into account cut across the traditional dichotomy between industry and services. Unfortunately, however, the data in hand does not allow us to say much about them.

Tables 3 and 4 show the distribution of firms between clusters by more detailed categories of the standard NACE, rev. 2 classification.[4] As expected, the high-tech cluster is the most frequent in industries, for which the labels of “high-technology” and “medium-high-technology” manufacturing have been established in the literature by Hatzichronoglou (1997), such as chemicals, electronics and machinery. And the

[4] Firms have been classified into the standard NACE industries on the base of their principal activity at the 2-digit level, but most of them must have been aggregated into broader sectors encompassing several 2-digit categories, in order to avoid using industries with only few observations.

high-tech services cluster dominates in industries for which the label of "knowledge-intensive" services has been proposed by OECD (2003: 140), such as information, communication and professional business activities. Arguably, this is reassuring for the interpretation proposed above.

Table 3
Distribution of firms between clusters by detailed industry categories (in %)

NACE (rev. 2)	Name	Number of observations	Cluster	
			1 High-tech industry	2 Low-tech industry
05 - 09	Mining and quarrying	8	37.5	62.5
10, 11, 12	Food, beverages and tobacco products	123	43.1	56.9
13, 14, 15	Textiles, apparel and leather products	69	47.8	52.2
16, 17, 18	Wood, paper and printing products	97	33.0	67.0
19, 20, 21	Chemicals, petroleum and coke products	27	74.1	25.9
22, 23	Rubber, plastic and non-metallic products	142	43.0	57.0
24	Basic metals	101	46.5	53.5
25	Fabricated metal products	170	47.6	52.4
26	Computer and electronic products	49	73.5	26.5
27	Electrical equipment	84	64.3	35.7
28	Machinery and equipment n.e.c.	132	68.9	31.1
29, 30	Motor vehicles other transport equipment	51	56.9	43.1
31, 32	Furniture and other manufacturing	52	34.6	65.4
35-39	Energy and utilities	55	16.4	83.6

Source: Own calculations using the IAB-ReLOC survey

Table 4
Distribution of firms between clusters by detailed service categories (in %)

NACE (rev. 2)	Name	Number of observations	Cluster	
			3 High-tech services	4 Low-tech services
41, 42, 43	Construction	162	40.1	59.9
45, 46	Wholesale and trade of motor vehicles	307	42.7	57.3
47, 55, 56	Retailing, hotels and restaurants	132	23.5	76.5
49-53	Transportation and storage	111	31.5	68.5
58-63	Information and communication	65	69.2	30.8
64-66	Financial and insurance activities	59	40.7	59.3
33, 68, 77-82	Real estate and other support services	146	25.3	74.7
69-75	Professional and technical activities	178	77.5	22.5
85-88	Health, education and social services	54	44.4	55.6
84, 90-96	Other services n.e.c.	67	29.9	70.1

Source: Own calculations using the IAB-ReLOC survey

At the same time it is important to realize that these figures confirm the point by Srholec/Verspagen (2012) about within industry heterogeneity of firms in the sense that most of the industries are anywhere close to be uniform and many of them actually came out distributed quite evenly between the clusters. All industries, except one that proves the rule, contain at least 20% of firms in the less frequent cluster, and in half of them the dominant cluster does not account for more than 60% of firms. There are some broad patterns that can be recognized, but there is also a great deal of heterogeneity of the clusters within industries, and therefore the former classification cannot be confused with the latter and vice versa. In other words, the high- vs. low-tech label is problematic, if used at the industry level, because the technology, education and skill intensity of firms is not predetermined by industry.

Table 5 reports the clustering results by ownership and location of the firms, which is at the heart of the interest in this paper. As explained in more detail above, the data allows us to directly compare the distribution of MNC mothers in Germany (T_DE) to their greenfield (T_CZ1) and M&A (T_CZ2) affiliates in the Czech Republic and to the control groups of other firms in each country (C_CZ and C_DE). In addition, in the bottom part of the table are reported subtotals of firms located in the Czech Republic (CZ) and Germany (DE) on the one hand and firms that are involved in the mother-daughter relationships (T) and those that are not (C) on the other hand, respectively.

Not surprisingly, the MNC mothers located in Germany are by far the most advanced firms, as about half of them belong to the high-tech industry cluster, more than a fourth of them concentrates in the high-tech services cluster and only about every fifth of them is classified as low-tech either in industry or services. This points to the fact that the technological superiority of MNC mothers might be one of the primary reasons why they venture into investing abroad, and therefore why they belong to this category. More interesting is therefore to compare this outcome to the distribution of their affiliates in the Czech Republic. Here, we can observe sharp differences between industry and services.

Affiliates in industry seem to be a reverse mirror of the mothers, as by far the most prevalent category is the low-tech industry cluster; with a little difference between the greenfield and M&A investment projects. The technological superiority of industrial mothers seems not to be transmitted to the operations of their daughters. In fact, quite the opposite seems to be the case, because the affiliates are concentrated even more in the low-tech segment than the control group. Hence, the available evidence suggests that there is a vertical division of labor between the industrial mothers and daughters, in which the former specialize in technologically intensive activities, while the latter operate on the low-end side of the spectrum, probably driven by the availability of cheap manual labor.

Table 5
Distribution of firms between clusters by location and ownership categories (in %)

Code	Ownership	Location	Number of observations	Cluster 1 High-tech industry	 2 Low-tech industry	 3 High-tech services	 4 Low-tech services
T_CZ1	Greenfield affiliate	Czech Republic	264	11.7	44.3	26.5	17.4
T_CZ2	M&A affiliate	Czech Republic	86	19.8	51.2	15.1	14.0
C_CZ	Control group	Czech Republic	662	17.1	30.8	21.6	30.5
T_DE	MNC mother	Germany	364	49.7	6.3	28.8	15.1
C_DE	Control group	Germany	1,065	21.1	19.2	20.6	39.1
CZ	Subtotal	Czech Republic	1,012	15.9	36.1	22.3	25.7
DE	Subtotal	Germany	1,429	28.4	16.0	22.7	33.0
T	Affiliate & mother	Subtotal	714	32.1	25.8	26.3	15.8
C	Control group	Subtotal	1,727	19.6	23.7	21.0	35.8
Total			2,441	23.2	24.3	22.5	29.9

Source: Own calculations using the IAB-ReLOC survey

However, this does not seem to be the case in services, where the proportion of high-tech and low-tech operations comes out to be very similar for the mothers and their greenfield foreign projects. Admittedly, M&A affiliates appear somewhat behind in this respect, but even in this category the high-tech cluster prevails over the low-tech one. This is in a sharp contrast to their unaffiliated domestic counterparts in the control group, for which the low-tech cluster is significantly more populated. From this follows that the cross-border direct investment in the service sector, particularly greenfield projects, is predominantly horizontal, as the affiliates tend to engage in a similar portfolio of activities in terms of technology, education and skill intensity as their mother companies.

Overall, as a result, firms located in Germany appear notably more advanced than those operating in the Czech Republic, because if added together the high-tech clusters account for 51.1.% in the former and 38.1% in the latter, respectively. But this is primarily driven by differences in terms of the cluster classification in industry, in which the Czech firms are clearly technologically inferior to the German ones, however there is not that much difference in the service sector, where the proportion between firms classified as high-tech and low-tech is even higher in the Czech Republic than in Germany. And the investment of German firms into their Czech operations tends to further deepen the technological gap between industrial sectors in both countries. According to this data, therefore, the difference boils down to the question how advanced are affiliates in the industrial stratum of the economy.

5 Regression analysis

Yet from descriptive tabulations we can derive only preliminary conclusions, because the observed patterns can be driven by a host of factors that are properly taken into account. Arguably, we have a better chance to derive more confident statements by investigating the data in an econometric framework. Hence, we estimate a probit model with the classification of firms obtained in the cluster analysis as the outcome variable. As covariates we use the size of the firms given by the log of employees, age given by the log of years since the firm was established, the set of location and ownership dummies, for which the MNC mother dummy is the base category, and the set of NACE industry dummies.

The idea is that firms make a strategic choice to specialize in the respective cluster. Arguably, this is most relevant for the segment of affiliates, because the mother companies generally decide on their specialization depending on a number of factors, including the main motive for the foreign direct investment, global investment strategy of the corporation, lifecycle of the affiliate, factor endowments of the local economy, factor cost differences, etc. In other words, the MNC mothers have a freedom to choose whether the affiliate engages in a low-tech strategy primarily exploiting cheap labour advantages or whether the affiliate develops into a complex high-tech facility with own R&D department, cutting-edge equipment, high-skill intensity, etc.

Table 6 gives the results. Since the cluster solution splits the sample into the broad industry and service sectors, we estimate the model separately for each of them; hence the dependent variable is a dummy with the value 1 for firms classified as high-tech and with the value 0 for firms in the low-tech cluster. In the first column the results for industry and in the second column the results for services are reported. For comparing the magnitude of the estimated relationships we need to derive marginal effects. A marginal effect generally refers to the percentage change in the probability of a success in response to one percentage change in the covariate, holding constant all other variables at some fixed values, at the mean of the other covariates variables here. Specifically for the binary covariates the marginal effect refers to the discrete change from the base level. For details on the maximum likelihood procedure see Stata (2009b: 1404 ff.).

Table 6
Results of a probit model

	Cluster	
	1 and 2	3 and 4
Dependent variable	High-tech industry	High-tech services
Log of employees	0.094 (0.014)***	-0.003 (0.010)
Log of age	0.072 (0.023)***	0.016 (0.020)
Greenfield affiliate	-0.642 (0.050)***	-0.049 (0.064)
M&A affiliate	-0.616 (0.067)***	-0.124 (0.108)
Czech control group	-0.460 (0.042)***	-0.208 (0.051)***
German control group	-0.391 (0.039)***	-0.312 (0.045)***
Industry dummies	Included	Included
Wald χ^2	301.74***	191.51***
Log pseudo likelihood	-589.80	-757.63
Pseudo R^2	0.26	0.12
Number of observations	1,150	1,267

Note: Marginal effects at the mean of other explanatory variables are reported; robust standard errors in brackets; ***, **, and * indicate significance at the 1, 5, and 10 percent level.

Source: Own calculations using the IAB-ReLOC survey

The main interest is in the estimated marginal effects of the location and ownership dummies. Even after controlling for the size, age and NACE industry differences, the results generally support the conclusions presented in the previous section. Both greenfield and M&A affiliates are significantly less likely to be high-tech than their MNC mothers in industry, but there does not seem to be a statistically significant difference at the conventional levels in this respect in the service sector. The control groups are always significantly inferior to the MNC mothers, and even more so in industry than in services. Moreover, both types of affiliates appear technologically less sophisticated than the control groups in industry, while the reverse tendency is detected in services; these differences are statistically significant at the 5% level, except of the M&A affiliates in the service sector only.

According to expectations is the positive effect of size in industry, because of various scale economies in manufacturing production. Large firms are in a much better position to finance, for example, their own R&D department, which is the essential identification criterion of the high-tech industry cluster. But size does not seem to be important in services, because the potential for exploiting economies of scale is known to be considerably smaller, hence does not make much difference. Age represents factors that are the function of time, including various learning effects, such as learning by doing and other resources that accumulate gradually over the years. Again, this appears to be much more relevant in industry than in the service sector.

6 Conclusions

Using cluster analysis to assess the heterogeneity of German affiliates in the Czech Republic and their mother companies in Germany, based on unique evidence on technology, education and skill intensity of their operation from the IAB-ReLOC survey, we identified four main groups that partition the sample in: i) High-tech industrial firms; ii) Low-tech industrial firms; iii) High-tech service providers; and iv) Low-tech service providers. More detailed examination of the classification by location, ownership and industry of the firms and in the framework of a probit model revealed that on the one hand there is a significant technological gap between the mothers and their cross-border daughters in industry but on the other hand there is little difference in the service sector.

From this follows a straightforward vertical division of labour in industry, in which the German mothers specialize in technologically advanced activities, while the Czech affiliates concentrate on less demanding jobs; most probably based on exploiting cheap labour advantages, as this is the typical architecture of cross-border production networks motivated by cost differences. Conversely, their modus operandi in services appears to be similar in both countries, from which we conclude that the nature of cross-border investment in this sector is horizontal, meaning that similarly demanding activities are developed across the border. Arguably, this is important to realize for technological upgrading on both sides of the border, and therefore a potent policy finding.

Looking from the German perspective, the results indicate that fears of hollowing out of local innovation milieu by the increasing extent of cross-border investment do not seem to be justified in industry, as the technologically advanced activities remain concentrated near the headquarters. But there is the possibility that highly qualified jobs are being transferred across the border in the service sector. From the Czech point of view, however, this suggests that the cross-border affiliates in industry fall short of expectations as far as their contribution to technological upgrading is concerned, as they predominantly deepen specialization of the local economy in low-tech jobs, possibly leading to a lock-in situation. Somewhat surprisingly, cross-border investment in the service sector might be much more promising in this respect.

Of course, the ultimate welfare impact begs for closer scrutiny, but this clearly goes beyond the scope of this paper.

Admittedly, this points to the main limitations of the paper. First and foremost, it would have been of interest to analyze the impact of these patterns on productivity growth; however, this requires integrating the IAB-ReLOC survey data with information from other sources, most notably with balance sheets data and employment statistics, which exists at least for a subsample of the firms, and hence this is a feasible next step. It may also be useful to analyze dynamic aspects of the issues under consideration, something that may be possible, if the ReLOC survey is repeated in the coming years.

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