London School of Economics and Political Science

# The Geography of Firm Internationalisation in Germany: Exploring Domestic and Foreign Heterogeneity Across Regions and Sectors

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# Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work.



I warrant that this authorisation does not, to the best of my belief, infringe the rights of any third party.

I declare that this thesis consists of 48,132 words.

# Abstract

The present thesis explores the internationalisation of firms in relation to region-sector characteristics. We focus on outward investment by German firms and classify the heterogeneity across firms, regions and sectors, as well as foreign destinations. The thesis is structured in 5 chapters: a general introduction, followed by 3 empirical chapters and a final conclusion.

In the introductory chapter we provide a general conceptual framework and selective review of the literature. Our starting point is that internationalisation is heterogenous across firms as it requires ownership advantages. However, the source of these is less explored and we discuss how regional factors such as the proximity to MNEs can influence foreign expansions. Conceptually we rely on spillover and competition effects and put forward that MNEs can act as catalysts for internationalising domestic firms.

Chapter 2 analyses the propensity of German firms to be active as outward investors, exploring and qualifying the heterogeneity across firms, regions and sectors. We find that different forms of proximity matter for the intensive and extensive margins of outward investment by German firms. First, region-sector co-location with MNEs is more important than regional co-location. This lends support to the notion of technological proximity as a facilitator of spillovers. Second, the association between region-sector proximity and the propensity of firms to invest abroad is larger at finer spatial scales. This hints to the tacitness of some knowledge and information about internationalisation processes, as these types of effects and externalities mainly arise between spatially proximate firms. Third, region-sector proximity is shown to matter most when the firm and the proximate MNE are both German-owned. It highlights a potential role of cultural proximity and regional embeddedness for positive externalities or feedback loops to occur.

Chapter 3 enquires how destination-specific ties available in the home region in Germany can be leveraged by the internationalising firm when making location decisions abroad. We provide empirical evidence on this by using data on inward

and outward investment linkages and migrant networks between a German region and foreign destination. Our findings also reveal that those matter more for likely first-time investors, while within business group experience is not shown to play a role. Using a mixed logit model we further highlight significant heterogeneity across firms in their directionality of outward investments. Larger firms are found to be able to expand to more distant foreign destinations while smaller firms mainly choose European locations.

Chapter 4 turns our focus to whole sectors and compares their domestic and global geography. To do so we use detailed geocoded data on the global locations of German manufacturing firms. We reveal that also at the global level there is considerable heterogeneity in the spatial pattern across sectors. The concentration 'intensity' is also generally higher than at the domestic level and the level of technology in a sector plays a key role for its pattern. While at the domestic level high-tech sectors are found to be the most concentrated, at the global level it is rather low and medium-low tech sectors. At the same time, firms in medium-high tech sectors are the least concentrated in both. As they are often referred to as the 'backbone' of the German economy, we see potential implications for territorial cohesion and regional disparities.

*Für meine Eltern, deren selbstlose Unterstützung anderer eine permanente Inspiration bleibt.*

*(To my parents, whose tireless support of others remains a constant inspiration.)*

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# Chapter 1

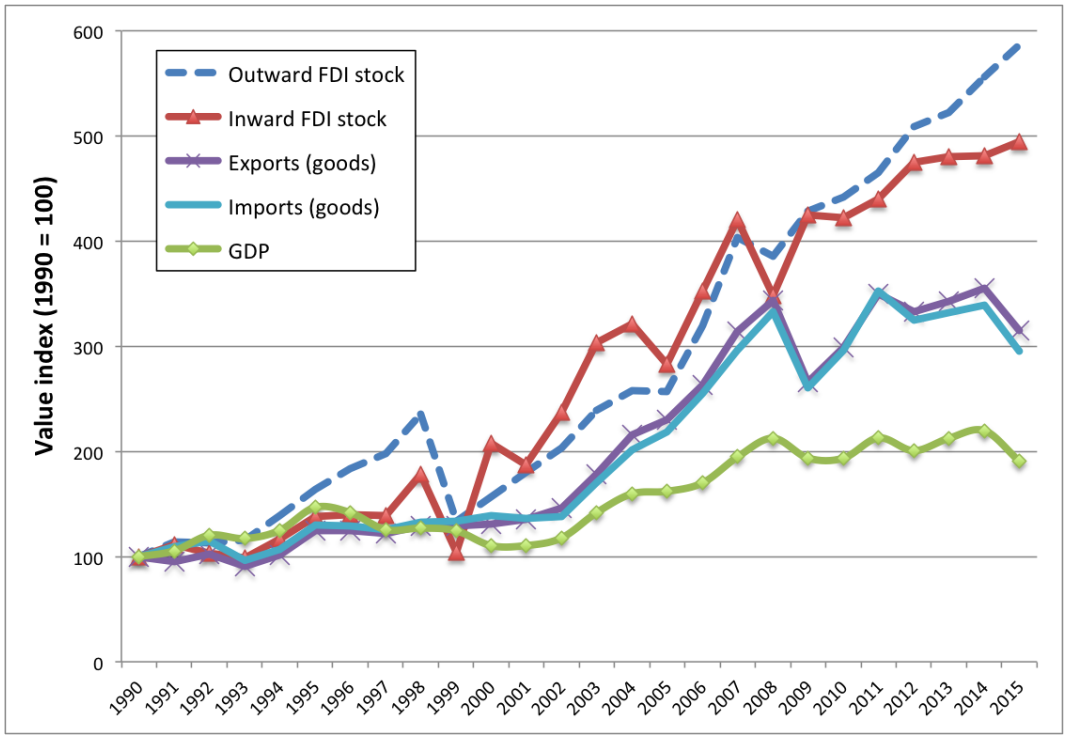
# Introduction

## 1.1 Overview

The present thesis explores the internationalisation of firms in relation to region-sector characteristics. We focus on outward investment by German firms and qualify the heterogeneity across firms, regions and sectors as well as foreign destinations. In 2015 the total stock of outward investment held by German businesses surpassed 1.8 trillion USD (UNCTAD, 2016). This comes close to a sixfold increase compared to 1990 (see Figure 1.1) and means that the growth of outward investment has not only outperformed the growth in inward investment, but also exports, imports and GDP. As a result, this topic has evoked considerable interest among academics and policymakers alike. However, an annual survey by the Association of German Chambers of Commerce and Industry highlights that firms face also increasing barriers and levels of uncertainty in some sectors and foreign markets (DIHK, 2017b, 2016). This makes it central to understand what drives the heterogeneity of foreign expansions by German firms.

Where most studies examine the determinants of outward investment mainly based on characteristics of firms or foreign destinations, it is our intention to shed light on the external environment a firm interacts with and is embedded in. We are interested in regional factors, such as the proximity to other firms, and ask whether a common sector or shared nationality matter for outward investment

Figure 1.1: Growth of FDI, GDP and trade in Germany, 1990-2015 (Source: authors' elaboration on UNCTAD data).




decisions. Beyond the probability of firms to become foreign investors we enquire which home-region factors facilitate the location choice in particular overseas destinations. Furthermore, we analyse how the geography of industry sectors, driven by colocation decisions of firms, differs at home and abroad. Here we are interested in cross-sectoral differences, technology intensity and employment patterns.

Beyond implications for the research community, this thesis also holds relevance for policy makers, as firms that engage in international markets are generally larger and more productive. Foreign investment can provide access to new markets and technologies, and internationalised firms tend to invest more and expand employment at home (DIHK, 2017a). This has been shown to have direct implications for the economic competitiveness of countries and regions within countries (Storper, 1992; Mayer and Ottaviano, 2008; Yeaple, 2009). It becomes obvious that we need a full understanding of the international expansions of firms, especially for an economy in which firms rely heavily on foreign expansions and increasingly so. For the purpose of this thesis we interpret *internationalisation* as the expansion of

domestic firms via investment abroad. This includes the establishment of foreign subsidiaries (or 'affiliates') via greenfield investment or the acquisition of existing business units.

In this introductory chapter we will provide a conceptual framework for the thesis and motivate our research by specifying the research gap we aim to fill. The framework is developed in the next section, followed by a review of relevant studies in the German context. The last part then provides an overview of our three empirical chapters including how they connect to our conceptualisation and a brief summary of main findings. We finish with few concluding remarks.

## 1.2 Conceptual framework

> *"European firms, partly as a reaction to the United States penetration of their markets, and partly as a natural result of their own growth, have begun to invest abroad on an expanded scale and will probably continue to do so in the future, and even enter into the United States market. [...] The reaction of the United States business will most likely be to meet foreign investment at home with more foreign investment abroad." - Stephen Hymer (1972, p.122)*

The internationalisation of firms has been the subject of extensive research since many decades. One key feature emerging across literature strands is that internationalisation is heterogenous across firms. However, the sources of heterogeneity itself are less explored, though significant differences across firms, regions, industries and countries exist. This section aims to summarise key conceptual developments and empirical studies found in the literature dealing with the internationalisation of firms in relation to regional and sectoral factors. We aim to integrate them in a comprehensive framework to guide our thesis.

In a first step we will address the elephant in the room that internationalising firms are somewhat *better*. The common reasoning is that multinationals are more productive, innovative and have developed specific advantages that allow them to overcome the barriers to global markets. Zaheer (1995) refers to the

latter as the *liability of foreignness* of newcomers to a foreign market that need to gain organisational capabilities, e.g. via copying practices from other firms. Among others, barriers include information disadvantages on foreign consumer tastes, business regulations, product and production standards, as well as suppliers and buyers, vis-á-vis firms that are already established in a market. We further acknowledge that firms can also become *better* ex post to internationalising (Temouri et al., 2010), and that there is considerable heterogeneity across regions and sectors in the propensity of firms to internationalise. The central research theme we explore is that MNEs can serve as catalysts for non-MNEs during their internationalisation. The idea is that proximity to MNEs can decrease costs and barriers and hence facilitate the process of internationalisation and choice of foreign destination. In doing so we refer to localised effects between firms in terms of spillovers and competition effects. Taken together we show in conceptual terms that, while internationalisation entails overcoming barriers (sunk costs), there are region-sector specific factors that can make the process easier for some firms. In that sense we allude to the concept of *path-dependency* in a region's or sector's long-term trajectory of development (Sunley, 2000), and aim to conceptually add the operations of MNEs in contributing to shaping these.

### 1.2.1 Internationalised firms are 'better'

The prevailing conception is that firms expanding beyond their domestic market via investment abroad are on average superior to firms that do not. We focus on key contributions in the literature that have dealt with this phenomenon from different angles and often in a parallel rather than in a complementary way. More than providing a summary we aim to discuss how they hold valuable conceptual and empirical insights and can be integrated for this thesis. Our framework remains relatively broad at this stage as the individual empirical chapters add conceptual elements specific to the respective research questions.

Undoubtedly the most widely adopted and accepted framework explaining the occurrence of multinational enterprises is John Dunning's *OLI framework* (Dunning, 1971, 1977, 1988, 2013). Also referred to as the *eclectic paradigm*

it argues that ownership ("O") advantages allow firms to derive market power and expand their business abroad. Location ("L") advantages refer to the *host* location that a firm chooses to locate in, and encompasses access to inputs or intermediate goods or services or intangible assets. They act as incentives to choose a specific foreign location and can become part of a firms' O advantages. However, Dunning later also mentions that they can be related to the *home* location of a firm (Dunning and Lundan, 2008; Dunning, 2009), though this side is less developed conceptually and empirically (Bannò et al., 2015). Since the existence of ownership and location advantages per se does not necessitate global expansion, the decision to internalise ("I") is the crucial component (Dunning, 1998). This in turn depends on the costs and benefits (i.e. profitability) of producing within the boundaries of the firm as opposed to licensing or franchising them to other firms. We will discuss these in more detail below by making reference to earlier and later conceptual contributions that Dunning successfully integrated in his work.

The need for firm-specific O advantages can be explained by market imperfections as in perfect markets domestic firms would have no absolute advantages over foreign competitors. Hymer was the first to highlight the importance of market imperfections for the existence of MNEs (Hymer, 1960). His work builds on earlier theories on the nature and growth of firms (Coase, 1937; Penrose, 1956) and is complemented with contributions by Kindleberger (1969) and Caves (1971). Building on the idea that firms 'control' markets across space, Hymer provides a first attempt to integrate geography with MNEs (Hymer, 1970). This again has been picked up by Dunning and formalised as L and I advantages. Interestingly, already Hymer acknowledges that foreign investment is heterogenous across industries where some are more prone to internationalisation.[1] Our framework builds on this early idea as we argue that the internationalisation has a strong sector-specific element. Related studies also consider different modes of serving a foreign market, emphasising the substitutability of exports and foreign investment (Horst, 1972a,b). Especially the so-called 'product-life-cycle model' as developed

[1] Similar conclusions are reached in the International trade literature ('New' New Trade Theory) that is reviewed below.

by Vernon (1966, 1971, 1979) discusses how a product typically passes three stages during its life-cycle. In the first stage the new product is sold by the most innovative firms and mainly in the domestic market. The second stage involves exporting the maturing product to other (mainly developed) markets, while in stage three the firm invests in foreign markets as local demand grows and the product becomes more standardised. During the third stage also re-imports of goods formerly produced in the home market are considered.

The issues of heterogeneity in internationalisation across firms has also received attention in the international trade literature. Empirical analyses of exporting vs. non-exporting firms by Lipsey et al. (1983), Bernard and Jensen (1995) and Roberts and Tybout (1997) inspired theoretical studies by Melitz (2003) and Bernard et al. (2003), demonstrating that exporting is heterogenous across firms with the level of productivity being the most important determinant. Helpman et al. (2004) also show that exporters are more productive than purely domestic firms, and add that only the most productive firms engage in investment abroad. The common assumption is that entering international markets implies overcoming considerable sunk costs. Hence, only the most productive firms 'select' into global expansion. In that sense these studies are in line with the literature on international production including the OLI paradigm, as discussed above in which in fact some of this literature is subsumed. Nevertheless the attention of more 'mainstream' economics scholars has sparked numerous empirical studies for different countries and subsets of firms.[2] A comprehensive literature survey on firm heterogeneity in internationalisation is provided in Helpman (2006) and Greenaway and Kneller (2007). According to Castellani and Zanfei (2007) one of the shortcomings of the trade literature is that it does not explore the origins of productivity differences between firms. Our conceptualisation builds on this claim as we integrate spillover and competition effects between multinational and non-multinational firms and discuss potential implications for firm-level productivity.

[2] See Roberts and Tybout (1997) for Colombia, Clerides et al. (1998) for Colombia, Mexico and Morocco, Bernard and Jensen (1995, 1999, 2004a) and Yeaple (2009) for the US; Head and Ries (2003) for Japan; and Girma et al. (2005) for the UK.

### 1.2.2 Region-sector heterogeneity at home: Space for Economic Geography

We have shown that the OLI framework, by grouping together different theoretical perspectives, explains in a comprehensive manner why some firms expand abroad while others do not. In essence, firms become multinationals if they possess specific advantages that can be profitably exploited in certain places abroad if done within the boundaries of the firm. Iammarino and McCann (2013) describe the strength of the paradigm in *"combining both micro- and macroeconomic perspectives, by allowing multiple levels and units of analysis, and by accommodating different theoretical strands under a unifying umbrella"* [p.35]. However, despite Dunning's renewed call for the importance of location factors at home and abroad for the existence of MNEs (Dunning, 1998; Dunning and Lundan, 2008), specific geography itself has not been fully integrated in the concepts on international production (McCann and Mudambi, 2004, 2005; Iammarino and McCann, 2013, 2015). We follow an increasing number of studies arguing that this is particularly the case for the home location of firms (Dimitratos, 2002; Cook et al., 2012; Bannò et al., 2015). In the following we will discuss contributions that stress the importance of the home location and specific sector for the international expansions of firms.

Early studies that consider the home location as an important factor of firm internationalisation do so mainly at the national level (Swedenborg, 1979; Blomström and Lipsey, 1991). They generally find that a larger home market leads to a later foreign expansion when firms are larger, as more sales can be achieved at home in relative terms. Nevertheless, also a significant difference across sectors is highlighted. The subnational level is only introduced in later studies, possibly due to the previous lack of consistent data on the home sub-national location of multinationals. Cook et al. (2012) examine the probability of outward investment by British firms based in 11 different home regions. They highlight that especially the regional colocation with same-industry firms matters. In a study based on 20 Italian regions, Bannò et al. (2015) find that regional accumulation of knowledge and competence as well as policy measures related to provision of access to finance, infrastructure and information matter for outward internationalisation of firms.

Interestingly, also the international connectedness approximated by the presence of foreign MNEs is demonstrated to play an important role. Both of the above mentioned studies conclude that in addition to the regional dimension there is significant heterogeneity in their findings across industry sectors, and that the regional level is most appropriate to study outward investment.

The overall number of studies exploring the regional dimension of outward investment at home is limited. However, a number of related studies look at the regional heterogeneity of firm internationalisation via exports (Malmberg et al., 2000; Becchetti and Rossi, 2000; Becchetti et al., 2007; Antonietti and Cainelli, 2011; Farole and Winkler, 2014). Since exports and foreign investments are related and often seen as sequential operations of firms (Conconi et al., 2016) this allows us to draw some additional insights. This group of studies generally demonstrates that the size of a region is associated with the propensity of firms to export. The direction of the effect is disputed as a large local market may reduce the need to sell abroad. Here market size can refer to general economic activity as well as activity in the same industry sector as the firm in question.[3] Conceptually especially the study by Malmberg et al. (2000) is interesting as they see export performance as a reflection of the strength of a firms' home locality. We will build on these by acknowledging the importance of the economic critical mass at home, across and within industry sectors in a region.

### 1.2.3 MNEs as catalysts for firm internationalisation

> "MNEs are a natural conduit for information about foreign markets, foreign consumers, and foreign technology" - Aitken et al. (1997, p.107)

This section conceptualises how the proximity to other firms can be a key determin-

[3] Conceptually these studies place their setting within the debate of urbanisation vs. localisation economies (Jacobs, 1969; Glaeser et al., 1992). However the empirical distinction between urbanisation and localisation economies is difficult (Mameli et al., 2008; Ellison et al., 2010) leading to potential confounding or interaction effects between both. In essence, larger regions are more likely to be home to specialised clusters, though the direction of causality is unclear.

ant for foreign expansions. In doing so we build on the previous discussion of firm- as well as region-sector heterogeneity in internationalisation. We acknowledge that sunk costs and barriers to internationalisation are firm-specific, however internationalisation appears to differ across regions and sectors. Following Aitken et al. (1997) and recent evidence by Bannò et al. (2015), we ask to what degree the concentration of MNEs in some regions can be leveraged by domestic firms to lower these barriers and hence explain (parts of) the region-sector heterogeneity. Hence, our conceptualisation relies on the integration of MNEs and space, as the literature has highlighted that the exact interaction of both remains under-explored (Beugelsdijk et al., 2010). After a brief discussion of localised externalities between firms we focus in more depth on spillover and competition effects. We explicitly allow for a distinction between domestic- and foreign-owned MNEs, based on additional forms of proximity beyond spatial distance.

Localised effects or externalities between proximate firms arise for a variety of reasons. They can be positive or negative, depending on the type of effect and firm under consideration. At the same time they can either be *intended* - usually involving a market transaction - or *unintended*. Finally, they vary depending on the type of proximity that is considered. Considering the complexity of these dimensions it is paramount to narrow down and define the mechanisms we want to focus on here. Since the aim of this thesis is to show how proximity between firms can facilitate their internationalisation we will focus on those that can potentially influence this process. Before going into more detail on the individual channels it is necessary to define what we mean by *proximity*. The term is generally associated with *spatial proximity* though also other forms of proximity have been discussed in the literature. Boschma (2005) describes cognitive, organisational, social, and institutional proximity in addition to pure geographical proximity. The economic actors in our study are firms and distance between them can differ among all of these dimensions. Following Nooteboom (2000), cognitive distance can lead to problems of communication and understanding, though little distance limits the potential for sources of novelties. Organisational proximity refers to similar knowledge, relations and interactions at comparable spatial scales and institutional contexts (Torre and Gilly, 2000). The local institutional context is also highlighted

by Diez et al. (2016) as a crucial factor for the two-way relationship between MNEs and the local environment. All three are crucial for our understanding of how firms in region-sector proximity can influence each other. We specifically test whether a shared home country and industry sector lead to a higher potential for effects or externalities between firms in addition to spatial proximity. The literature has noted that spatial proximity can facilitate face-to-face contacts and the exchange of knowledge - especially its tacit components. Hence it can be seen as necessary but not sufficient to generate knowledge exchanges between firms (Breschi and Lissoni, 2001; Gertler, 2003; Bathelt et al., 2004). Nevertheless, spatial proximity may be a proxy for other forms of proximity and also reinforces them (Nooteboom, 1999; Boschma, 2005; Torre and Rallet, 2005).

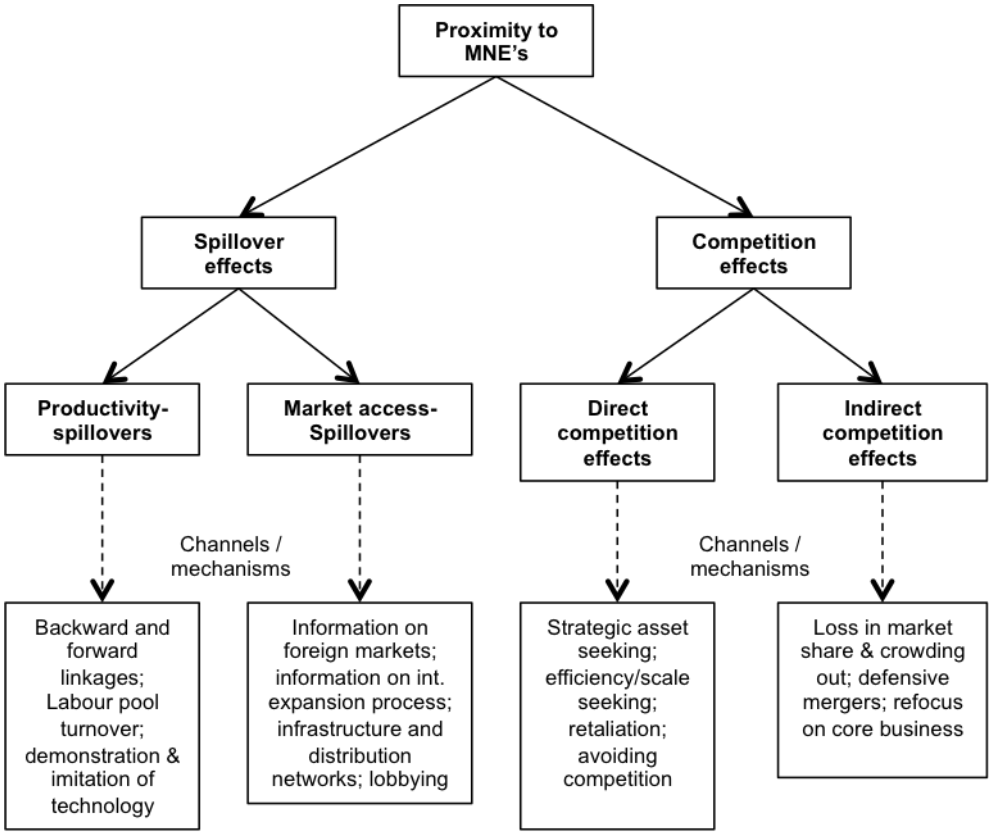
Related to this is also the concept of embeddedness of firms or other economic actors in a local economic environment. Dating back to Granovetter (1985) the central thesis of the concept is that formal market transactions are not sufficient to explain all of the local inter- and transactions between economic actors. Grabher (1993) integrated the firm into the concept, and similarly to the discussion above, various forms or proximity interact to create embeddedness. Ben Dankbaar (2004, p.692) points to the complexity of a decision-making process based on the concept of embeddedness:

> *"Decision making is embedded in a variety of settings, all of which impinge on the decision-making process, without determining it. [...] It is precisely because of that multitude of factors that choice is possible. Embeddedness stands for making choices in a complex environment"*

The quote exemplifies how embeddedness is connected to our conceptualisation of how firms form decisions to invest abroad. As we will show in more detail below, the firm is subject to various competition and spillover effects arising from the proximity to other firms. It can decide whether to intentionally benefit from other firms via local labour pool turnover or licensing of technologies. This typically involves a market transaction and costs, meaning that the firm needs to balance costs and benefits (Castellani and Zanfei, 2006; Zanfei, 2012). However,

benefits can also arise unintentionally if other firms require similar support such as infrastructure or government support.

Figure 1.2: Conceptualisation of spillover and competition effects from MNEs




### *Spillover effects*

We conceptualise that MNEs can generate two types of spillovers that raise the prospects of successful internationalisation for domestic firms. Specifically, MNEs are supposed to generate productivity-spillovers and market-access-spillovers. The former operate more indirectly as higher productivity was found to be a key factor in firm internationalisation. By market-access we mean that MNEs can directly lower barriers to access foreign markets, for example via the provision of information on foreign consumers. Based on the left-hand side of Figure 1.2 we will discuss each in more detail in the following.

Building on work by Marshall (1890) productivity spillovers can arise via knowledge or technological spillovers, labour pool specialisation and turnover,

and input-output relations between buyers and suppliers. Conceptually, a rise in productivity of domestic firms can involve several channels at the same time (Breschi and Lissoni, 2001). For example technological knowledge can be embodied in workers that travel between proximate firms. In most studies the exact spillover channel remains a black box leading to overall mixed results. Comprehensive literature reviews on the topic of MNEs and spillovers are provided in Blomström and Kokko (1998), Görg and Strobl (2001), Görg and Greenaway (2004) and Barba Navaretti et al. (2004).

If MNEs are the source of positive knowledge spillovers the innovative performance and productivity of domestic firms can be increased (Javorcik, 2004; Girma and Gorg, 2005; Branstetter, 2006; Keller and Yeaple, 2009). A higher productivity may allow some firms to overcome barriers to internationalisation. Knowledge spillovers can arise if MNEs introduce new technologies into a market that are then adopted by other firms, or indirectly spur increases in R&D of domestic firms to protect their market share. Based on our discussion of the superiority of MNEs it is reasonable to assume that their specific advantages can induce such behaviour. Smeets (2008) reviews this literature strand in great detail and calls for a clear distinction between (unintentional) knowledge spillovers and (intentional) knowledge transfers. Intentional spillovers occur if MNEs are the source for purchasing or licensing of technologies in a market transaction. Unintentional spillovers are operationalised via demonstration and imitation effects. Increases in the innovative capacity of local firms can also be the result of heightened efforts to innovate or commitments to R&D if the firm feels the competitive pressure focusing it to innovate or lose market share. Knowledge or information can be tacit and hence knowledge spillovers from MNEs are localised (Keller, 2004) and often travels with workers (Fosfuri et al., 2001). This highlights the crucial importance of understanding the spatial dimension and other forms of proximity that can give rise to these tacit knowledge exchanges. Empirical studies have confirmed that knowledge spillovers indeed exhibit distance-decay effects (Jaffe et al., 1993). Recent evidence on the UK show that MNEs can raise the innovation capacity of other firms in the same sector (Crescenzi et al., 2015), in contrast to previous studies (Braconier et al., 2001). Finally, a number of

studies also highlights the role of absorptive capacity of domestic firms in order for positive spillovers to occur (Barrios and Strobl, 2002; Girma and Gorg, 2005; Damijan et al., 2013; Ferragina and Mazzotta, 2013). Absorptive capacity means that domestic firms need a certain level of productivity and human capital to be able to access and benefit from knowledge of proximate firms. A lack of it can mean that spillovers between firms are not realised.

Another source of productivity spillovers are direct interactions between domestic and multinational firms via backward and forward linkages. More specifically, MNEs can act as suppliers or buyers to their domestic counterparts. The implications of these linkages are highlighted by numerous studies, whereas the pure linkage itself does not imply a knowledge spillover or increase in productivity (Lall, 1980; Kokko, 1992; Dunning, 1994; Aitken et al., 1996; Markusen and Venables, 1999; Javorcik, 2004). Following Kokko (1992) and Dunning (1994) backward linkages include technical and financial assistance or training to suppliers as well as help in finding production inputs. In addition, MNEs can insist on higher quality standards and control, or more reliable and speedy delivery of output. The potential outcomes on the side of the domestic subcontractor are heightened product quality and production efficiency. Further, being a subcontractor to an MNE can also help domestic firms achieve the appropriate scale of output to make internationalisation feasible (Blomström and Kokko, 1998). However, it becomes clear that the existence of such spillover depends on the degree of integration of the MNE in domestic value chains. If the MNE imports larger parts of the inputs than other domestic firms it can even have negative spillovers (Dunning, 1994; Rugraff, 2013). Forward linkages are more difficult to conceptualise. Some authors argue that MNEs can provide stable supply of production factors (Markusen and Venables, 1999) and if MNEs assist their clients to use them more efficiently they can gain new technological capabilities (Dunning, 1994). We argue that input-output linkages are more likely if firms are proximate to each other, facilitated by a shared location and industry sector.

Finally, localised labour mobility of high-skilled personnel from MNEs can raise the productivity of domestic firms. Various studies discuss how workers employed by MNEs gain valuable work experience and training and subsequently

their human capital becomes available in the local labour market (Blomström and Persson, 1983; Kokko, 1992; Dunning, 1994; Aitken and Harrison, 1999). Fosfuri et al. (2001) formalise knowledge spillovers via the mobility of workers as firms need to train local workers first in order to exploit their superior technology. The authors also discuss potential pecuniary spillovers if MNEs pay higher wages to prevent employees from moving to domestic competitors. Also Javorcik (2004) discusses the importance of this channel in conjunction with the aforementioned demonstration and imitation effects.

As mentioned above there are various ways in which the proximity to MNEs can directly enhance the prospects of domestic firms to access foreign markets. We discuss them here together as 'market-access spillovers'. The review of barriers to internationalisation showed that the knowledge about foreign markets and business environments is key for firms that want to expand abroad. Firms need to gather information about the preferences of foreign consumers, suppliers and buyers to adapt products and build up distribution channels. A natural source of information are other firms that have accumulated experience of operating in international markets, either via trade relations or foreign investment. Following Aitken et al. (1997) and Blomström and Kokko (1998) MNEs can provide information about the business environment and consumer tastes in a foreign market. Other relevant knowledge held by MNEs includes marketing and management skills, contacts and buyer-supplier relationships (Aitken and Harrison, 1999). Considering that some of the information is of intangible or tacit nature it is plausible that it travels more easily between proximate firms (Aitken and Harrison, 1999; Keller, 2004) and is embedded within workers (Fosfuri et al., 2001). The hiring of internationally experienced personnel as a precondition for successful internationalisation is also highlighted in a study by Mion and Opromolla (2014), though they focus on exports. Since studies on market-access spillovers and investment abroad are limited, we also consider findings on 'export-spillovers'. The logic of this type of spillover can be exemplified by an anecdote mentioned by Aitken et al. (1997) who describe the entry of a Korean garment producer in Bangladesh and how it spurred the growth of hundreds of local exporters. Various subsequent studies find evidence of export spillovers (Clerides et al., 1998; Greenaway et al., 2004; Koenig

et al., 2010), while others do not (Bernard and Jensen, 2004b,a). In general they highlight the importance of region-sector proximity between firms for positive spillovers to occur.

### *Competition effects*

Considering that MNEs have certain advantages over domestic firms is not only the source of potential spillovers but can also impact the local competitive environment in an industry or region. Hence we now turn to the right-hand side of the schematic conceptualisation in Figure 1.2 and consider direct and indirect competition effects. In conceptual term increased competition makes it more difficult for firms to protect their market share (Aitken and Harrison, 1999). This can induce increases in productivity if domestic firms raise their level of efficiency or innovation in order to stay competitive. Average firm productivity is also increased if competition pushes less efficient firms out of the market. Since we have shown that the level of productivity is directly linked to internationalisation patterns, it is important to review studies that show how MNEs impact the competitive environment. In addition we conceptualise how competition can directly raise the internationalisation of firms. We discuss how firms engage in strategic asset seeking abroad to defend their market share at home, or they seek scale abroad to avoid competition at home.

In an early empirical study of foreign investment and market competition Caves (1971) shows that inward investment pushes small firms to go out of business or engage in defensive mergers. Also Lall (1979) discusses how the entry of MNEs can raise market concentration (i.e. fewer, larger firms) and thus lower competition. He argues that MNEs are superior and create significant entry barriers, inducing price wars and defensive mergers. He states that *"industries that give rise to MNCs are concentrated"* (Lall, 1979, p.327).[4] This argument is challenged by Driffield (2001) who claims that rather than creating higher barriers, MNEs are attracted by sectors

[4] Chapter 3 of this thesis will discuss the relation between sector concentration and firm internationalisation in great detail.

that have higher barriers to start with as this is a signal for potential profitability. Their superiority allows MNEs to overcome these barriers and successfully cut into the market of domestic oligopolies. The result is hence lower concentration (more firms are competing now) and higher levels of competition. His argument is confirmed by various other authors who have demonstrated that local firms introduce new products and technologies as a response to competition, which subsequently raises their productivity and efficiency (Kokko, 1992; Dunning, 1994). Bowen and Wiersema (2005) show that competition from MNEs induces domestic firms to concentrate on their core business. A follow-up study adds that domestic firms have a higher degree of international diversification when they can build on experiences of local competition with foreign MNEs (Wiersema and Bowen, 2008), which is confirmed by Hilger (2008). Opposite to higher productivity levels due to spillovers, if competition by MNEs reduces the productivity of domestic firms, then the probability and success of internationalisation is reduced. Markusen and Venables (1999) show theoretically that increased competition in product and production factor markets can reduce sales and profits of local firms. Similarly Scherer and Huh (1992) report a reduced R&D activity due to import competition and Tybout (2001) hints towards lower mark-ups and production levels. Kosova (2010) adds that these are probably only short-term effects. In conclusion, we need to acknowledge that competition can potentially negatively affect internationalisation patterns, but effects are heterogenous across firms, regions, sectors and countries.

The direct impact of competition on internationalisation of domestic relies on the notion that firms go abroad in order to stay competitive. Dunning (1994) reports cases of firms moving abroad to avoid domestic competition. A different response can also be enhanced strategic asset- or efficiency-seeking investments, where firms want to access better assets or cheaper production inputs internationally to be able to compete locally (Sethi et al., 2003; Wiersema and Bowen, 2008). Without specifically addressing foreign competition Caves (1971) states that a firm only engages in foreign direct investment if there are no sufficient scale economies at home in terms of production and sales. He also suggests another interesting reason for firm internationalisation as a direct

response to foreign entry - *"reciprocal invasions of home territories"* (Caves, 1971, p.16). While we are not aware of studies explicitly testing this channel it would conceptually represent another possibility of how the proximity to foreign MNEs directly induces investment abroad by domestic firms.[5] On the other hand, Vernon (1966) suggests that, as firms observe their national competitors investing abroad, they can perceive this as a threat as they are 'losing' market share in global terms.

## 1.3 Internationalisation patterns of German firms

> "[T]he know-how of global business management [...] has been transferred to German business through competition or cooperation with American companies" - Susanne Hilger (2008, p.276)

This section reviews relevant studies on firm internationalisation in Germany to get a better understanding of the specific research gap we aim to fill. We summarise the heterogeneity across firms, regions and industries and how German firms interact with other firms in proximity to them. In a study key for this conceptualisation, Hilger (2008) argues that German firms have learned how to conduct business globally from their American competitors that had invested in Germany. Her study is based on three case studies of large German global players and highlights the importance of managerial and technical know-how along with superior modes of organisation, accounting, personnel and marketing. Similar arguments have been put forward by Dunning (1994), as he highlights that particularly German firms have relied on foreign MNEs investing in Germany to upgrade their own technological capabilities.

First evidence on the internationalisation of German firms using firm-level data have been pioneered by Wagner (1995, 1996). He shows that exporting firms in Lower Saxony are generally larger and more human capital- and technology-intensive. Based on the same data Joachim Wagner subsequently co-authored

[5] Also anecdotal evidence by Hymer (1972) regarding cumulative causation between American FDI in Europe and vice-versa hints in this direction.

two empirical studies with Andrew Bernard on the heterogeneity of German manufacturing exporters (Bernard and Wagner, 1997, 2001). Analogue to the highly influential studies on US manufacturing exporters by Bernard and Jensen (1995, 1997, 1999, 2004b,a), they find that productivity is a key predictor of overcoming the sunk costs to internationalisation. Similar findings are reported by Arnold and Hussinger (2005) and summarised in Wagner (2007).

Later studies start exploring the heterogeneity of firm internationalisations also with regards to investment abroad. Wagner (2004) shows that German firms that expanded abroad gradually (as opposed to rapidly) are more economically successful. In a series of papers Claudia Buch and co-authors explore the heterogeneity across firms in terms of foreign investment and exports. In the first comprehensive firm-level study of outward investment Buch et al. (2005) report a large heterogeneity in terms of internationalisation, based on firm characteristics and strategic motives for international expansion. Arnold and Hussinger (2010) confirm the influential findings by Helpman et al. (2004) and Bernard et al. (2003) in that only the most productive German firms establish subsidiaries abroad. At the same time less productive firms export and the least productive only serve only the domestic market.[6] Also Arndt et al. (2012) highlight the importance of firm size and productivity as key factors to overcoming barriers to internationalisation, in addition to labour market frictions in the home market of the MNE. The authors argue that higher flexibility in labour markets would decrease the costs of employing people, as currently many firms find it difficult to hire the necessary qualified personnel. This is an interesting insight for this thesis as we hypothesise that labour mobility between MNEs and domestic firms can raise the prospects of internationalisation. Buch et al. (2009, 2010, 2014) find that also financial constraints have a negative impact on the decision of German MNEs to invest abroad, though this holds less for exports. The effect is more pronounced for larger firms and less important for the intensive margin, i.e. the sales of foreign affiliates. Hence, as firms can face significant external barriers, we conclude that

[6] Findings by Temouri et al. (2010) also hint at an additional positive effect on firm productivity after the firm expanded via investment abroad.

increasing productivity levels alone might not be sufficient to raise the prospects of internationalisation.

Turning to the characteristics of foreign destinations, we note that there are also important pull factors that increase the probability of foreign investment by German firms. Buch et al. (2005) report that German MNEs mainly invest abroad to access larger markets, while some manufacturing firms are also driven abroad to save costs. They also seem to discriminate between foreign destinations. Here the level of human capital seems to matter and subsidiaries in less distant countries are found to be smaller on average. In addition, German firms in the same sector are shown to agglomerate in certain countries, while distance is overall negatively related to the number of subsidiaries.[7] Agglomeration patterns by country and industry confirm well-established patterns in the literature (Head et al., 1995; Barry et al., 2003; Crozet et al., 2004; Head and Mayer, 2004). Further evidence on the determinants at the level of foreign destinations are provided by Becker et al. (2005), who highlight lower labour costs in Central-Eastern Europe (CEE) as a key determinant for German investment abroad, potentially leading to a substitution for labour at home. Marin (2004) adds that this is mainly about skill-intensive labour in CEE due to a shortage of skills in Germany. She concludes that this does not lead to job losses at home and helps German firm to remain competitive. The issue of offshoring, i.e. the re-localisation of firm activities from the domestic to foreign markets, ties in the firm-specific characteristics and home market conditions with the pull-factors of different foreign locations. Buch et al. (2007) provide the most comprehensive and complete analysis of offshoring activities by German MNEs.[8] The group of authors reports that market-seeking and access to cheaper factors of production, including labour and intermediate goods, are the main motives for offshoring. Lowering production costs is found to

[7] Interestingly, the authors find that the number of German firms matters, rather than the amount of FDI invested. This will be picked up by the empirical analyses in Chapters 2 and 3.

[8] The analysis is partially based on an annual survey of foreign investment by German MNEs conducted by the Association of German Chambers of Commerce and Industry (DIHK) and only available in German. The survey started in 2005 and is now in its 13. edition (DIHK, 2017b).

matter most for large firms investing in new EU member states in CEE, as well as Asia. This holds especially for younger firms in key manufacturing industries in Germany including basic metals, machinery, automotive and electronics.[9] Finally, Buch et al. (2007) report decreasing employment levels in Germany for firms that offshore production in order to decrease production costs (i.e. mainly those investing in CEE).[10] This finding stands in contrast to Wagner (2011) who shows that offshoring overall does not lead to lower employment levels in Germany. Another related study demonstrates that investment by German manufacturing firms in low-wage countries leads to a reduction in domestic investment (Onaran et al., 2013). On the other hand, investment in high-wage countries outside of Europe has the opposite effect. In line with Buch et al. (2007) the authors argue that investment in low-wage countries is mainly cost-seeking, while market-seeking investment is dominated by replacement of exports.

Since we aim to explore how domestic firms potentially leverage their proximity to MNEs, we now turn to foreign-owned MNEs in Germany to get a better understanding of their operations in Germany. Buch et al. (2006) find that German federal states with a higher stock of migrants from specific countries also have a higher stock of inward investment from the same country (or other high-income countries). This is interesting as it shows an association between migration and foreign investment though the direction of causality remains ambiguous. Their findings demonstrate another interesting channel of lowering barriers to internationalisation, as firms can potentially leverage migrant networks. Chapter 2 of this thesis will discuss this in more detail and provide an empirical analysis at even lower spatial scales. A study by Peri and Urban (2006) shows that German firms in spatial and sectoral proximity to foreign MNEs experienced positive

[9] The authors hypothesise that older firms are more embedded in their local economy and hence less likely to offshore production.

[10] However, the authors acknowledge that data limitations preclude a precise estimation of the effect. In fact, the decrease in employment could relate to the immediate relocation of production and the medium-term development of employment at home could still be positive. In addition it is possible that employment at home would have decreased regardless of the offshoring decision.

productivity spillovers during the 1990s. Regarding the characteristics of foreign-owned MNEs in Germany, research has shown that they have higher propensity to export, levels of productivity, investment in R&D, and wages (Arndt and Mattes, 2010; Raff and Wagner, 2014). These results hold for high- and low-tech sectors (Weche Gelübcke, 2013) and provide the basis for potential positive spillover effects to occur. At the same time, foreign firms themselves have a higher risk of exiting the market (Wagner and Weche Gelübcke, 2012). However, their presence is also shown to be associated with lower levels of productivity at the industry level (Bitzer and Görg, 2009) and hence supports the evidence in favour of competition effects. Similarly, heightened competition leads to a higher probability of market exit by German competitors if they are in low-tech sectors and regions (Franco and Weche Gelübcke, 2014). The former study assumes that foreign firms can steal market share, and the latter adds that German low-tech competitors are less likely to balance negative competition effects with potentially positive spillovers.

The aim of our study is to complement and extend some of the aforementioned studies. We want to explore the internationalisation decision of German firms but go beyond the heterogeneity across firms and shed more light on the region-sector heterogeneity. Based on the literature above we see scope to tie some of the evidence together. First, mounting evidence highlight the importance of firm productivity and size to overcome barriers to internationalisation.[11] Second, external factors such as rigid labour or financial markets can act as additional barriers to global expansions and the former are certainly sector- and to some degree region-specific. Third, the motivations to invest abroad differ across firms and sectors but are mainly driven by market- or cost-seeking considerations. This has implications for the choice of the location abroad and potentially for employment in Germany. Fourth, foreign MNEs in Germany can be the source of spillover but also competition effects with differing impacts across regions and sectors.

Taken together we see room to further scrutinise the region-sector heterogeneity

[11] Firm size is often used to proxy productivity as larger firms are better able to exploit scale economies.

across German firms and add the proximity to MNEs as a potential factor, driving heterogeneous internationalisation patterns. Research on this is limited, not only in the German context, as shown in our conceptual framework. A theoretical and empirical integration of firm-heterogeneity with region-sector heterogeneity and the role of MNEs in the German context is novel and leaves plenty of scope for research in other contexts. As mentioned above, the idea to look at the role of MNEs as a way to explain internationalisation patterns in Germany is most developed in an Economic History study by Hilger (2008). She explicitly analyses the channels of cooperation and competition between German and American firms and concludes that the superiority of the latter in various fields has paved the way for German firms to operate on international markets. Another related study on the biotech industry in Germany revealed that firms embedded in same-industry clusters with many international linkages are more likely to internationalise via new research alliances (Al-Laham and Souitaris, 2008). Though both studies offer detailed insights into the channels that can be at work they remain case studies, and the present thesis will provide a more large scale exercise by building on- and complementing their findings. In addition we provide a more detailed analysis of the region-sector heterogeneity, accounting for various spatial scales and sectoral aggregations. Similar to the channels based on proximity to foreign MNEs we see similarity in the case of domestic MNEs or migrants with destination-specific ties. The following section summarises the research approach and findings of the following three empirical chapters.

## 1.4 Summary of empirical chapters and contribution to the literature

### 1.4.1 Chapter 2: Proximity to MNEs and firm internationalisation: The case of Germany

In chapter 2 we analyse the propensity of German firms to be active as outward investors, exploring and classifying the heterogeneity across firms, regions and

sectors. Building on our general conceptual framework we hypothesise that domestic firms active in regions with a concentration of multinational enterprises are more likely to be outward investors themselves.

We compile a dataset of around 100,000 German firms in manufacturing and service sectors,[12] which allows us to allocate firms to regions (Redding et al., 2011; Burchardi and Hassan, 2013). To test the propensity of firms to invest abroad we run a number of linear and non-linear probabilistic models, controlling for firm-, region- and sector-level factors. As previous studies, we rely on the cross-sectional dimension of the data (Buch et al., 2010, 2014) since key internationalisation variables are not available as a panel. Hence our analysis should be seen as a test for the long-term association between regional and sectoral factors and the propensity of firms located in these to invest abroad (Becker et al., 2005).

Our study reveals three main findings regarding the importance of proximity to MNEs for the internationalisation of firms. Firstly, region-sector proximity seems to be more important than spatial proximity on its own. This lends support to the notion that technological proximity between firms matters for positive externalities to occur (Peri and Urban, 2006). Second, the association between region-sector proximity and the propensity of firms to invest abroad is larger at finer spatial scales. This hints to the tacitness of some knowledge and information about internationalisation processes, as this type of externalities mainly arise between spatially proximate firms. Third, region-sector proximity is shown to matter most when the firm and the proximate MNE are both German-owned. It highlights a potential role of cultural proximity and regional embeddedness for positive externalities or feedback loops to occur. On the other hand, there is a strong incentive in MNEs to minimise knowledge outflows (Javorcik, 2004) and possibly foreign firms are simply better at this.[13]

[12] Data are extracted from ORBIS which is a commercial database compiled by Bureau van Dijk. A detailed description of the database and extraction process is provided in Chapter 2.

[13] Other studies also highlight the tendency of MNEs to locate away from domestic firms (Mariotti et al., 2010; Alfaro and Chen, 2016), which could reduce the occurrence of spillover and competition effects.

We furthermore discuss some additional findings that also check the robustness of our results. Using a sample split we demonstrate that proximity matters more for firms that also have a domestic network of subsidiaries or branches. This is interesting, as firms potentially use experiences from domestic expansions in their internationalisation process as they already know how to manage an organisation cross multiple locations. The study also confirms some previous findings in the German context, and offers some new insights as well: As our analysis highlighted, German firms are no exception to the established pecking order in terms of size and productivity advantages of MNEs over non-MNEs. We also confirm higher propensities to foreign investment of firms in manufacturing and those that are engaged in exporting. However, our main finding is that region-sector proximity between firms can enhance the propensity of outward investment. While the existing literature has highlighted similar dynamics for the co-location of exporters, this is the first study to do so for outward investment. Finally, estimations of zero-inflated and negative binomial models show that proximity to MNEs also matters for the intensive margin of outward investment, i.e. the number of subsidiaries that a firm owns abroad.

### 1.4.2 Chapter 3: The Geography of German Subsidiaries Abroad: Importance of Destination-Specific Ties

Chapter 3 digs deeper into the overarching research question regarding the proximity effects between firms and their internationalisation. While the previous chapter has explored characteristics of firms, regions and sectors in Germany and their heterogeneous propensity to invest abroad, this chapter shifts the focus to outward investors and the foreign destinations. More specifically, we enquire to what degree the availability of ties between the home region of a German outward investor and foreign destinations enhances the probability to choose that location. Our analysis reveals that these ties (based on firm- and migration-linkages) do in fact matter for the location choices of German MNEs. Considering the significance of overcoming barriers to internationalisation, our study highlights that firms benefit from very specific knowledge and information to do so.

The empirical analysis uses a choice model setting commonly found in the literature on firm location choices (Head et al., 1995; Guimaraes et al., 2000; Crozet et al., 2004; Alcácer and Delgado, 2016) as it allows to compare a choice to a set of alternative destinations. We opt for the random-utility Mixed Logit model to allow for unobserved correlation among the alternative destination choices (Basile et al., 2008; Spies, 2010; Defever, 2012; Ascani et al., 2016). In other words, firms are expected to make heterogeneous choices across the same set of alternatives and this model allows for such behaviour. To approximate destination-specific linkages available to a firm we explore three channels. First, we use information on the home country of foreign MNEs active in Germany to see how targeted a region is via inward investment from a specific destination. Second, location decisions abroad of German MNEs from the same region are aggregated by destination to test for same-destination internationalisation of surrounding firms. Thirdly, we approximate linkages via migrant communities based on the nationality of migrants living as permanent residents in a German region. Again, the proximity to foreign or domestic MNEs distinguishes intra- and inter-sector proximity. The regional level of choice are employment areas as they capture the spatial distribution of economic activity, rather than administrative aggregations.

Our main finding is that all three proxies for region-destination ties are positively associated with the directionality of location choices abroad. The strongest in economic terms are proximity to other German MNEs and migrants. As in the previous chapter, region-sector proximity to foreign MNEs is significant but possibly localised effects do not occur as frequently. This finding that effects between MNEs are destination-specific is novel for outward investment though a large body of literature has confirmed similar effects for export entry choices (Silvente and Giménez, 2007; Koenig, 2009; De Simone and Manchin, 2012; Mayneris and Poncet, 2013). Second, this is the first study to look at the association between inward migration and outward investment by German MNEs.[14] While foreign investment and migration are no strangers to empirical studies, they tend to

[14] The only similar study we are aware of looks at the impact of *inward* migration on *inward* investment (Buch et al., 2006)

be investigated at the country-level (Kugler and Rapoport, 2007; Gheasi et al., 2013) though the sector-region level should be preferred (Javorcik et al., 2011). Third, we show that destination-specific ties matter most for single-destination investors. As they are more likely to be first-time investors than multi-destination investors, it is not surprising that they tend to rely more on locally available information to overcome the significant sunk costs to internationalisation. Similar effects have been found for first time exporters (Silvente and Giménez, 2007). The fourth and final finding is that also in the choice of locations there is a strong heterogeneity across firms. The Mixed Logit Model confirms that firms indeed make different choices over the same set of destinations, and for some proximity to MNEs matters more than for others. In addition, interactions with firm size reveal that larger firms are able to expand to more distant foreign destinations, while smaller outward investors are mainly active in Central Eastern- and West Europe.

### 1.4.3 Chapter 4: Domestic and Foreign Spatial Patterns of Industry Sectors: Exploring Global Locations of German MNEs.

The fourth chapter of this thesis explores the domestic and foreign locations of German manufacturing firms. Hence, while the previous two chapters focussed on the firm-level, we now turn to the spatial patterns of whole sectors. We believe that studying domestic and foreign firm locations in conjunction is crucial as the spatial organisation of value chains within and across sectors is increasingly shaped at a global scale (Helpman, 2006; Los et al., 2015). This study is the first to offer a detailed quantitative assessment of the heterogeneity in the spatial patterns of a large number of sectors and their domestic and global spread. Of particular interest to us is the role of technology intensity as a key driver of these internationalisation patterns (Baldwin and Evenett, 2015; Brakman et al., 2015). We find that especially medium-high technology sectors appear to drive the spatial extent of German manufacturing in Germany as well as globally, while other sectors are much more concentrated on average.

In terms of literature background our analysis mainly discusses and integrates two separated streams of studies. On the one hand there is the large field of what we loosely summarise as 'agglomeration economies' literature, and we use it to conceptualise the concentration of industry sectors. While the theoretical discussion dates back to Marshall (1890), empirical studies increasingly use detailed geocoded data to test the spatial patterns of sectors (Duranton and Overman, 2005; Vitali et al., 2013; Koh and Riedel, 2014; Behrens and Bougna, 2015; Brakman et al., 2017). Our methods are inspired by this field as we also rely on geocoded establishment-level data of around 220,000 locations of German firms. This allows us to overcome well-known issues of analysing spatial concentration of economic activity at the level of pre-defined regional aggregations (Openshaw and Taylor, 1979; Briant et al., 2010). In our case this is particularly relevant as we look at concentrations across national borders.

The second literature stream deals with global expansions and location decisions of MNEs and is rooted in management science and international strategy. Scholars highlight that firms closely account for locations of competitors (Alcácer et al., 2013, 2015) and tend to cluster by sector and nationality when going abroad (Smith and Florida, 1994; Head et al., 1995; Blonigen et al., 2005). Hereby they balance the costs and benefits of co-location vs. locating in distance (Alcácer and Chung, 2007; Mariotti et al., 2010; Baldwin and Venables, 2013). These studies are of relevance for our analysis in conceptual as well as empirical terms, as we look at the global geography of German manufacturing firms and the heterogeneity of spatial patterns across sectors.

Curiously these vast literatures have not been integrated yet, possibly due diverging research agendas and empirical methods. Nevertheless, leading scholars such as Duranton and Kerr (2015) describe the analysis of the global spread of MNE establishments and their impact on clusters across national borders as one of the frontier topics in economic geography research. In addition, Alcácer and Zhao (2016) advocate for using geocoded establishment-level data in cross-country settings as the concentration of economic activity takes many different forms and shapes. The most closely related study is conducted by Alfaro and Chen (2014) who study the global location patterns of MNEs compared to those of domestic

firms. The authors find that global locations of MNEs are not a simple mirror image of domestic clusters but partially depend on other factors such as diffusion of technology. However they do not discuss the heterogeneity across sectors or distinguish the nationality of MNEs, which is done in our study.

Despite the exploratory nature of this study it has revealed a few interesting findings. First, we find that also at the global level there is considerable heterogeneity in the spatial pattern across sectors. The concentration 'intensity' is also generally higher than at the domestic level. Here our benchmark is the global pattern of German-owned manufacturing firms and hence controls for the uneven spread of German MNEs globally. Second, our research highlights the central role of distinguishing several levels of technology-intensity when analysing the spatial pattern of sectors. While at the domestic level high-tech sectors are found to be the most concentrated, at the global level it is rather low and medium-low tech sectors. We hypothesise that these firms cluster more as they face higher uncertainty, rely more on local suppliers and are less able to organise production across space. The literature has found that while all firms strategically account for locations of their competitors when expanding abroad (Mariotti et al., 2010; Alcácer et al., 2013; Alfaro and Chen, 2014), high tech firms seem to rely more on internal instead of external agglomeration (Alcácer and Delgado, 2016). This can further support our strong finding of more intensive clustering at the global level by firms in lower technology sectors (especially in CEE countries). Third, our findings suggest that particularly medium-high technology sectors (e.g. automotive, machinery and equipment, chemicals) are among the least concentrated domestically and globally. At the same time a detailed review of German manufacturing competitiveness highlights their crucial importance for the German economy. It is often described as its 'backbone', with vast value chains and suppliers across a variety of sectors (European Commission, 2015; IMF, 2016; OECD, 2016). From a policy perspective this is an interesting insight as less concentration could be related to territorial cohesion, though we would ideally need a comparison across countries that have more centralised economic structures (France, UK) as well as developing countries. Finally, a joint analysis of spatial patterns and sector characteristics revealed some additional insights that should be explored further in the future. Here we

advocate for the use of dynamic as well as static factors. This includes trade and integration in global value chains, employment patterns and whether a sector concentrates further over time.

## 1.5 Concluding Remarks

This introductory chapter has provided an overview of this thesis and outlined our motivation and main research questions. We also developed an overarching conceptual framework to embed the subsequent empirical chapters. Nevertheless, each chapter also contains a separate review of relevant studies, that support the specific research questions and inform the empirical analysis. Furthermore we discussed and summarised key empirical studies that deal with our main research theme: the internationalisation of German firms and their associated geography. Finally, to forward-guide the reader, this chapter has provided a brief summary of the three following empirical chapters and located them in the relevant literatures.

### *Contribution*

We aim to explore the geography of the internationalisation of German firms and we are interested in the heterogeneity across firms, regions, sectors and foreign destinations. Each empirical chapter addresses a different but complementary aspect of this main research theme, and provides original insights that are relevant for academic research and policy makers alike. In the first chapter we explore which types of firms internationalise and which regional characteristics are associated with a heightened propensity of firms to internationalise. Our findings go beyond confirming the heterogeneity of internationalisation across firms based on size and productivity. We provide novel evidence as firms located in regions with a concentration of multinational enterprises are more likely to be outward investors themselves. We assume that MNEs act as internationalisation catalysts for domestic firms. While this has been empirically shown for exporters, this is the first study to extend the literature regarding the co-location of MNEs in their home market. Hereby we explore and confirm a significant

regional heterogeneity in terms of internationalisation and highlight several forms of region-sector proximity between firms. The first is that region-sector proximity to MNEs matters more than pure spatial proximity and this lends support to the notion of technological proximity as a pre-condition to positive externalities (Peri and Urban, 2006). Second, the empirical association is stronger at smaller spatial aggregation and we attribute this to the potential tacitness of knowledge or information of internationalisation processes, as these types of externalities are more likely at the local level (Breschi and Lissoni, 2001). Third, proximity effects are larger between German firms when compared to foreign ones in the same region and sector. Explanations are a potential role of cultural proximity and embeddedness but also prevention of knowledge outflows of MNEs (Javorcik, 2004).

The second empirical chapter adds another dimension: the heterogeneity of foreign expansions across destinations. We approach this in a highly complementary way to the first chapter as we connect these foreign location decisions with specificities of the home region of a firm. More specifically, we explore the importance of region-destination ties for the directionality of outward investments of German firms and, as above, a key assumption is that firms rely on local factors for overcoming barriers to internationalisation. The chapter makes a number of important and original contributions to the literature on foreign expansions of firms. The first lies in showing that regions do have specific ties with foreign destinations that are associated with the directionality of foreign location decisions of German MNEs. We interpret this as evidence for the destination-specificity of support that firms require for their foreign expansions.[15] This has also important implications when thinking about regional development as these ties have a path-dependent nature (Castellani, 2002; Mitze et al., 2010; Crescenzi et al., 2013). If firms do not find it beneficial to locate in smaller places without a critical mass of other firms this can have lasting impact on economic disparities (Behrens, 2016; Crescenzi and Iammarino, 2017). Second, we demonstrate that firm size matters for expanding

[15] Previous studies have shown similar effects only for the case of exporting firms (Silvente and Giménez, 2007; Koenig, 2009).

to more distant foreign destinations as smaller MNEs tend to mainly invest in Europe. Our explanation is straightforward as more distant foreign destinations entail more uncertainty, which smaller firms cannot overcome due to more limited availability of resources. Finally, one of the proxies for the ties between a region and a foreign destination we find to be relevant is the amount of inward migration from that destination. To the best of our knowledge this is the first study in the German context to test this channel empirically and one of the first in general to do so at a fine spatial scale in the receiving country, though various related studies exist (Kugler and Rapoport, 2007; Javorcik et al., 2011; De Simone and Manchin, 2012; Gheasi et al., 2013).

In the third and final empirical chapter we build on our findings from above and scale up the analysis to whole sectors. While the underlying data points are still firms, this allows us to test for sector-specific factors that drive the geography of global expansions by German firms. Our chapter is novel in several ways as a direct comparison of domestic and foreign spatial patterns of sectors from the viewpoint of a single country does not exist. This is important, however, as location decisions of firms are connected to locations of competitors (Alcácer et al., 2013, 2015), and at the same time are largely undertaken with a global view (Helpman, 2006; Duranton and Kerr, 2015). Hence previous studies that only look at a single country (Duranton and Overman, 2005; Barlet et al., 2013; Behrens and Bougna, 2015) miss part of the picture. Our analysis also highlights an interesting aspect of the German economy as we group sectors by their level of technology-intensity. This reveals that it is mainly medium-high tech sectors such as the often-cited automotive or machinery and equipment industries (see e.g. European Commission (2015)) that define the geography of German manufacturing in Germany, but also their global extent. Finally, we also provide technical improvements over the few existing studies using point-pattern analysis to study sector concentrations in Germany, as we geocode the firm location directly by using Google Maps. Previous studies have either used centroids of postcodes or municipalities (Vitali et al., 2013; Koh and Riedel, 2014; Bade et al., 2015), which can be relatively large and hence some weaknesses associated with previous indicators using regional aggregations remain.

We will return to these points in more detail in the individual chapters and also the final conclusion. While the chapters will address some of the limitations of our studies, as well as policy and research implications, these will also be expanded upon in the concluding chapter.

# Chapter 2

# Proximity to MNEs and Firm Internationalisation: The Case of Germany

## 2.1 Introduction

This first empirical chapter explores the question to which degree firms can 'learn' how to internationalise by being located in proximity to multinational enterprises (MNEs). Building on a large firm-level dataset we provide evidence that in the German context the proximity to MNEs is an important factor for the internationalisation of firms. We furthermore show that several forms of proximity, including spatial, cultural and technological dimensions, can be distinguished.

Our conceptual starting point follows the literature on international production and international trade by acknowledging that internationalisation is an expensive endeavour for firms (Hymer, 1960; Dunning, 1977; Bernard and Jensen, 1995; Melitz, 2003). They thus need ownership advantages to overcome the liability of foreignness and successfully compete in international markets (Zaheer, 1995). As a result internationalisation is heterogeneous across firms and the literature has confirmed that it is indeed better firms that become MNEs (Helpman et al., 2004; Helpman, 2006; Greenaway and Kneller, 2007). However, beyond firm-specific

factors, less is known about where these advantages stem from (Castellani and Zanfei, 2007) and especially to what degree the home location of a firm matters. Importantly, also Aitken et al. (1997, p.104) state that *"MNEs are a natural conduit for information about foreign markets, foreign consumers, and foreign technology"*. Our study will integrate these notions and test empirically whether the propensity of firms to internationalise is related to the proximity to MNEs in the home region and/or sector.

Similar dynamics have been shown for the proximity between exporters (Aitken et al., 1997; Greenaway et al., 2004; Koenig, 2009; Farole and Winkler, 2014) and we integrate the literatures on externalities between MNEs and non-MNEs, particularly spillovers and competition effects. Here the superiority of MNEs is the key reason for these externalities to arise (Girma and Wakelin, 2001). The presence of MNEs can raise the productivity of surrounding firms (Blomström and Persson, 1983; Javorcik, 2004; Girma and Gorg, 2005; Keller and Yeaple, 2009) as well as their innovative capacity (Coe and Helpman, 1995; Crescenzi et al., 2015). In addition, training and mobility of labour between MNEs and non-MNEs can be key for the turnover of knowledge (Fosfuri et al., 2001). It has been shown that this labour turnover requires relatively little effort from domestic firms, though it has to be paid for (Castellani and Zanfei, 2006). Interestingly a study on Germany found that where local labour market frictions were high the level of internationalisation of firms was lower (Arndt et al., 2012).

The specific research question we explore has so far not been adequately addressed in the literature. A notable exception is a study by Cook et al. (2012) that specifically addresses the question to what degree a clustering of economic activity leads to a higher propensity of outward investment by local firms. They find that particularly region-sector concentration matters and that there is a large heterogeneity across firms to rely on a cluster's strength. Unfortunately, they rely on relatively broad spatial aggregations and do not consider the concentration of MNEs separately. Hence we aim to provide original insights for a large indus-

trialised country such as Germany.[1] Our study covers manufacturing as well as service sectors and for the empirical analysis we use a large firm-level dataset that includes MNEs and non-MNEs located in Germany. To test for the propensity of firms to be active as outward investors we run linear and non-linear probability models, while controlling for firm-, region- and sector- characteristics. Since we exploit the cross-sectional dimension of the data, our results should be interpreted as long-term associations between regional characteristics and the internationalisation propensity (Becker et al., 2005). Our main variable of interest is the proximity to MNEs and we compute it at the region-, sector- and region-sector level. Here we use 4 different spatial and 3 sectoral aggregations to compare the coefficients, rather than pre-imposing a structure. A final set of models uses the number of subsidiaries that a German MNEs owns abroad to test for the intensive margin of internationalisation. We estimate those using two-step zero-inflated and negative-binomial models to account for the fact that most firms in our sample only operate on the domestic market.

Insights from our analysis are highly relevant from a policy point-of-view. Internationalised firms are generally larger, more productive and provide more and better paid jobs (Bernard and Jensen, 1999; Bernard and Wagner, 2001; Arnold and Hussinger, 2005; Buch et al., 2014; DIHK, 2017b). Hence it is crucial to fully understand all the drivers of their foreign expansions, and this includes the proximity to other MNEs. Studies have also highlighted the need for policymakers to increase the number of MNEs for the competitiveness of their national or regional economies (Storper, 1992; Mayer and Ottaviano, 2008; Yeaple, 2009). Hence if the stock of MNEs benefits other domestic firms this also has implications for the long-term development (or the absence of such) of regions within countries.

The next section discusses the related literatures and reviews some relevant studies focussing on the German context. Section 3 then goes on to describe the dataset, construction of variables and empirical methods. This is followed by Section 4 in which we present and discusses the main findings. Section 5 concludes

[1] Appendix 2.A.1 provides a descriptive overview on the engagement of German firms in international trade and investment as well as foreign firms in Germany.

and discusses limitations as well as areas for future research.

## 2.2 Related literature

### 2.2.1 Proximity to MNEs as catalyst for firm internationalisation

This section aims to review some key empirical studies that can inform and guide our empirical analysis. We start by looking at externalities between domestic firms and MNEs arising at the region-sector level.[2] We draw on studies looking at on 'productivity-' or 'export-spillovers'. Especially the training and mobility of labour from MNEs to non-MNEs is a possibly conducive factor for internationalisation (Fosfuri et al., 2001; Mion and Opromolla, 2014), which in turn requires little effort by local firms though it has to be paid for (Castellani and Zanfei, 2006; Zanfei, 2012). In the empirical literature localised effects are usually analysed at the country- or industry-level, while few studies also distinguish the region-industry-level. Since a number of good literature reviews exist on productivity-spillovers from international trade and investment (Görg and Strobl, 2001; Görg and Greenaway, 2004; Keller, 2004; Barba Navaretti et al., 2004) we do not attempt to provide an exhaustive review here. We rather aim to pick out some key studies to inform and guide our own empirical analysis.

Most quantitative studies analysing externalities between domestic firms and MNEs look at productivity spillovers. The typical empirical setup regresses some measure of foreign investment (count of firms, investment stock, MNE employment) at the level of sectors, regions or a combination on firm-level productivity measures (labour productivity, TFP). Evidence for this type of spillovers has been found for

[2] We are aware that 'spillovers' or 'externalities' can be understood as unintentional and not-paid-for and some authors argue that is is more about knowledge 'transfers' or intended spillovers (Smeets, 2008; Zanfei, 2012). Our study acknowledges this separation of intended and unintended spillovers though we cannot empirically control for it.

a large number of countries,[3] including Germany (Peri and Urban, 2006). These studies put forward a number of channels for these effects, including increased efficiency and rate of technology adoption due to competitive pressures. Keller and Yeaple (2009) find that the presence of foreign affiliates increases productivity of domestic firms mainly in high-tech sectors and also for smaller firms with a lower level of productivity. Similar findings are presented by Girma and Wakelin (2001). Together this highlights the likely heterogeneity across firms and sectors that our empirical models need to account for.

Other studies present more mixed results and discuss the importance of the empirical specification (Aitken and Harrison, 1999; Girma et al., 2001; Jordaan, 2008; Damijan et al., 2013). For example Girma and Wakelin (2001) report positive productivity spillover effects at the region-sector level but negative outside the region of them firm. The authors furthermore show differences depending on the nationality of the foreign investor with Japanese firms especially generating spillovers. While Jordaan (2008, 2009) presents evidence on positive productivity spillovers for manufacturing firms in Mexico at the intra-industry level, this does not hold at the regional level as foreign firms potentially raise local prices of production inputs.

Other important effects that can arise when firms are co-located with MNEs are increasing levels of technology and innovation (Coe and Helpman, 1995). These could in turn influence the prospects of international expansions if innovations lead to firm growth and higher levels of productivity. In fact, in a series of papers Marion Frenz and co-authors show that internationalisation and innovation are closely related and exhibit elements of cumulative causation (Frenz et al., 2005; Frenz and Ietto-Gillies, 2007; Filippetti et al., 2011, 2017). They also highlight the importance of absorptive capacity, though it is subject to diminishing returns. A recent empirical study by Crescenzi et al. (2015) goes beyond the national level and reports positive spillovers from sector-proximity to MNEs on the innovative

[3] This includes the UK (Girma and Wakelin, 2001; Griffith et al., 2003; Girma and Gorg, 2005), US (Keller and Yeaple, 2009), Mexico (Blomström and Persson, 1983), Spain (Barrios and Strobl, 2002) Lithuania (Javorcik, 2004), and Italy (Ferragina and Mazzotta, 2013).

performance of firms in the UK. Assumed channels include demonstration and imitation effects, backward and forward linkages as well as local labour turnover. They also find that absorptive capacity matters and domestic firms that are internationalised generally benefit less. On the contrary, Braconier et al. (2001) do not find any spillovers from inward or outward FDI on the innovativeness of Swedish firms. Van Pottelsberghe de la Porterie and Lichtenberg (2001) only find evidence for the benefit of outward FDI but not inward.

Since this study is interested in the question whether firms can 'learn to internationalise' from MNEs it is important to consider insights from the related literature on 'export spillovers'. The underlying idea is that firms can learn how to export by being proximate to other exporters. While exports represent a different mode of internationalisation than investment abroad they are closely related and often sequential.[4] Aitken et al. (1997) report positive export spillovers at the region-sector level for manufacturing firms in Mexico. They show that specifically the proximity to foreign MNEs matters. Clerides et al. (1998) find that the presence of exporters in the same industry in Colombia makes it easier for domestic firms to access international markets. These are further confirmed by later studies (Greenaway et al., 2004; Koenig, 2009), though others do not find supportive evidence (Bernard and Jensen, 2004b,a). Finally, Wiersema and Bowen (2008) also report a positive impact of import competition on the international diversification (share of exports in turnover) of US manufacturing firms. Nevertheless, their study lacks a regional dimension as it considers sector-level trade flows.

### 2.2.2 Internationalisation patterns of German firms

Several firm-level studies have analysed the internationalisation of German firms. In line with the bulk of the literature they find firm productivity and size to be an important factor for internationalisation. In their analysis of manufacturing firms in Lower Saxony, Bernard and Wagner (1997, 2001) show that larger firm

[4] This will be discussed in more detail when we review the internationalisation of German firms.

size and productivity increase the probability of exporting. Arnold and Hussinger (2005) confirm this sorting into exporting for a representative sample of German firms. A follow-up study demonstrates a sorting into foreign investment, foreign trade and serving only the domestic market, based on a firm's level of productivity (Arnold and Hussinger, 2010). In two studies Buch et al. (2010, 2014) confirm the importance of size and productivity for the intensive and extensive margins of exports and foreign investment of German firms. In addition they show that access to external finance plays a role during the internationalisation process. Other authors show that external finance is of no importance but highlight local labour market frictions which significantly influence the internationalisation of firms (Arndt et al., 2012). Here labour market frictions refer to personnel shortage, collective wage bargaining and worker protection laws. This finding is interesting since the local mobility of labour can be a key spillover channel enhancing internationalisation prospects of firms (Mion and Opromolla, 2014). Finally, Temouri et al. (2010) demonstrate that German firms not only sort into international investment but can experience productivity gains at the parent level following their entry into international markets. Taken together the literature highlights a considerable heterogeneity across German firms in terms of their internationalisation patterns and the need to control for firm characteristics.[5]

Another important aspect of firm internationalisation are exports as both are ways of serving a foreign market directly. Investment abroad and exports can be complements if increasing exports lead to increasing investment abroad or substitutes if investment replaces exports. This has been highlighted by the product life cycle model (Vernon, 1966, 1971) where firms first serve the domestic market, then start to export and in the final stage they move production abroad. Some recent empirical studies have highlighted this sequencing of internationalisation stages (Conconi et al., 2016) and this confirms earlier findings in the German context (Jost, 1997; Tüselmann, 1998), though also contrary evidence exist (Egger and Pfaffermayr, 2004; Mitze et al., 2010). Nevertheless, for any empirical study

[5] Table 2.7 in Appendix 2.A.1 compares key firm-level studies, their findings, as well as data and methods used.

it is thus crucial to control for the export behaviour of firms as it can enhance the propensity of firms to invest abroad (whether investments and exports are complements or substitutes).[6]

### 2.2.3 Effects of MNEs on firms in Germany

There are a few studies looking specifically at the effects of MNE's on domestic firms in the German context. Interestingly, Dunning (1994) states that specifically German firms have used inward investment as a fast and affordable way to upgrade technological capacities. Peri and Urban (2006, p.72) refer to this as the 'Veblen-Gerschenkron effect of FDI' and their empirical analysis supports Dunning's hypothesis. They compute the concentration of FDI at the level of federal states and 20 manufacturing sectors and find that region-sector proximity to MNEs raises the productivity of German firms. Similarly Hilger (2008) describes the competitive pressure introduced by American firms in Germany. After providing several case studies she concludes that German firms adopt American management strategies in the areas of production, accounting, corporate organisation, human resources and marketing. She also argues that those adopted strategies were important tools used by German firms during their own internationalisation from the 1970s onwards. In a study of the bio-tech industry Al-Laham and Souitaris (2008) report similar learning effects where domestic firms learn to internationalise from MNEs. Finally, an early study by Bertschek (1995) concludes that inward investment and imports heighten competition and induce domestic manufacturing firms to increase their innovative capacities. This is one case where competition appears to be positive for an economy, though this necessarily means that those firms that cannot adjust will go out of business. All of these studies show that the proximity to inward investment in Germany can benefit domestic firms.

In contrast to this, Bitzer and Görg (2009) find that inward and outward

[6] A detailed review of the engagement of German firms in international investment and trade is provided in Appendix 2.A.1. Here we also discuss the link between both in the German context.

investment in Germany are associated with lower levels of productivity. This is an interesting finding as it suggests the dominance of negative competition effects and crowding out of domestic firms. However, we have to treat their findings with caution as the presence of foreign firms is measured via the stock of FDI at 10 very broad industry classifications and does not include any spatial dimension. Nevertheless, their study is insightful as it analyses inward and outward investment in the same estimation regression and highlights the need for studies looking at single countries in more detail. Franco and Weche Gelübcke (2014) also analyse the effect of FDI on German firms in the light of spillover and competition effects. They claim to provide first empirical evidence on the effect of foreign MNEs on domestic firms in Germany. In their cross-sectional analysis they show a crowding out effect, especially in West Germany. They also report that only those domestic firms with a higher absorptive capacity can reap the benefits from spillovers and thus exhibit lower exit rates.

## 2.3 Data and methods

### 2.3.1 Data

Firm data are retrieved from ORBIS, which is a commercial dataset compiled by Bureau van Dijk (BvD) that is increasingly used to analyse the internationalisation of firms (Budd et al., 2005; Castellani and Zanfei, 2007; Chen and Moore, 2010; Vitali et al., 2013; Stiebale, 2016; Driffield et al., 2016; Alfaro and Chen, 2017).[7] The availability of regional identifiers also makes it a useful dataset for research in Economic Geography (Peri and Urban, 2006; Redding et al., 2011; Burchardi and Hassan, 2013; Lennert, 2015). Nevertheless a potential issue of 'headquarter bias' remains, which we will address in detail during the discussion of our results.

[7] It has also been used in firm-level studies by international organisations such as the OECD (Ribeiro et al., 2010) and country reports by the European Commission (European Commission, 2015). Also the widely-cited World Investment Reports published by UNCTAD use ORBIS (UNCTAD, 2016, 2017).

Data on regional characteristics including GDP, educational attainment and value-added in manufacturing are retrieved from the Federal Statistical Office and the Statistical Offices of the Länder (Destatis).

Previous studies have also used ORBIS to study the internationalisation of German firms. For example, Mayer and Ottaviano (2007, 2008) combine it with the Bundesbank's MiDi database in their analysis of firm internationalisation in several European countries.[8] Using the same data Buch et al. (2010, 2014) specifically examine the internationalisation patterns of German firms. They rely on the cross-sectional dimension as key internationalisation variables such as exports and investment abroad are not available over time.[9] Also Wagner (2004) uses BvD data for in a study of 83 large stock-quoted German companies and Temouri et al. (2010) for an analysis of productivity effects and investment abroad.

For the empirical analysis we retrieve all data on solvent firms located in Germany with a minimum of 10 employees and annual turnover of €500,000. As the date of the foreign investment decision is not available, our main analysis relies on the cross-sectional dimension of the data. The extracted sample contains a total of 103,741 firms, of which 3,252 are fully German-owned with investments outside of Germany, and 9,782 are foreign-owned but geographically based in Germany. Since we are interested in the internationalisation patterns of German firms the latter will not be included in the regression sample. However, they are used to compute the region-sector penetration of foreign MNEs in Germany as a potential source for spillover- and competition effects. A further restriction of the regression sample is necessary due to missing entries for regional identifiers. We also follow the common practice in firm-level empirical studies and truncate our data at the 1st and 99th percentile for firm productivity to correct for outliers

[8] MiDi is a plant-level dataset administered by Deutsche Bundesbank and includes all German outward and inward investment stocks above a minimum reporting threshold. More information can be found in Lipponer (2011).

[9] Unfortunately recent updates on confidentiality requirements make it now very difficult to combine ORBIS and MiDi, especially when detailed spatial identifiers are involved.

(Martin et al., 2011; Buch et al., 2010; Arndt et al., 2012). In Table 2.8 (Appendix 2.A.2) we provide a more detailed comparison of the extracted sample with the regression sample. As expected, the average firm in the regression sample is smaller (155 compared to 232 employees) and less productive (164,000 compared to €217,000 turnover per employee). Also the level of patents and trademarks and number of subsidiaries owned in Germany is lower. Other key characteristics are stable between the samples. Most importantly, the share of firms with outward investment only drops slightly from 3.5% to 3.1%, while the share of exporters increases from 19.1% to 19.3%.[10]

### 2.3.2 Firm-level variables and heterogeneity in the data

This section discusses the construction of the firm-level variables and how they vary across firms according to their internationalisation status. A full list and description of variables is provided in Appendix 2.A.2, Table 2.9 and the corresponding correlation matrix in Table 2.10. We distinguish firms that are based in Germany using three categories: domestic firm, outward investor (OFDI), and inward investor (IFDI). Each firm is only part of one category, indicated by a 0-1 dummy variable. Domestic firms do not own subsidiaries outside of Germany and also do not have any foreign owners. Outward investor refers to firms that are based in Germany and own one or more subsidiaries outside of Germany (minimum of 10% ownership).[11] We refer to them as 'German parent firms' and as discussed they have no foreign owners. Finally, inward investors are geographically based in Germany and have a foreign ultimate owner.[12] At the same time these firms do not have any German owner.

[10] In a related study, Arndt et al. (2012) perform a similar restriction of the data and report that 2% of firms engage in outward investment and 23% in exports, though they rely on a different data source.

[11] The empirical analysis will also explicitly distinguish outward investors with single- and multiple foreign subsidiaries.

[12] ORBIS defines the Global Ultimate Owner (GUO) as the firm that has the highest percentage of ownership with a minimum of 25.01%.

Table 2.1: Descriptive statistics: Firms in the sample by internationalisation status

| | Count | Mean | Median | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|
| *(a) Purely domestic firms* | | | | | | |
| Productivity | 84863 | 160.050 | 106.165 | 171.813 | 15.980 | 1601.362 |
| Employment | 84863 | 101.449 | 22.000 | 831.519 | 10.000 | 112310.000 |
| Turnover | 84863 | 18.261 | 2.538 | 184.298 | 0.500 | 29558.900 |
| Exporter | 84863 | 0.027 | 0.000 | 0.161 | 0.000 | 1.000 |
| Manufacturer | 84863 | 0.225 | 0.000 | 0.418 | 0.000 | 1.000 |
| Young firm | 84863 | 0.189 | 0.000 | 0.392 | 0.000 | 1.000 |
| Patents | 84863 | 1.129 | 0.000 | 22.983 | 0.000 | 3937.000 |
| Trademarks | 84863 | 0.282 | 0.000 | 2.902 | 0.000 | 342.000 |
| Subsidiaries | 84863 | 0.482 | 0.000 | 3.005 | 0.000 | 543.000 |
| Branches | 84863 | 0.862 | 0.000 | 3.671 | 0.000 | 283.000 |
| *(b) Outward investors* | | | | | | |
| Productivity | 2738 | 289.544 | 206.316 | 256.558 | 16.668 | 1596.854 |
| Employment | 2738 | 1870.484 | 301.000 | 9972.374 | 10.000 | 273484.000 |
| Turnover | 2738 | 415.955 | 68.649 | 2125.372 | 0.560 | 52516.000 |
| Exporter | 2738 | 0.414 | 0.000 | 0.493 | 0.000 | 1.000 |
| Manufacturer | 2738 | 0.375 | 0.000 | 0.484 | 0.000 | 1.000 |
| Young firm | 2738 | 0.096 | 0.000 | 0.294 | 0.000 | 1.000 |
| Patents | 2738 | 68.466 | 1.000 | 514.405 | 0.000 | 15123.000 |
| Trademarks | 2738 | 11.061 | 1.000 | 59.506 | 0.000 | 2221.000 |
| Subsidiaries | 2738 | 5.585 | 2.000 | 17.658 | 0.000 | 369.000 |
| Branches | 2738 | 2.489 | 0.000 | 7.284 | 0.000 | 180.000 |
| *(c) Inward investors* | | | | | | |
| Productivity | 8772 | 308.621 | 212.034 | 284.463 | 16.129 | 1600.000 |
| Employment | 8772 | 392.755 | 89.000 | 2263.546 | 10.000 | 170000.000 |
| Turnover | 8772 | 109.044 | 21.648 | 601.121 | 0.500 | 39600.000 |
| Exporter | 8772 | 0.241 | 0.000 | 0.428 | 0.000 | 1.000 |
| Manufacturer | 8772 | 0.335 | 0.000 | 0.472 | 0.000 | 1.000 |
| Young firm | 8772 | 0.221 | 0.000 | 0.415 | 0.000 | 1.000 |
| Patents | 8772 | 15.177 | 0.000 | 107.629 | 0.000 | 3682.000 |
| Trademarks | 8772 | 2.443 | 0.000 | 14.968 | 0.000 | 629.000 |
| Subsidiaries | 8772 | 0.947 | 0.000 | 3.270 | 0.000 | 100.000 |
| Branches | 8772 | 2.121 | 0.000 | 7.450 | 0.000 | 229.000 |

Notes: All firms classified as outward and inward investors at the same time are dropped to avoid any confusion in the empirical analysis.

All in all our sample contains 84,869 purely domestic firms, 2,732 outward investors, and 9,782 inward investors. To get a first intuition of the data and characteristics of the firms in our sample we provide a comparison of these three groups in Table 2.1. From the descriptive statistics we can see that purely domestic firms are the smallest in terms of employment and turnover at €18.3 million and 101 employees, respectively. In comparison, German firms that invest abroad have an average of 1,870 employees and €190 million turnover.[13] Domestic firms are also less productive with average sales of €160,000 per employee, compared to €290,000 for outward investors. 27% of domestic firms are exporters and 22.5% are active in manufacturing. For outward investors these figures are higher at 41.4% and 37.5%. Regarding their domestic network, purely domestic firms own on average 0.48 subsidiaries and 0.86 branches in Germany. Firms that have investments abroad on the other hand also have a larger domestic network with 5.59 subsidiaries and 2.49 branches on average. Finally, outward investors hold considerably more patents and trademarks than domestic firms. This superiority in terms of innovative capabilities is well-established in the literature (Frenz et al., 2005; Frenz and Ietto-Gillies, 2007; Filippetti et al., 2011). Overall these stylised facts are in line with earlier findings on the superiority of multinational over non-multinational enterprises. However, we observe that they are also older on average as the fraction of firms being classified as 'young' (i.e. less than 10 years from incorporation date) is lower for outward investors. We prefer this measure as age in years is likely to be associated with other firm characteristics such as size and productivity (Arnold and Hussinger, 2005). We expect these firm-level characteristics to be positively associated with outward investment also in statistical terms. Characteristics of foreign firms in Germany (i.e. inward investors) are shown in panel (c) of Table 2.1 and they appear to be yet more productive than German outward investors. However, they are smaller in terms of employment and turnover.

[13] A related study of outward investment by German firms that also uses ORBIS, reports an average MNE size between 5,000 - 6,000 employees (Temouri et al., 2010). The authors do not report how their unbalanced panel of 300-600 MNEs was selected, but the small number of firms per year indicates a bias towards very large firms.

Table 2.2: Descriptive statistics: Regional characteristics by level of aggregation

| | Count | Mean | Median | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|
| *(a) Federal states (NUTS-1) / Bundesländer* | | | | | | |
| Regional market | 16 | 182.228 | 106.896 | 189.272 | 30.119 | 632.848 |
| Regional manuf. share | 16 | 0.199 | 0.199 | 0.065 | 0.093 | 0.327 |
| Regional education | 16 | 0.160 | 0.151 | 0.036 | 0.116 | 0.243 |
| Regional OFDI | 16 | 180.250 | 78.000 | 230.910 | 11.000 | 695.000 |
| Regional OFDI (int) | 16 | 2147.375 | 538.500 | 3011.374 | 28.000 | 8500.000 |
| Regional IFDI | 16 | 589.438 | 289.500 | 664.695 | 92.000 | 2354.000 |
| Regional dom. firms | 16 | 5489.000 | 2992.000 | 5764.106 | 610.000 | 20695.000 |
| *(b) Government districts (NUTS-2) / Regierungsbezirke* | | | | | | |
| Regional market | 38 | 76.728 | 63.547 | 52.689 | 14.513 | 231.612 |
| Regional manuf. share | 38 | 0.230 | 0.233 | 0.072 | 0.093 | 0.370 |
| Regional education | 38 | 0.145 | 0.140 | 0.036 | 0.091 | 0.243 |
| Regional OFDI | 38 | 75.895 | 53.000 | 63.995 | 11.000 | 275.000 |
| Regional OFDI (int) | 38 | 904.158 | 501.500 | 1166.364 | 28.000 | 4687.000 |
| Regional IFDI | 38 | 248.184 | 145.500 | 273.234 | 51.000 | 1178.000 |
| Regional dom. firms | 38 | 2311.158 | 1938.000 | 1418.589 | 610.000 | 6768.000 |
| *(c) Employment areas (EAs) / Arbeitsmarktregionen* | | | | | | |
| Regional market | 255 | 11.372 | 5.672 | 19.854 | 1.450 | 161.346 |
| Regional manuf. share | 255 | 0.254 | 0.238 | 0.105 | 0.063 | 0.692 |
| Regional education | 255 | 0.123 | 0.114 | 0.039 | 0.056 | 0.257 |
| Regional OFDI | 255 | 11.290 | 6.000 | 20.527 | 0.000 | 192.000 |
| Regional OFDI (int) | 255 | 134.671 | 28.000 | 370.480 | 0.000 | 3691.000 |
| Regional IFDI | 255 | 36.863 | 14.000 | 96.493 | 1.000 | 809.000 |
| Regional dom. firms | 255 | 341.565 | 195.000 | 492.513 | 43.000 | 4066.000 |
| *(d) Counties (NUTS-3) / Kreise* | | | | | | |
| Regional market | 396 | 7.292 | 4.492 | 11.284 | 1.031 | 117.748 |
| Regional manuf. share | 396 | 0.241 | 0.223 | 0.115 | 0.015 | 0.745 |
| Regional education | 396 | 0.133 | 0.119 | 0.050 | 0.055 | 0.318 |
| Regional OFDI | 396 | 7.242 | 4.000 | 11.162 | 0.000 | 115.000 |
| Regional OFDI (int) | 396 | 86.634 | 18.000 | 250.225 | 0.000 | 2900.000 |
| Regional IFDI | 396 | 23.652 | 11.000 | 51.137 | 0.000 | 450.000 |
| Regional dom. firms | 396 | 218.449 | 147.000 | 253.026 | 25.000 | 3123.000 |

### 2.3.3 Region-sector level variables and heterogeneity in the data

We now take a closer look at the region- and sector- heterogeneity in the data and describe how we construct our main variables of interest regarding the proximity to MNEs. The choice of the spatial scale of data is a sensitive issue as different aggregations can influence the results (Openshaw and Taylor, 1979; Briant et al., 2010). Hence our analysis relies on 4 separate spatial aggregations and we will compare our results across these rather than picking one ex ante. From large to small these are federal states, government districts, employment areas, and counties. Apart from employment areas they correspond to regional administrative boundaries and those can be problematic if they do not appropriately reflect the underlying spatial distribution of economic activity. Employment areas (EAs) on the other hand are constructed based on economic rather than administrative considerations. EAs are based on a maximum one-way travel to work commuting time below 45 minutes.[14] Since they are based on an upward aggregation of counties and by definition there are no overlaps between them, a county cannot be part of two employment areas at the same time. The advantage of using counties is that they are smaller (402 counties compared to 256 EAs) and usually contain only one major city or in the case for 107 counties entirely consist of a single city.

In Table 2.2 we show key characteristics for the different regional aggregations in panels (a) to (d). Regional market size is approximated by total GDP in billion euros and not surprisingly it declines as we move down from large to small spatial aggregations. An alternative measures for market size is the total number of domestic firms. The average county hosts 218 purely domestic firms, though the considerably lower median and high standard deviation hints at the fact that there are some large counties in the data. Both market size variables enter our empirical model in logs and we can think of a positive as well as negative association with firm internationalisation. On the one hand a large local market helps firms to achieve the scale or access resources to expand abroad, while on the other hand

[14] They are comparable to 'travel-to-work areas' used in the UK or 'zone d'emploi' in France.

a larger local market is often associated with a smaller need to expand in order to seek sales. The latter has been found for country-level studies (Blomström and Lipsey, 1991; Swedenborg, 1979). Other regional variables included in the analysis are the share of manufacturing in total regional GVA, and the level of education, approximated by the share of employees with tertiary education. The average county has a manufacturing share of 24%[15] and share of workers with tertiary education of 13.3%.[16] We assume that regional education is positively associated with outward investment as German firms in these regions can find the skilled labour needed to expand globally. Prior assumptions regarding the regional manufacturing share are more difficult. We see it more as a control as a high share of local manufacturing increases the likelihood that a firm is active as a local supplier and hence might not see the need to expand globally.

Our main variables of interest in this study are based on region-, sector- and region-sector aggregations of outward- and inward investment. They are computed based on a count of domestic and foreign MNEs by region and sector, which is widely adopted in the literature (Malmberg et al., 2000; Jindra, 2011; Farole and Winkler, 2014; Muñoz-Sepúlveda and Rodríguez, 2015). Instead of counts, some other studies use the number of employees (Peri and Urban, 2006). However, as employment figures for multi-plant firms in ORBIS are sometimes reported at the level of the headquarters we decide to stick to firm counts. In the sample the typical county is home to 7.2 outward investors (OFDI) and 23.7 inward investors (IFDI). A map of the number of inward and outward investments by employment areas shows that they are highly concentrated in the West and South of Germany, though some hotspots exist across the country (Berlin, Hamburg, Hannover, Bremen, Dresden).[17] In addition we also construct an 'intensive' measure of OFDI

[15] The counties with the highest share are Ingolstadt (74.5%), Wolfsburg (70.1%), and Dingolfing-Landau (69.2%). The lowest share can be found in Potsdam (1.5%), Cottbus (3.1%) and Bonn (3.5%).

[16] The counties with the highest educational attainment are Bonn (31.8%), Heidelberg (31.7%), and Jena (30.8%). The lowest share can be found in Tirschenreuth (5.5%), Freyung-Grafenau (5.6%) and Salzgitter (6%).

[17] For details see Figure 2.1 and Figure 2.2 of Appendix 2.A.2.

based on the total number of foreign subsidiaries that the German parent firms own. This is important as studies on multinationality and innovation propensity of firms discuss the importance of a higher degree of internationalisation (Frenz et al., 2005). More specifically this means that a firm owning 4 subsidiaries abroad is 'counted' 4 times to get OFDI (int). Our reasoning is that externalities could be more pronounced when a German MNE owns more than one subsidiary abroad. We use this intensive measure of OFDI as a robustness check.

In addition to the regional, we are interested in the sectoral aggregation of OFDI and IFDI. This provides us with an additional form of proximity between domestic firms and MNEs as firms within the same sector are assumed to be close to each other also in terms of technology (Peri and Urban, 2006). At the same time, firms that operate in the same sector are also more likely to collaborate or compete for market share. Here one immediate caveat of choosing a sectoral classification is the trade-off between the level of technological proximity and wider backward and forward linkages between firms beyond the immediate sectoral classification (Malmberg et al., 2000). To address this issue we compute the sector-level variables at various levels of aggregation using 2-, 3- and 4-digit classifications based on NACE Rev.2. The full tabulation of counts for OFDI and IFDI by sector- and region-sector is provided in Table 2.11 in Appendix 2.A.2. Not surprisingly the average number of OFDI and IFDI firms in proximity to the average firm declines as we move from high to low spatial and sectoral aggregations. While there are on average 100 OFDI and 354 IFDI firms in the same 2-digit sector, these figures decline to 21.5 and 56.8 at the 4-digit sector. At the region-sector level we only consider 2-digit sectors as a finer disaggregation would decrease the average number of OFDI and IFDI by region-sector considerably. In the sample there are on average 14.4 OFDI and 50.3 IFDI firms in the same federal state and 2-digit sector for the average firm. The same figure at the level of counties and 2-digit sectors are 0.8 and 3.2, respectively.

A final set of variables at the region-sector level is supposed to control for the regional specialisation in certain industry sectors as this can have positive implications for the internationalisation of firms. Since we cannot use domestic or foreign MNEs and data on trade flows are not available at a fine geographical level,

we rely on the number of domestic firms. We count the number of domestic firms in the same 2-digit industry sector and region as the firm under consideration and compute the share to the total number of firms in a region. This gives us a measure of regional specialisation that can vary across spatial aggregations. Descriptive statistics for regional specialisation are included in Table 2.11 (Appendix 2.A.2). It shows that the average regional specialisation is 4.7% at the level of federal states (NUTS1) and increases to 5.6% at the level of counties (NUTS3). Interestingly, some regions appear to be highly specialised with up to 29.2% of firms operating in the same 2-digit sector in some counties, or 27.1% in some employment areas. As done in previous studies this also highlights the importance of controlling for region-sector specialisation (Aitken et al., 1997; Antonietti and Cainelli, 2011; Jindra, 2011; Cook et al., 2012).

### 2.3.4 Methods

To estimate the probability that a German firm is active on foreign markets via outward investment we specify a number of models. Our baseline specification is a Linear Probability Model (LPM) with a dummy dependent variable ($OFDI_{irs}$) indicating whether a firm has current investments abroad or not (0/1). As discussed, ORBIS only provides the most recent information on ownership linkages of parent and subsidiary firms, which in most cases this is 2015 or 2016. Hence we will mainly rely on the cross-sectional dimension and estimate the LPM using OLS. The key advantage of this model is that coefficients are very easy to interpret. However the drawback is that the association between right- and lefthand side variables is constant, meaning that e.g. increases in productivity are assumed to have the same effect at low and high levels. We partially alleviate this concern by including sector dummies to eliminate cross-sector differences. In addition we follow the literature and specify a Probit model to confirm the sign of the coefficients (Koenig et al., 2010; Jindra, 2011; Buch et al., 2014; Muñoz-Sepúlveda and Rodríguez, 2015). The advantage of a Probit model over the LPM is that the predicted probability is bound to the unit interval (0/1), while the LPM can potentially lead to predicted probabilities larger than 1 or lower than 0 if the

explanatory variables become very large or small (Cameron and Trivedi, 2005). The main drawback is that the coefficients are not as straightforward to interpret as in the LPM. The estimated regression model becomes:

$$OFDI_{irs} = \beta_0 + \beta_1 FIRM_i + \beta_2 REGION_r + \beta_3 MNE\_PROXirs + \mu_s + \epsilon_{irs} \quad (2.1)$$

Here the i refers to the firm, r to the regional aggregation, and s to the chosen sectoral classification. The latter two vary between models and we indicate the chosen spatial and sectoral aggregations in the results. $\text{FIRM}_i$ contains the firm characteristics discussed above and found in the literature to be associated with outward investment. In addition, $\text{REGION}_{ir}$ refers to any regional characteristics and $\text{SPECIAL}_{irs}$ to region-sector specialisation patterns as we discussed in the data section in detail. Finally, $MNE\_PROX_{irs}$ holds all variables counting the number of foreign or domestic FDIs by region-, sector- and region-sector. $\mu_s$ denominates 2-digit sector dummies, $\beta_{irs}$ is the model constant and $\epsilon_{irs}$ the error term. As $\epsilon_{irs}$ is by definition heteroskedastic in the LPM we only estimate robust standard errors (Cameron and Trivedi, 2009).

## 2.4 Discussion of results

### 2.4.1 Findings on firm heterogeneity in internationalisation patterns

Before we discuss our main results regarding the proximity to MNEs and the outward investment of German firms we analyse the heterogeneity across firms and sectors. Our literature review and conceptualisation highlighted the large heterogeneity of internationalisation across firms. This makes it necessary to discuss first which type of firms in which regions are prone to international expansions and how our sample of firms compares to previous firm-level studies.

We run a number of models using OLS, adding regressors in a step-wise fashion from (1) to (9) and present results in Table 2.12 of Appendix 2.A.2. Our findings

confirm previous studies, as more productive and larger firms that are exporters or manufacturers have a higher probability to be outward investors (Arnold and Hussinger, 2010; Arndt et al., 2012; Buch et al., 2014). Also firms that hold more trademarks or own domestic subsidiaries or branches have a higher probability. On the other hand, younger firms are less likely to be outward investors though the coefficient is not significant in all specifications. Specification (10) adds 2-digit sector dummies and most explanatory variables appear to be robust, while slightly decreasing in magnitude. Using a Probit model estimated with maximum likelihood we get qualitatively similar results.[18]

Turning to regional level variables we can highlight a few additional insights (see Table 2.14 in Appendix 2.A.2). We include variables for regional market size, manufacturing base (share of manufacturing in total GVA), education and specialisation. All four are initially computed at the level of employment areas and the regressions also employ a full set of 2-digit sector dummies. We find that a firm's local market is positively associated with the probability of outward investment and statistically significant. The same holds for the level of regional education, while the regional manufacturing share does not seem to be associated with the probability of outward investment. Finally, regional specialisation appears to be negatively and significantly associated with outward investment. The most plausible explanation for the latter finding is that we capture the existence of regional clusters with a higher chance that a firm acts as a supplier to other firms. Hence the need to expand internationally is smaller. This is also supported when we look at the results at different spatial aggregations in Table 2.15 of Appendix 2.A.2. We can see that the coefficients for regional specialisation become smaller at the employment area level and even positive and significant at higher levels of aggregation. This supports our hypothesis as supplier-buyer networks are more likely to matter at smaller spatial scales. The positive coefficients at larger spatial scales hint at the importance of specialisation at larger administrative areas, e.g.

[18] See Table 2.13, Appendix 2.A.2. To get a converging model we transform the count of trademarks, domestic subsidiaries and branches using a natural logarithm and alternatively dummies.

due to relevant policy support or international marketing of federal states. In a detailed review, Kroll et al. (2016) show that federal states in Germany have considerable expertise and autonomy in designing and implementing strategic policies regarding innovation and technology. Comparing coefficients for the other three regional variables also reveals some additional findings. While the regional market is relevant at all spatial scales, the share of manufacturing only appears to matter at higher levels. This is consistent with our previous explanation for regional specialisation that also plays a positive role only at higher aggregations. Finally, the level of education is only significantly and positively associated at smaller scales. As this excludes the level of federal states, this could potentially be explained by the fact that firms recruit skilled labour on more local markets.

In summary the typical German firm acting as an outward investor is large, productive, and exporting. Further, it is a manufacturing firm that operates a domestic network of subsidiaries and branches, based in a larger local market with more highly educated employees.

### 2.4.2 Main results: Proximity to MNEs and firm internationalisation

We now turn to the findings for our main explanatory variables of interest: proximity to MNEs. Table 2.3 reports the findings for region-sector proximity to domestic and foreign MNEs. In specifications (1) to (4) we report the proximity variable for domestic MNEs (OFDI) at a decreasing spatial scale from federal states to counties. The same holds for proximity to foreign MNEs (IFDI) in specifications (5) to (8). The sector level is always at the 2-digit classification. This means that in (1) we show the proximity to the number of domestic MNEs (OFDI) aggregated at the level of federal states and 2-digit sectors. Looking at the results more closely, we see that the coefficient for OFDI increases in magnitude as we decrease the spatial scale.[19] The coefficient for federal states in (1) is 0.0043,

[19] These results also hold if we look at the 'intensive' measure of OFDI as discussed in the data section.

Table 2.3: Empirical results: Region-sector proximity to domestic and foreign MNEs

| | (1) OLS | (2) OLS | (3) OLS | (4) OLS | (5) OLS | (6) OLS | (7) OLS | (8) OLS |
|---|---|---|---|---|---|---|---|---|
| Productivity | 0.015*** | 0.015*** | 0.015*** | 0.015*** | 0.015*** | 0.015*** | 0.015*** | 0.015*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Employment | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** | 0.034*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Exporter | 0.192*** | 0.192*** | 0.192*** | 0.192*** | 0.192*** | 0.192*** | 0.192*** | 0.192*** |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) |
| Young firm | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Trademarks | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Subsidiaries | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Branches | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| OFDI (NUTS1, 2-dig) | 0.004*** | | | | | | | |
| | (0.001) | | | | | | | |
| OFDI (NUTS2, 2-dig) | | 0.005*** | | | | | | |
| | | (0.001) | | | | | | |
| OFDI (EA, 2-dig) | | | 0.006*** | | | | | |
| | | | (0.001) | | | | | |
| OFDI (NUTS3, 2-dig) | | | | 0.007*** | | | | |
| | | | | (0.001) | | | | |
| IFDI (NUTS1, 2-dig) | | | | | 0.003*** | | | |
| | | | | | (0.001) | | | |
| IFDI (NUTS2, 2-dig) | | | | | | 0.003*** | | |
| | | | | | | (0.001) | | |
| IFDI (EA, 2-dig) | | | | | | | 0.003*** | |
| | | | | | | | (0.001) | |
| IFDI (NUTS3, 2-dig) | | | | | | | | 0.003*** |
| | | | | | | | | (0.001) |
| Sector dummies | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig |
| $R^2$ | 0.219 | 0.219 | 0.219 | 0.219 | 0.219 | 0.219 | 0.219 | 0.219 |
| Observations | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

meaning that an increase of domestic MNEs in the same federal state and 2-digit sector by 100% (i.e. doubling) is associated with a 0.43 percentage points increase in the probability of a firm being an outward investor, assuming all else stays equal. Going down the spatial scale to counties in (4) this coefficient increases to 0.007, or an increase in the probability by 0.7 percentage points. While this figure seems low we need to keep in mind that the average firm is in proximity to 0.79 domestic MNEs in the same county and 2-digit sector.[20] Hence doubling or tripling the number seems less unachievable when looking at these averages.

Next we take a closer look at the proximity to foreign MNEs or inward investment (IFDI) in the same region and sector. Compared to the proximity to domestic MNEs (OFDI) two interesting observations can be made. First, the coefficients do not change much in magnitude when moving from high (5) to low spatial aggregations (8). Second, the coefficients are smaller and about half the size at the lowest spatial scale. Related to this, Javorcik (2004) mentions that MNEs actively try to prevent information leakages, and we speculate that foreign MNEs are either better at this, or just less locally embedded. On the other hand this could refer to a cultural proximity between German domestic firms and MNEs that facilitates the emergence of positive externalities. At the county level a doubling of foreign-owned firms (IFDI) in the same 2-digit sector is associated with a 0.3 increase in the probability of outward investment. Again, this appears low though the average number of IFDI at this level is 3.2. In addition, while this is an average effect, it is plausible to expect that there is significant heterogeneity across firms on the importance of proximity to MNEs and for some it could be significantly higher. We explore this question in more detail further below when looking at additional results and robustness checks. Overall it emerges that proximity to MNEs matters and more so at lower spatial scales and when the proximate MNE is also German. The fact that a common sector matters could be seen as evidence for the importance of technological proximity. These findings also hold in qualitative terms when using a non-linear Probit model (see Table 2.17 in Appendix 2.A.2).

[20] See descriptive statistics in Table 2.11 in Appendix 2.A.2.

In addition to region-sector proximity to MNEs we are interested in region- and sector-proximity separately to get a better understanding of their individual importance. Another reason is that externalities between firms across sectors are not captured by our previous analysis, though they are very important for spillovers to occur (Javorcik, 2004). The empirical analysis resembles the models presented in Table 2.3, though now we include region- and sector-level counts of domestic and foreign MNEs as separate variables.[21] Our analysis shows that both are of relevance for a firm's internationalisation via outward investment. However, in terms of economic importance OFDI appears superior. Sector-level proximity to IFDI or OFDI does not differ between models (1) to (4) (as the variable itself is the same) and the coefficients are larger than regional-level proximity by a factor of 2 - 3. Since including sector-level proximity variables precludes the use of sector-level dummies we add a dummy for manufacturing firms. The dummy is positive and significant in all specifications, highlighting the higher propensity of manufacturing firms to invest abroad (Arndt et al., 2012). Also the coefficients for proximity to MNEs at different regional levels are all highly statistically significant. For OFDI and IFDI they are largest at the NUTS-2 level in absolute size. This is interesting as our previous findings highlighted the importance of smaller spatial scales for region-sector proximity. One interpretation we can offer is that sector-specific knowledge about internationalisation travels at a small spatial scale between firms, while an overall presence of MNEs at the wider regional level captures other positive externalities, e.g. related to supporting institutions or infrastructure.

Finally, we also check for sectoral proximity to outward and inward investors at different levels of sectoral aggregations. Table 2.18 in Appendix 2.A.2 shows that the coefficients for OFDI are larger than IFDI. This again confirms a higher importance of proximity to domestic MNEs. In addition, coefficients at the 2- and 3-digit level are marginally larger than the 4-digit level in (3) and (6). Especially the presence of foreign MNEs in the same 4-digit sector appears less important than the 2- or 3-digit levels. Without over-interpreting these high-level results it could hint at potential competition effects operating at narrower sectors.

[21] Results are presented in Table 2.16 in Appendix 2.A.2.

### 2.4.3 Additional results and robustness checks

*Single- vs. multi-location firms*

The literature has discussed potential data limitations if a foreign subsidiary is assigned to the headquarters of a firm or characteristics such as employment or turnover are recorded at the level of headquarters (Lennert, 2015). This so called 'headquarter bias' can be an issue if a firm with multiple domestic locations benefits not only from proximity to MNEs in its headquarter location but also through its domestic subsidiaries and branches. Hence multi-location firms can have a higher propensity to invest abroad for their experience in managing a multi-locational firm but also due to the internal transfer of knowledge and information acquired in other domestic locations. On the other hand it is possible that we underestimate the effect if the decision to internationalise arises in a domestic subsidiary that is highly exposed to outward or inward FDI in its region or sector, rather than the headquarters. However, it has been argued that internationalisation decisions tend to be taken at the headquarter (Koenig, 2009; Koenig et al., 2010). For these reasons our main econometric analysis always controls for the number of domestic branches and subsidiaries of a German firm.

To get a deeper insight into the role of proximity for single- vs. multi-location firms we split our sample in two ways and report the results in Table 2.4. First, as in Koenig (2009) we split the data in firms without domestic subsidiaries and firms with domestic subsidiaries. Models (1) and (3) are estimated for 70,654 single-location firms and (2) and (4) for 16,947 firms with a minimum of 1 subsidiary in Germany. This means that around 19.3% of firms in our sample own subsidiaries domestically, while 11.5% of these also own subsidiaries abroad. Of the single-location firms only around 1.1% are active as foreign investors. Holding all else constant and keeping in mind that we apply a full set of 2-digit sector dummies we can see from specifications (1) and (2) that region-sector proximity to German outward investors (OFDI) is positive and significant for the probability of being an outward investor yourself for single- as well as multi-location firms. Nevertheless, we note that the coefficient is larger for the latter. The same holds for region-sector proximity to foreign investors as in seen in (3) and (4). These findings further

Table 2.4: Empirical results: Single- vs. multi-location firms

| | (1) OLS | (2) OLS | (3) OLS | (4) OLS | (5) OLS | (6) OLS | (7) OLS | (8) OLS |
|---|---|---|---|---|---|---|---|---|
| Productivity | 0.010*** | 0.023*** | 0.010*** | 0.023*** | 0.010*** | 0.019*** | 0.010*** | 0.019*** |
| | (0.001) | (0.003) | (0.001) | (0.003) | (0.001) | (0.002) | (0.001) | (0.002) |
| Employment | 0.016*** | 0.055*** | 0.016*** | 0.055*** | 0.014*** | 0.045*** | 0.014*** | 0.045*** |
| | (0.001) | (0.002) | (0.001) | (0.002) | (0.001) | (0.002) | (0.001) | (0.002) |
| Exporter | 0.106*** | 0.195*** | 0.106*** | 0.196*** | 0.071*** | 0.202*** | 0.071*** | 0.203*** |
| | (0.011) | (0.012) | (0.011) | (0.012) | (0.012) | (0.010) | (0.012) | (0.010) |
| Young firm | -0.001 | -0.015** | -0.001 | -0.014** | -0.001 | -0.004 | -0.001 | -0.004 |
| | (0.001) | (0.006) | (0.001) | (0.006) | (0.001) | (0.003) | (0.001) | (0.003) |
| Trademarks | 0.005*** | 0.001** | 0.005*** | 0.001** | 0.006*** | 0.001** | 0.006*** | 0.001** |
| | (0.002) | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| OFDI (EA, 2-dig) | 0.002*** | 0.017*** | | | 0.001 | 0.011*** | | |
| | (0.001) | (0.004) | | | (0.001) | (0.002) | | |
| IFDI (EA, 2-dig) | | | 0.001*** | 0.010*** | | | 0.001 | 0.006*** |
| | | | (0.000) | (0.002) | | | (0.000) | (0.001) |
| Sector dummies | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig |
| Subsidiaries | No | Yes | No | Yes | | | | |
| Subs & branches | | | | | No | Yes | No | Yes |
| $R^2$ | 0.081 | 0.259 | 0.081 | 0.259 | 0.059 | 0.246 | 0.059 | 0.246 |
| Observations | 70,654 | 16,947 | 70,654 | 16,947 | 52,740 | 34,861 | 52,740 | 34,861 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Subsidiaries & branches refers to domestic locations only (i.e. in Germany).

qualify our empirical findings above that indicate a positive association between the number of domestic subsidiaries and outward investment. Taken together this allows for the tentative conclusion that a domestic network of subsidiaries increases the probability of outward investment as well as the benefit from positive externalities from being located in proximity to MNEs. As discussed, we cannot conclude whether the channel is multi-locality per se or multi-locality as a way of benefitting from being close to MNEs in some places and transferring knowledge and information internally. In reality this is likely to be a combination of both and heterogeneous across firms.

To gain further insights into multi-location firms we repeat Models (1) to (4) but now we consider multi-location firms as those with either domestic subsidiaries or domestic branches. The key difference is that branches are legally fully integrated in the firm and though they can be located in other locations they are not registered as a subsidiary. Hence it can be easier to set up a branch as compared to a subsidiary. Our results are indicated in (5) to (8) in Table 2.4 and show that while the coefficient for single-location firms remains positive it is not significant anymore. Also the coefficients for multi-location firms are lower though they

Table 2.5: Empirical results: Young firms and exporters

| | (1) OLS | (2) OLS | (3) OLS | (4) OLS | (5) OLS | (6) OLS | (7) OLS | (8) OLS |
|---|---|---|---|---|---|---|---|---|
| Productivity | 0.016*** | 0.013*** | 0.016*** | 0.013*** | 0.018*** | 0.028** | 0.018*** | 0.028** |
| | (0.001) | (0.002) | (0.001) | (0.002) | (0.001) | (0.012) | (0.001) | (0.012) |
| Employment | 0.040*** | 0.021*** | 0.040*** | 0.021*** | 0.032*** | 0.123*** | 0.032*** | 0.124*** |
| | (0.001) | (0.002) | (0.001) | (0.002) | (0.001) | (0.007) | (0.001) | (0.007) |
| Young firm | | | | | -0.000 | -0.096*** | -0.000 | -0.095*** |
| | | | | | (0.001) | (0.024) | (0.001) | (0.024) |
| Exporter | 0.197*** | 0.126*** | 0.197*** | 0.126*** | | | | |
| | (0.009) | (0.023) | (0.009) | (0.023) | | | | |
| Trademarks | 0.002** | 0.008*** | 0.002** | 0.008*** | 0.001** | 0.003*** | 0.001** | 0.003*** |
| | (0.001) | (0.002) | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) |
| OFDI (EA, 2-dig) | 0.006*** | 0.003 | | | 0.005*** | 0.018* | | |
| | (0.001) | (0.002) | | | (0.001) | (0.010) | | |
| IFDI (EA, 2-dig) | | | 0.003*** | 0.002** | | | 0.002*** | 0.014* |
| | | | (0.001) | (0.001) | | | (0.001) | (0.007) |
| Sector dummies | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig |
| Young firm | No | Yes | No | Yes | | | | |
| Exporter | | | | | No | Yes | No | Yes |
| $R^2$ | 0.222 | 0.149 | 0.222 | 0.150 | 0.108 | 0.179 | 0.108 | 0.179 |
| Observations | 71,271 | 16,330 | 71,271 | 16,330 | 84,216 | 3,385 | 84,216 | 3,385 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

remain highly significant. Overall it seems that German firms with no branch or subsidiary in Germany do not benefit from being in proximity to MNEs. Nevertheless other firm-level characteristics remain significant predictors of the probability of being an outward investors. This includes productivity, size, export status as well as the number of trademarks, which appear even more important than for multi-location firms.

*Firm age and exporting status*

In Table 2.5 we further split the sample by firms with an incorporation date below 10 years (young firms) and firms that are active as exporters. As the literature highlighted their importance, our main analysis controls for them but we believe a sample split can offer additional insights. In the sample around 18.6% of firms are classified as 'young' firms. Looking at young vs. old firms first in (1) to (4) it emerges that young firms do not seem to benefit from being in region-sector proximity to German outward investors. Rather, it is older firms that seem to capitalise on this, potentially because they had time to build up relationships either informally between personnel, or formally as suppliers or buyers. The size of the coefficient for older firms is comparable to what we found in the main

specifications.

Next we look at export status in models (5) to (8) and note that more than half of all the exporters are located in service sectors. While proximity to domestic or foreign MNEs is positive and significant regardless of a firm being an exporter, the coefficients are larger for the 3,385 exporting firms in our sample. Since the literature has highlighted the importance of exporting for outward investment (Conconi et al., 2016) this finding is not surprising. A firm that already exports has gathered some experience in operating in international markets and hence can build on this when thinking of expanding abroad via investments.

*Intensive margin of outward investment*

We also test for the intensive margin of outward investment using a count model. Instead of using a dummy dependent variable for investment abroad we follow Buch et al. (2014) and use the count of the number of subsidiaries that a German parent owns abroad. The explanatory variables remain unchanged and results are reported in Table 2.6. We specify a number of models following the methods outlined in (Cameron and Trivedi, 2009). In addition to the standard Poisson model (1-2) we work with a Negative Binomial model (3-4) as it can control for unobserved firm heterogeneity and for over-dispersion in the data. Considering that for most variables in our model the standard deviation is larger than the mean, this model seems appropriate. In addition we also make use of a zero-inflated Poisson (5-6), as it attaches an even larger weight to the probability that the majority of firms does not invest abroad at all. This makes sense in our case as not every firm wants to expand abroad in the first place and hence we have 'excess' zeroes in the data. We use firm size and productivity in the first part of the model to predict the excess zeroes based on the argument that only firms with a certain size and level of productivity start to consider to invest abroad. We plot the kernel density of firm size in employment and turnover as well as productivity in Figure 2.3 (included in Appendix 2.A.2). This shows us in a straightforward way that the outward investors are fundamentally different than purely domestic firms and hence using these variables to distinguish the two

empirically makes statistical sense. As before, this first part uses a 0/1 dependent variable for outward investment and maximum likelihood estimation. Finally, we follow Cook et al. (2012) and combine the negative binomial and zero-inflated models to exploit the advantages of each. Results for the zero-inflated negative binomial model are included in columns (7-8).

Table 2.6: Empirical results: Intensive margin of outward investment

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Poisson | Poisson | Neg-bin | Neg-bin | ZI | ZI | ZI neg-bin | ZI neg-bin |
| Productivity | 0.757*** | 0.757*** | 0.910*** | 0.942*** | 0.403*** | 0.408*** | 0.460*** | 0.497*** |
| | (0.091) | (0.083) | (0.053) | (0.058) | (0.095) | (0.089) | (0.117) | (0.144) |
| Employment | 0.908*** | 0.936*** | 0.932*** | 0.949*** | 0.581*** | 0.591*** | 0.483*** | 0.505*** |
| | (0.048) | (0.051) | (0.032) | (0.032) | (0.053) | (0.057) | (0.040) | (0.041) |
| Exporter | 0.602*** | 0.740*** | 1.057*** | 1.058*** | -0.251** | -0.211* | 0.887*** | 0.892*** |
| | (0.157) | (0.171) | (0.080) | (0.080) | (0.119) | (0.126) | (0.080) | (0.081) |
| Young firm | -0.483** | -0.517** | -0.145 | -0.118 | -0.085 | -0.125 | -0.155 | -0.135 |
| | (0.231) | (0.228) | (0.124) | (0.129) | (0.184) | (0.181) | (0.114) | (0.122) |
| Trademarks | 0.000 | 0.000 | 0.050*** | 0.050*** | -0.000 | -0.000 | 0.029*** | 0.027*** |
| | (0.000) | (0.000) | (0.009) | (0.009) | (0.000) | (0.000) | (0.006) | (0.005) |
| Subsidiaries | 0.009*** | 0.007** | 0.137*** | 0.153*** | 0.008*** | 0.007** | 0.087*** | 0.100*** |
| | (0.003) | (0.003) | (0.018) | (0.019) | (0.002) | (0.003) | (0.010) | (0.011) |
| Branches | -0.012 | -0.015 | -0.012** | -0.013*** | -0.016* | -0.019** | -0.011** | -0.013** |
| | (0.009) | (0.010) | (0.005) | (0.005) | (0.008) | (0.010) | (0.005) | (0.006) |
| OFDI (EA, 2-dig) | 0.404*** | | 0.494*** | | 0.257*** | | 0.557*** | |
| | (0.071) | | (0.041) | | (0.063) | | (0.048) | |
| IFDI (EA, 2-dig) | | 0.171*** | | 0.286*** | | 0.086* | | 0.320*** |
| | | (0.059) | | (0.030) | | (0.049) | | (0.033) |
| *Inflate* | | | | | | | | |
| Productivity | | | | | -0.761*** | -0.773*** | -0.870*** | -0.858*** |
| | | | | | (0.034) | (0.033) | (0.159) | (0.185) |
| Employment | | | | | -0.803*** | -0.815*** | -1.219*** | -1.216*** |
| | | | | | (0.025) | (0.026) | (0.053) | (0.056) |
| Pseudo $R^2$ | 0.651 | 0.636 | 0.230 | 0.227 | | | | |
| Observations | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Neg-bin = negative-binomial model; ZI = zero-inflated model; ZI neg-bin = zero-inflated negative binomial model.

Our results indicate no qualitative differences to our previous findings. Most importantly the region-sector proximity to FDI is positive and significant in all count models, with a larger coefficient for proximity to OFDI. The means that variables discussed above to be of importance for firms to select into outward investment also matter for the number of foreign subsidiaries a firm has. This is in line with Buch et al. (2014) who apply a similar set of models and also do not find deviating results for the intensive margin of outward investment. Looking at the results for the zero-inflated (ZI) models in (5-8) we can also interpret the probability of observing a zero dependent variable, i.e. no outward investment. This probability decreases with a higher productivity or firm employment, which explains the negative sign of the coefficients for variables used to predict the

excess zeroes. Finally, the Vuong tests (Vuong, 1989; Cameron and Trivedi, 2009) showed that the ZI models perform better than the negative-binomial models and a likelihood ratio test showed the superiority of the ZI negative binomial models. Hence our preferred specifications are columns (7-8).

## 2.5 Conclusion

In 2015 German MNEs had invested more than €1,200 billion in 35,000 subsidiaries abroad, employing 6.7 million people and generating almost 2,400 billion euro of turnover (Deutsche Bundesbank, 2017). At the same time, 15,000 foreign MNEs accumulated an investment stock of €450 billion in Germany, employing 3 million people and generating an annual turnover of €1,500 billion. It is without doubt that MNEs have a large influence on the German economy. This study has shown that the proximity of firms to multinationals also plays a role in the internationalisation of firms via outward investment. In addition, these proximity effects vary across regions, sectors and the nationality of MNEs. This relationship holds across linear and non-linear probability models as well as two-step zero-inflated models and when we control for various firm, region and sector characteristics.

We started the chapter by conceptually integrating firm-level studies on internationalisation with studies on localised spillover and competition effects between MNEs and non-MNEs. Here we also built on the more detailed conceptual framework in the introductory chapter. Spillover and competition effects are shown to be important for local firms (Markusen and Venables, 1999; Barba Navaretti et al., 2004) and this holds in the German context as well (Bertschek, 1995; Bitzer and Görg, 2009; Franco and Weche Gelübcke, 2014). This allows us to conclude that externalities between MNEs and other firms are significant and that the presence of MNEs matters in conceptual and empirical terms. The attested superiority of MNEs (Arnold and Hussinger, 2010) is also apparent in our dataset and we provided descriptive statistics to explore this heterogeneity. The first part of the statistical analysis confirms that outward investors are on average larger and

more productive. However, we also showed that they come from regions with a larger local market and higher share of highly educated employees. This adds to the findings by Arndt et al. (2012) who stress the negative effect of local labour market frictions for firm internationalisations in Germany.

Our main finding regarding the importance of proximity to MNEs can be qualified further. First, region-sector proximity appears to be more important than pure spatial proximity, hinting at the importance of technological proximity between firms for positive externalities to occur (Peri and Urban, 2006). Second, the importance of region-sector proximity is larger at finer spatial scales. This allows for the tentative interpretation that some knowledge and information about internationalisation processes is tacit and hence only travels locally between firms. Third, region-sector proximity seems to matter most when the proximate MNEs are also German-owned, thus hinting at a potential role of cultural proximity and regional embeddedness. On the other hand, as MNEs have the incentive to minimise knowledge outflows (Javorcik, 2004) it is possible that foreign firms are simply better at this.[22]

We also provide some additional findings that also check the robustness of our results. Using a sample split we demonstrate that proximity matters more for firms that also have a domestic network of subsidiaries or branches. Firms potentially use experiences from domestic expansions in their internationalisation process as they already know how to manage an organisation cross multiple locations. A second sample split confirms the importance to control for export status and firm age as exporters and older firms are more likely to internationalise and also benefit from the proximity to MNEs. The role of exports for outward investment is well-established in the literature (Vernon, 1966, 1971; Conconi et al., 2016). The fact that older firms benefit more could have various explanations but it is plausible that they had more time to gather knowledge from MNEs, e.g. via supplier-buyer relations (Mariotti et al., 2014). Finally, using zero-inflated and negative binomial models we also confirm the importance of proximity to MNEs

[22] Other studies also highlight the tendency of MNEs to locate away from domestic firms (Mariotti et al., 2010; Alfaro and Chen, 2016).

for the intensive margin of outward investment, i.e. the number of subsidiaries that a firm owns abroad.

Considering all of these findings, of which some are novel, our study naturally has a number of limitations. Our main findings are based on a cross-sectional dataset and do not allow for the conclusion that a previously existing stock of MNEs in turn causes firms to invest abroad. However, they qualify as long-term associations between region-sector concentrations of MNEs and the internationalisation of firms (Becker et al., 2005). Considering that the concentration of MNEs in certain regions and sectors probably does not exhibit large annual variations and the fact that externalities take time to materialise it is questionable what a panel study could really add in terms of explanatory power. Furthermore, as many related studies we cannot pin down the exact operating channel or mechanism in empirical terms (Choquette and Meinen, 2015). Nevertheless we could show that the association holds across varying spatial and sectoral aggregations and also differs qualitatively depending on different proxies for types of proximities.

The German government (as many others) spends large sums on supporting the internationalisation of its firms via investment and export promotion schemes and financial guarantees.[23] Hence, a detailed understanding of what drives the internationalisation can assist policymakers in designing better policies. In our case this could be a facilitation of linkages between multinational and non-multinational firms, e.g. via enhancing labour pool turnover, joint research and integration in local value chains. Finally, future research in this direction should consider analysing the heterogeneity in foreign and domestic MNEs in terms of innovativeness and productivity. We would assume that proximity effects are qualitatively different depending on their relative economic strength as compared to local firms. It could be that German firms mainly benefit from proximity to leading MNEs as they can potentially gain more, while on the other hand these firms also introduce more competition.

[23] See Appendix 2.A.1 for details on these schemes.

# 2.A Appendix

## 2.A.1 Stylised facts on outward and inward investment in Germany

*Stylised facts on outward and inward investment in Germany*

German firms continue to be very active on global markets via international trade and investment. According to data by the German Central Bank there are 36,203 firms outside of Germany that are partially- or wholly-owned by German firms in 2015 (Deutsche Bundesbank, 2017). As firms are legally required to report on their foreign capital engagements these figures are highly reliable. The minimum threshold to report is 10% ownership for directly held investment positions and 50% for indirect investments if the establishment abroad has a balance sheet of more than €3 million. In total they employ more than 7 million employees abroad with an annual turnover exceeding €2,700 billion. These figures show a considerable increase since 2012 from 35,166 firms with German ownership, employing 6.55 million employees and generating 2,400 billion in turnover. Of the 36,203 German-owned establishments in 2015 the EU hosts 51%, while it only accounts for around 45% of employment and 45.6% of turnover. The US hosts 13% of firms with around 12% of employees and 19.7% of turnover. China is home to 5.6% of German firms abroad, accounting for around 10% of their total employment and 9.7% of turnover. This hints to a higher profitability of firms in the US (turnover per employee) and larger average size in China (employment per number of firms). We will use these figures to benchmark our own dataset based on data from ORBIS.

With respect to inward investment the figures tend to be around half the size in magnitude. In 2015 there were 16,239 foreign investors active in Germany employing 2.9 million people with a turnover of €1,487 billion (Deutsche Bundesbank, 2017). Compared to 2012 this number has increased from 15,580 establishments with 2.8 million employees though turnover was higher at €1,517 billion. The total investment stock amounted to €465.9 billion in 2015, of which €356 billion

was held by firms from EU countries, €28 billion from the US and €2.2 billion from China. When comparing them to 2012 figures it is interesting to note that American engagement decreased from €32.8 billion and Chinese engagement more than doubled from €1 billion over the same period.

### *Exports and imports and their role for investment in Germany*

It is worth to consider that exports and investment abroad can be seen as substitutes or complements. In a recent study based on detailed firm-level data on export and foreign investment activity of Belgian firms Conconi et al. (2016) show that export activity generally tends to precede investment abroad to 'test' the foreign market. In the case of Germany Jost (1997) finds a complementary pattern and also Tüselmann (1998) shows that the shares of exports and investment abroad of German firms are largely comparable. However, in a study of Germany's trade relations with the EU-27 at the regional level, Mitze et al. (2010) find that investment abroad generally substitutes exports though it can stimulate re-imports of goods. On the other hand for a sub-sample of states in West Germany and EU-15 the authors find a complementary pattern between both. Egger and Pfaffermayr (2004) present similar results for German industries though the substitution effect is relatively weaker. For the empirical analysis it becomes clear that we need to control for export status of firms though the direction of the effect is not 100% established as we demonstrated here.

In 2012 German firms exported goods with a total value of €1,173 billion, while goods for a value of 995 billion were imported, exhibiting a large trade surplus (Deutsche Bundesbank, 2013).[24] Of those, goods for €675 billion had a buyer in the EU-27 (57.5% of total exports), and €571 billion were imported from the EU-27 (57% of total imports). Comparable figures for the US are €90 billion (7.7%) exports and €54 billion (5.4%) imports, and for (mainland) China €66 billion (5.6%) exports and €74 billion (7.4%) imports. Curiously the trade

[24] Special Statistical Publication 11: Balance of payments by regions, July 2013, Deutsche Bundesbank. This is the latest version available.

surplus and deficit of the US and China seem to almost exactly match each other. In addition Germany exported €210 billion worth of services and imported €230 billion, and half of each involved an EU-27 partner country. The US imported German services with a value of €27 billion, and Germany imported €30 billion, respectively. China bought services worth of €8 billion while there were virtually none purchased by Germans.

### *Government support for firm internationalisation in Germany*

The German government actively supports the internationalisation of German firms abroad as well as foreign firms in Germany. It promotes Germany as a business location via its economic development agency Germany Trade & Invest (GTAI). The organisation provides domestic and foreign firms with advice based on market reports, data and information on business law. In addition, German firms can apply for export and project financing support via the government-owned development bank KfW-IPEX. According to UNCTAD Germany is also the country with the largest network of bilateral investment treaties (BITs). Currently the country has 131 BITs in force putting it ahead of Switzerland (115), China (108), France (96) and the UK (95).[25] As a member state of the EU Germany benefits from an additional 52 international investment treaties (IIAs). German firms wanting to expand via investment or export can obtain government support via guarantees from the Federal Ministry of Economy and Energy. They are intended to safeguard against political, and rather than economic risks of the trade or investment deal. In 2014 there were a total of 831 granted investment guarantees with an overall volume of more than €36 billion.[26] Finally, the German government granted export credit guarantees with a volume of more

[25] For the full list of BITs and country rankings see www.unctad.org [retrieved in September 2015].

[26] Annual report of investment guarantees - 2014, Federal Ministry of Economy and Energy, Germany.

than 38 billion via the 'Hermes cover' programme.[27] Those represent 2.2% of total German exports, and 74% are granted to SMEs.

[27] Annual report of export credit covers - 2014, Federal Ministry of Economy and Energy, Germany.

Table 2.7: Firm-level studies on the internationalisation of German firms

| | Main findings | Data | Methods |
|---|---|---|---|
| Bernard and Wagner (2001) | Productivity and worker skills matter for exports | Statistical Office of Lower Saxony, manufacturing survey | Probit; 7,624 manufacturing plants; 1978-1992 |
| Becker et al. (2005) | Distance, GDP and skill-intensity matter for location choices abroad (country-level), also lower labour costs in CEE | Bundesbank DIREK (now MiDi) & USTAN | Conditional logit; 463 MNEs; cross-section (2000) |
| Arnold and Hussinger (2005) | Productivity (TFP) matters for exports | Mannheim Innovation Panel | Probit, matching; 389 firms; 1992-2000 |
| Buch et al. (2010) | Firm size and financial constraints matter for exports & outward FDI | Bundesbank MiDi & Bureau van Dijk | Probit and OLS; 70,000 firms; cross-section |
| Arnold and Hussinger (2010) | Firm size and productivity matter for exports & outward FDI | Bundesbank MiDI & Mannheim Innovation Panel | Stochastic dominance tests and quantile regressions on 6,234 firms; 1996-2002 |
| Temouri et al. (2010) | Productivity (TFP) gains ex-post to outward FDI | Bureau van Dijk | GMM; Heckman with Woolridge extension; 2,633 firms (unconsolidated); 1997-2006 |
| Arndt et al. (2012) | Firm size, labour productivity and labour market frictions matter for exports & outward FDI | IAB Establishment Panel | Probit, OLS and Heckman selection; 16,000 plants; 2004-06 |
| Buch et al. (2014) | Firm size and productivity and financial constraints matter for outward FDI | Bundesbank MiDi & Bureau van Dijk | Probit, OLS, Negative Binomial, Poisson, and Heckman selection; 1,000 German parent firms and 5,706 foreign affiliates; 2002-06 |

## 2.A.2 Additional tables and figures

Table 2.8: Comparison of full sample to regression sample

| | Count | Mean | Median | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|
| *(a) Extracted sample* | | | | | | |
| Outward investment | 93,959 | 0.035 | 0 | 0.183 | 0 | 1 |
| Productivity | 93,959 | 217.359 | 108 | 1714.854 | 0 | 418791 |
| Employment | 93,959 | 231.922 | 23 | 4586.087 | 10 | 626715 |
| Turnover | 93,959 | 56.513 | 3 | 1342.181 | 0 | 225372 |
| Exporter | 93,959 | 0.038 | 0 | 0.191 | 0 | 1 |
| Manufacturer | 93,959 | 0.225 | 0 | 0.418 | 0 | 1 |
| Young firm | 93,959 | 0.187 | 0 | 0.390 | 0 | 1 |
| Patents | 93,959 | 10.027 | 0 | 784.426 | 0 | 190217 |
| Trademarks | 93,959 | 0.904 | 0 | 23.445 | 0 | 3890 |
| Subsidiaries | 93,959 | 0.834 | 0 | 7.842 | 0 | 781 |
| Branches | 93,959 | 0.933 | 0 | 3.996 | 0 | 283 |
| *(b) Regression sample* | | | | | | |
| Outward investment | 87,601 | 0.031 | 0 | 0.174 | 0 | 1 |
| Productivity | 87,601 | 164.097 | 108 | 176.526 | 16 | 1601 |
| Employment | 87,601 | 156.741 | 23 | 1967.679 | 10 | 273484 |
| Turnover | 87,601 | 30.691 | 3 | 422.883 | 0 | 52516 |
| Exporter | 87,601 | 0.039 | 0 | 0.193 | 0 | 1 |
| Manufacturer | 87,601 | 0.230 | 0 | 0.421 | 0 | 1 |
| Young firm | 87,601 | 0.186 | 0 | 0.389 | 0 | 1 |
| Patents | 87,601 | 3.234 | 0 | 94.428 | 0 | 15123 |
| Trademarks | 87,601 | 0.619 | 0 | 11.059 | 0 | 2221 |
| Subsidiaries | 87,601 | 0.641 | 0 | 4.391 | 0 | 543 |
| Branches | 87,601 | 0.913 | 0 | 3.846 | 0 | 283 |

Notes: Subsidiaries and Branches refers to locations in Germany only.

Table 2.9: List of variables used in the empirical analysis

| Variable | Definition | Source |
|---|---|---|
| Outward investor | Dummy = 1 if firm owns subsidiary abroad (min. 10% of shares) | *ORBIS* |
| Outward investor (intense) | Count of OFDI projects by firm | *ORBIS* |
| Inward investor | Dummy = 1 if firm has exclusively non-German owners | *ORBIS* |
| Domestic | Dummy =1 if firm is not engaged in OFDI or IFDI | *ORBIS* |
| Productivity | Labour productivity, measured as turnover per employee in Euro | *ORBIS* |
| Employment | Number of employees | *ORBIS* |
| Turnover | Annual turnover in million Euro | *ORBIS* |
| Exporter | Dummy = 1 for exporting firms | *ORBIS* |
| Manufacturer | Dummy = 1 if part of Section C, Division 10-33 in NACE Rev.2 | *ORBIS* |
| Firm age | Years since incorporation | *ORBIS* |
| Young firm | Dummy = 1 if Age $<$ 10 years in 2016 | *ORBIS* |
| Patents | Number of patents a firm holds | *ORBIS* |
| Trademarks | Number of trademarks a firm holds | *ORBIS* |
| Subsidiaries | Number of subsidiaries in Germany | *ORBIS* |
| Branches | Number of branches in Germany | *ORBIS* |
| Regional market | Regional GDP in billion Euro, 2014 | *Destatis* |
| Regional technology | Share of manufacturing in regional GVA, 2014 | *Destatis* |
| Regional specialisation | Share of domestic firms in same 2-digit sector | *ORBIS* |
| Regional education | Share of employees with tertiary education, 2014 | *Destatis* |

Notes: Region refers to NUTS1-3 or employment areas. Latest data from *Destatis* for 2014.

Table 2.10: Correlation matrix of variables used in the empirical analysis

| | 1. | 2. | 3. | 4. | 5. | 6. | 7. | 8. | 9. | 10. | 11. | 12. | 13. | 14. | 15. | 16. | 17. | 18. | 19. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Outward investor | 1.000 | | | | | | | | | | | | | | | | | | |
| 2. Productivity | 0.128 | 1.000 | | | | | | | | | | | | | | | | | |
| 3. Employment | 0.141 | 0.014 | 1.000 | | | | | | | | | | | | | | | | |
| 4. Turnover | 0.153 | 0.082 | 0.889 | 1.000 | | | | | | | | | | | | | | | |
| 5. Exporter | 0.349 | 0.166 | 0.069 | 0.074 | 1.000 | | | | | | | | | | | | | | |
| 6. Manufacturer | 0.062 | -0.032 | -0.009 | -0.005 | 0.102 | 1.000 | | | | | | | | | | | | | |
| 7. Young firm | -0.042 | -0.065 | -0.010 | -0.012 | -0.037 | -0.052 | 1.000 | | | | | | | | | | | | |
| 8. Patents | 0.123 | 0.018 | 0.195 | 0.195 | 0.047 | 0.031 | -0.011 | 1.000 | | | | | | | | | | | |
| 9. Trademarks | 0.170 | 0.046 | 0.252 | 0.328 | 0.091 | 0.037 | -0.017 | 0.450 | 1.000 | | | | | | | | | | |
| 10. Subsidiaries | 0.202 | 0.114 | 0.240 | 0.248 | 0.123 | -0.035 | -0.035 | 0.065 | 0.106 | 1.000 | | | | | | | | | |
| 11. Branches | 0.074 | 0.025 | 0.080 | 0.066 | 0.052 | -0.038 | -0.042 | 0.061 | 0.042 | 0.086 | 1.000 | | | | | | | | |
| 12. Reg. market (EA) | 0.021 | 0.024 | 0.012 | 0.013 | -0.011 | -0.110 | 0.034 | 0.013 | 0.013 | 0.023 | 0.023 | 1.000 | | | | | | | |
| 13. Reg. OFDI (EA) | 0.034 | 0.040 | 0.018 | 0.018 | 0.008 | -0.086 | 0.024 | 0.013 | 0.017 | 0.027 | 0.019 | 0.860 | 1.000 | | | | | | |
| 14. Reg. IFDI (EA) | 0.019 | 0.029 | 0.015 | 0.015 | -0.009 | -0.117 | 0.031 | 0.010 | 0.011 | 0.022 | 0.024 | 0.891 | 0.906 | 1.000 | | | | | |
| 16. Reg. techn. (EA) | 0.022 | 0.011 | 0.004 | 0.004 | 0.045 | 0.143 | -0.036 | 0.010 | 0.007 | -0.009 | -0.033 | -0.298 | -0.228 | -0.383 | 1.000 | | | | |
| 17. Reg. special. | -0.055 | 0.010 | -0.027 | -0.022 | -0.055 | -0.201 | -0.036 | -0.014 | -0.016 | -0.054 | -0.043 | -0.115 | -0.120 | -0.136 | 0.074 | 1.000 | | | |
| 18. Reg. edu. (EA) | 0.008 | 0.002 | 0.013 | 0.011 | -0.024 | -0.129 | 0.035 | 0.012 | 0.009 | 0.019 | 0.031 | 0.746 | 0.651 | 0.763 | -0.491 | -0.140 | 1.000 | | |
| 18. Reg.-sector IFDI | 0.106 | 0.142 | 0.032 | 0.039 | 0.085 | -0.023 | -0.015 | 0.018 | 0.025 | 0.058 | -0.001 | 0.507 | 0.507 | 0.479 | -0.102 | 0.133 | 0.349 | 1.000 | |
| 19. Reg.-sector OFDI | 0.062 | 0.123 | 0.019 | 0.025 | 0.036 | -0.092 | 0.000 | 0.016 | 0.018 | 0.023 | 0.005 | 0.685 | 0.649 | 0.704 | -0.255 | 0.186 | 0.536 | 0.759 | 1.000 |

Notes: OFDI and IFDI refer to the total number of outward and inward investments in a region or region-sector, respectively.

Table 2.11: Descriptive statistics: Sector- and Region-sector heterogeneity in OFDI and IFDI by spatial aggregation

| Variable | Count | Mean | Median | Std. Dev. | Min. | Max. |
|---|---|---|---|---|---|---|
| OFDI (NUTS1) | 87,601 | 408.844 | 564.000 | 264.386 | 10.000 | 695.000 |
| OFDI_int (NUTS1) | 87,601 | 5004.935 | 7039.000 | 3430.533 | 25.000 | 8500.000 |
| IFDI (NUTS1) | 87,601 | 1243.048 | 1272.000 | 793.715 | 92.000 | 2354.000 |
| OFDI (NUTS2) | 87,601 | 112.520 | 88.000 | 79.390 | 10.000 | 275.000 |
| OFDI_int (NUTS2) | 87,601 | 1479.512 | 612.000 | 1476.138 | 25.000 | 4687.000 |
| IFDI (NUTS2) | 87,601 | 398.748 | 219.000 | 363.519 | 51.000 | 1178.000 |
| OFDI (EA) | 87,601 | 39.532 | 16.000 | 51.533 | 0.000 | 192.000 |
| OFDI_int (EA) | 87,601 | 562.639 | 116.000 | 941.140 | 0.000 | 3691.000 |
| IFDI (EA) | 87,601 | 164.263 | 40.000 | 247.523 | 1.000 | 809.000 |
| OFDI (NUTS3) | 87,601 | 18.824 | 9.000 | 26.458 | 0.000 | 115.000 |
| OFDI_int (NUTS3) | 87,601 | 274.226 | 61.000 | 578.217 | 0.000 | 2900.000 |
| OFDI (NUTS3) | 87,601 | 75.538 | 24.000 | 127.811 | 0.000 | 450.000 |
| IFDI (2-dig) | 87,601 | 354.290 | 223.000 | 469.992 | 0.000 | 1745.000 |
| IFDI (3-dig) | 87,601 | 113.482 | 60.000 | 129.599 | 0.000 | 567.000 |
| IFDI (4-dig) | 87,601 | 56.816 | 28.000 | 81.710 | 0.000 | 454.000 |
| IFDI (NUTS1, 2-dig) | 87,601 | 50.301 | 16.000 | 93.880 | 0.000 | 513.000 |
| IFDI (NUTS2, 2-dig) | 87,601 | 16.866 | 5.000 | 41.266 | 0.000 | 322.000 |
| IFDI (EA, 2-dig) | 87,601 | 7.129 | 1.000 | 23.101 | 0.000 | 212.000 |
| IFDI (NUTS3, 2-dig) | 87,601 | 3.173 | 0.000 | 9.760 | 0.000 | 130.000 |
| OFDI (2-dig) | 87,601 | 99.766 | 39.000 | 126.686 | 0.000 | 489.000 |
| OFDI (3-dig) | 87,601 | 36.447 | 18.000 | 65.139 | 0.000 | 434.000 |
| OFDI (4-dig) | 87,601 | 21.597 | 6.000 | 60.084 | 0.000 | 434.000 |
| OFDI (NUTS1, 2-dig) | 87,601 | 14.407 | 4.000 | 24.592 | 0.000 | 135.000 |
| OFDI (NUTS2, 2-dig) | 87,601 | 4.226 | 1.000 | 8.174 | 0.000 | 50.000 |
| OFDI (EA, 2-dig) | 87,601 | 1.614 | 0.000 | 4.703 | 0.000 | 42.000 |
| OFDI (NUTS3, 2-dig) | 87,601 | 0.793 | 0.000 | 2.499 | 0.000 | 32.000 |
| Regional specialisation (NUTS1) | 87,601 | 0.047 | 0.031 | 0.042 | 0.000 | 0.171 |
| Regional specialisation (NUTS2) | 87,601 | 0.048 | 0.030 | 0.043 | 0.000 | 0.178 |
| Regional specialisation (EA) | 87,601 | 0.052 | 0.035 | 0.047 | 0.000 | 0.271 |
| Regional specialisation (NUTS3) | 87,601 | 0.056 | 0.038 | 0.049 | 0.000 | 0.292 |

Notes: OFDI and IFDI refer to the count of total outward and inward FDIs, respectively. Regional specialisation = share of domestic firms in same 2-digit sector divided by all firms in a region.

Figure 2.1: Map of outward investments by employment areas in Germany.

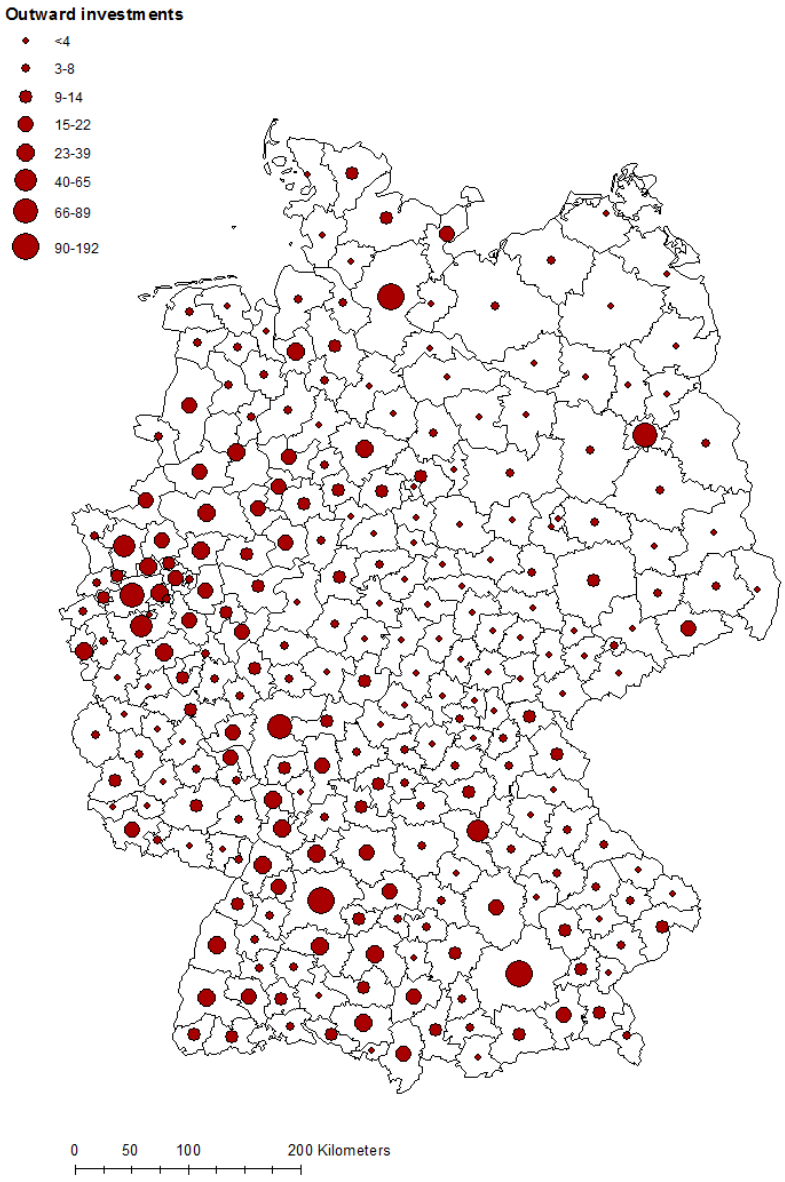


Figure 2.2: Map of inward investments by employment areas in Germany.

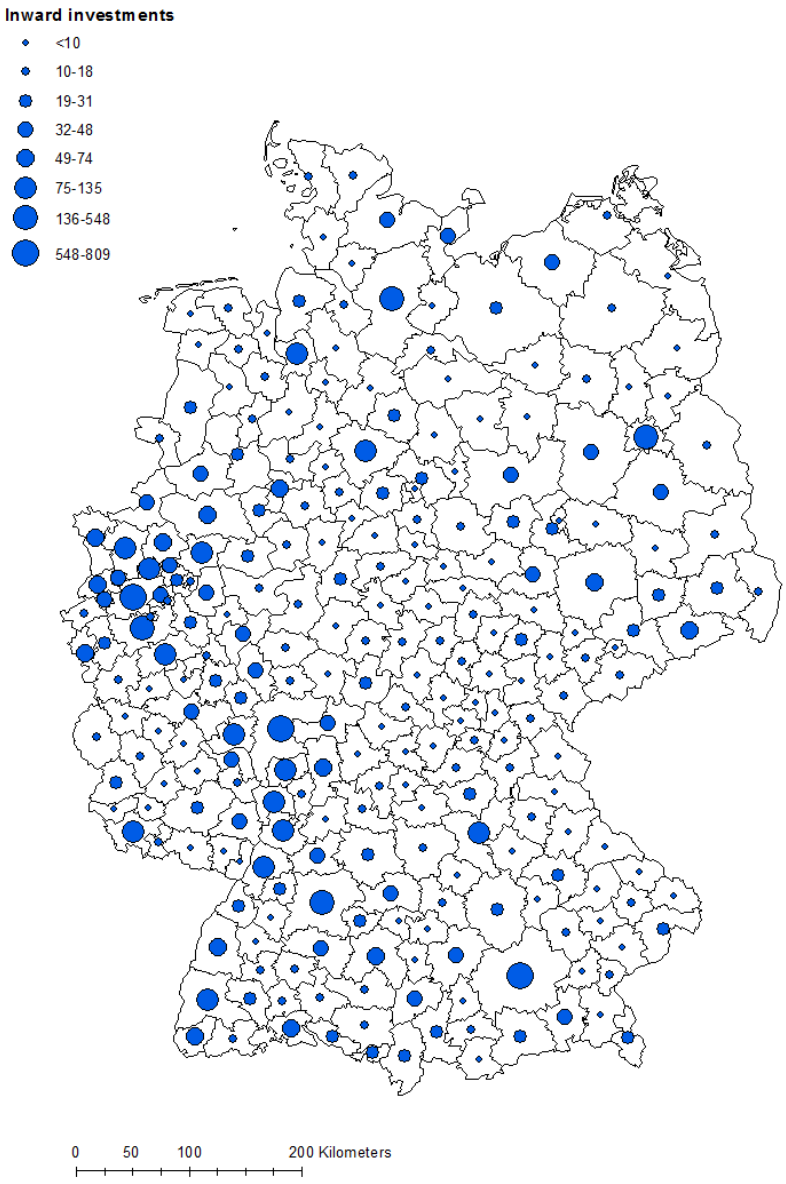


Table 2.12: Additional results: Firm heterogeneity in internationalisation via outward investment

| | (1) OLS | (2) OLS | (3) OLS | (4) OLS | (5) OLS | (6) OLS | (7) OLS | (8) OLS | (9) OLS |
|---|---|---|---|---|---|---|---|---|---|
| Productivity | 0.033*** | 0.029*** | 0.020*** | 0.020*** | 0.020*** | 0.019*** | 0.017*** | 0.017*** | 0.015*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Employment | | 0.050*** | 0.036*** | 0.036*** | 0.036*** | 0.034*** | 0.031*** | 0.031*** | 0.034*** |
| | | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Exporter | | | 0.217*** | 0.214*** | 0.214*** | 0.211*** | 0.210*** | 0.209*** | 0.192*** |
| | | | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) |
| Manufacturer | | | | 0.012*** | 0.011*** | 0.010*** | 0.012*** | 0.012*** | |
| | | | | (0.001) | (0.001) | (0.002) | (0.002) | (0.002) | |
| Young firm | | | | | -0.002* | -0.002* | -0.001 | -0.002 | -0.001 |
| | | | | | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Trademarks | | | | | | 0.002** | 0.002** | 0.002** | 0.002** |
| | | | | | | (0.001) | (0.001) | (0.001) | (0.001) |
| Subsidiaries | | | | | | | 0.004*** | 0.004*** | 0.004*** |
| | | | | | | | (0.001) | (0.001) | (0.001) |
| Branches | | | | | | | | -0.000* | -0.000 |
| | | | | | | | | (0.000) | (0.000) |
| Sector dummies | | | | | | | | | 2-dig |
| $R^2$ | 0.022 | 0.133 | 0.181 | 0.181 | 0.181 | 0.193 | 0.203 | 0.203 | 0.218 |
| Observations | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 2.13: Additional results: Firm heterogeneity in internationalisation via outward investment (Probit)

| | (1) Probit | (2) Probit | (3) Probit | (4) Probit | (5) Probit | (6) Probit |
|---|---|---|---|---|---|---|
| Productivity | 0.412*** | 0.391*** | 0.236*** | 0.248*** | 0.250*** | 0.256*** |
| | (0.011) | (0.016) | (0.014) | (0.017) | (0.014) | (0.018) |
| Employment | 0.449*** | 0.470*** | 0.246*** | 0.259*** | 0.286*** | 0.306*** |
| | (0.006) | (0.008) | (0.009) | (0.010) | (0.008) | (0.009) |
| Exporter | | | 0.607*** | 0.484*** | 0.584*** | 0.466*** |
| | | | (0.032) | (0.033) | (0.031) | (0.032) |
| Manufacturer | | | 0.175*** | | 0.137*** | |
| | | | (0.026) | | (0.026) | |
| Young firm | | | -0.049 | -0.073** | -0.055 | -0.086** |
| | | | (0.033) | (0.036) | (0.035) | (0.037) |
| Trademarks (log) | | | 0.414*** | 0.388*** | | |
| | | | (0.014) | (0.015) | | |
| Subsidiaries (log) | | | 0.288*** | 0.294*** | | |
| | | | (0.017) | (0.019) | | |
| Branches (log) | | | 0.028** | 0.089*** | | |
| | | | (0.014) | (0.016) | | |
| Trademarks (dummy) | | | | | 0.842*** | 0.750*** |
| | | | | | (0.025) | (0.026) |
| Subsidiaries (dummy) | | | | | 0.421*** | 0.421*** |
| | | | | | (0.026) | (0.028) |
| Branches (dummy) | | | | | 0.052** | 0.139*** |
| | | | | | (0.024) | (0.025) |
| Sector dummies | . | 2-dig | . | 2-dig | . | 2-dig |
| Pseudo $R^2$ | 0.308 | 0.373 | 0.403 | 0.440 | 0.402 | 0.436 |
| Observations | 87,601 | 85,733 | 87,601 | 85,733 | 87,601 | 85,733 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. (log) = natural logarithm and (dum) = dummy (0/1) indicating a count value >0. Specifications (2), (4) and (6) have less obs. as some sector dummies perfectly predict dep. variable.

Table 2.14: Additional results: Firm-region heterogeneity in internationalisation via outward investment

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | OLS | OLS | OLS | OLS |
| Productivity | 0.015*** | 0.015*** | 0.015*** | 0.015*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Employment | 0.034*** | 0.034*** | 0.034*** | 0.034*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Exporter | 0.192*** | 0.192*** | 0.192*** | 0.192*** |
| | (0.008) | (0.008) | (0.008) | (0.008) |
| Young firm | -0.001 | -0.001 | -0.001 | -0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Trademarks | 0.002** | 0.002** | 0.002** | 0.002** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Subsidiaries | 0.004*** | 0.004*** | 0.004*** | 0.004*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| Branches | -0.000 | -0.000 | -0.000 | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Regional market (EA) | 0.002*** | | | |
| | (0.000) | | | |
| Regional manuf. share (EA) | | 0.003 | | |
| | | (0.005) | | |
| Regional education (EA) | | | 0.037*** | |
| | | | (0.011) | |
| Regional specialisation (EA) | | | | -0.066*** |
| | | | | (0.021) |
| Sector dummies | 2-dig | 2-dig | 2-dig | 2-dig |
| $R^2$ | 0.219 | 0.218 | 0.219 | 0.218 |
| Observations | 87,601 | 87,601 | 87,601 | 87,601 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.15: Additional results: List of coefficients for regional characteristics from separate regressions at different spatial aggregations

| | NUTS-1 | NUTS-2 | EA | NUTS-3 |
|---|---|---|---|---|
| Regional market | 0.003*** | 0.004*** | 0.002*** | 0.002*** |
| | (0.001) | (0.001) | (0.000) | (0.001) |
| Regional manuf. share | 0.042*** | 0.016** | 0.003 | 0.004 |
| | (0.009) | (0.008) | (0.005) | (0.005) |
| Regional education | 0.026 | 0.051*** | 0.037*** | 0.023** |
| | (0.021) | (0.015) | (0.011) | (0.010) |
| Regional specialisation | 0.207*** | 0.105*** | -0.066*** | -0.095*** |
| | (0.052) | (0.040) | (0.021) | (0.019) |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Each coefficient from separate regression including full set of controls as in Table 2.14.

Table 2.16: Additional results: Separate analysis of region- and sector-proximity to domestic MNEs (OFDI)

| | (1) OLS | (2) OLS | (3) OLS | (4) OLS | (5) OLS | (6) OLS | (7) OLS | (8) OLS |
|---|---|---|---|---|---|---|---|---|
| Productivity | 0.011*** | 0.011*** | 0.012*** | 0.012*** | 0.014*** | 0.014*** | 0.014*** | 0.014*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Employment | 0.032*** | 0.032*** | 0.032*** | 0.032*** | 0.032*** | 0.032*** | 0.032*** | 0.032*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Exporter | 0.204*** | 0.204*** | 0.204*** | 0.204*** | 0.206*** | 0.206*** | 0.206*** | 0.206*** |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) |
| Young firm | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 | -0.001 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Trademarks | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Subsidiaries | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Branches | -0.000 | -0.000 | -0.000* | -0.000* | -0.000* | -0.000* | -0.000** | -0.000** |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| Manufacturer | 0.008*** | 0.008*** | 0.009*** | 0.009*** | 0.012*** | 0.013*** | 0.014*** | 0.014*** |
| | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) | (0.002) |
| OFDI (2-dig) | 0.008*** | 0.008*** | 0.009*** | 0.009*** | | | | |
| | (0.000) | (0.000) | (0.000) | (0.000) | | | | |
| IFDI (2-dig) | | | | | 0.007*** | 0.007*** | 0.007*** | 0.007*** |
| | | | | | (0.000) | (0.000) | (0.000) | (0.000) |
| OFDI (NUTS1) | 0.003*** | | | | | | | |
| | (0.000) | | | | | | | |
| OFDI (NUTS2) | | 0.005*** | | | | | | |
| | | (0.001) | | | | | | |
| OFDI (EA) | | | 0.003*** | | | | | |
| | | | (0.000) | | | | | |
| OFDI (NUTS3) | | | | 0.004*** | | | | |
| | | | | (0.000) | | | | |
| IFDI (NUTS1) | | | | | 0.003*** | | | |
| | | | | | (0.001) | | | |
| IFDI (NUTS2) | | | | | | 0.004*** | | |
| | | | | | | (0.001) | | |
| IFDI (EA) | | | | | | | 0.002*** | |
| | | | | | | | (0.000) | |
| IFDI (NUTS3) | | | | | | | | 0.003*** |
| | | | | | | | | (0.000) |
| $R^2$ | 0.208 | 0.208 | 0.208 | 0.208 | 0.206 | 0.206 | 0.206 | 0.206 |
| Observations | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.17: Additional results: Region-sector proximity to MNEs using a Probit model

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | Probit | Probit | Probit | Probit | Probit | Probit | Probit | Probit |
| Productivity | 0.255*** | 0.253*** | 0.254*** | 0.254*** | 0.255*** | 0.253*** | 0.254*** | 0.254*** |
| | (0.018) | (0.018) | (0.018) | (0.018) | (0.018) | (0.018) | (0.018) | (0.018) |
| Employment | 0.306*** | 0.307*** | 0.307*** | 0.306*** | 0.306*** | 0.307*** | 0.307*** | 0.307*** |
| | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) | (0.009) |
| Exporter | 0.461*** | 0.464*** | 0.467*** | 0.468*** | 0.463*** | 0.468*** | 0.469*** | 0.470*** |
| | (0.032) | (0.032) | (0.032) | (0.032) | (0.032) | (0.032) | (0.032) | (0.032) |
| Young firm | -0.085** | -0.086** | -0.088** | -0.088** | -0.084** | -0.085** | -0.087** | -0.088** |
| | (0.037) | (0.037) | (0.037) | (0.037) | (0.037) | (0.037) | (0.037) | (0.037) |
| Trademarks (dummy) | 0.745*** | 0.744*** | 0.743*** | 0.744*** | 0.746*** | 0.744*** | 0.742*** | 0.743*** |
| | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) | (0.026) |
| Subsidiaries (dummy) | 0.422*** | 0.422*** | 0.422*** | 0.421*** | 0.423*** | 0.423*** | 0.423*** | 0.422*** |
| | (0.028) | (0.028) | (0.028) | (0.028) | (0.028) | (0.028) | (0.028) | (0.028) |
| Branches (dummy) | 0.141*** | 0.139*** | 0.136*** | 0.137*** | 0.140*** | 0.137*** | 0.136*** | 0.136*** |
| | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) | (0.025) |
| OFDI (NUTS1, 2-dig) | 0.058*** | | | | | | | |
| | (0.013) | | | | | | | |
| OFDI (NUTS2, 2-dig) | | 0.062*** | | | | | | |
| | | (0.016) | | | | | | |
| OFDI (EA, 2-dig) | | | 0.054*** | | | | | |
| | | | (0.015) | | | | | |
| OFDI (NUTS3, 2-dig) | | | | 0.054*** | | | | |
| | | | | (0.018) | | | | |
| IFDI (NUTS1, 2-dig) | | | | | 0.057*** | | | |
| | | | | | (0.013) | | | |
| IFDI (NUTS2, 2-dig) | | | | | | 0.052*** | | |
| | | | | | | (0.013) | | |
| IFDI (EA, 2-dig) | | | | | | | 0.036*** | |
| | | | | | | | (0.010) | |
| IFDI (NUTS3, 2-dig) | | | | | | | | 0.040*** |
| | | | | | | | | (0.012) |
| Sector dummies | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig | 2-dig |
| Pseudo $R^2$ | 0.437 | 0.437 | 0.437 | 0.436 | 0.437 | 0.437 | 0.437 | 0.437 |
| Observations | 85,733 | 85,733 | 85,733 | 85,733 | 85,733 | 85,733 | 85,733 | 85,733 |

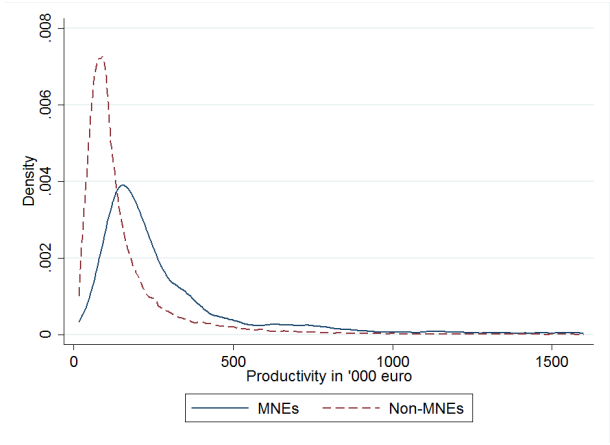
Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.18: Additional results: Sector proximity to MNEs at the 2-, 3- and 4-digit level

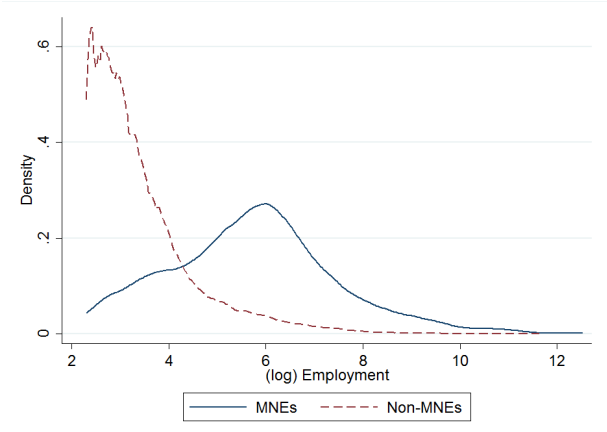
| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | ofdi | OLS | OLS | OLS | OLS | OLS |
| Productivity | 0.012*** | 0.012*** | 0.014*** | 0.014*** | 0.015*** | 0.016*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Employment | 0.032*** | 0.032*** | 0.031*** | 0.032*** | 0.031*** | 0.031*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Exporter | 0.206*** | 0.205*** | 0.205*** | 0.209*** | 0.209*** | 0.210*** |
| | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) | (0.008) |
| Young firm | -0.001 | -0.001 | -0.002* | -0.002* | -0.002 | -0.002** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Trademarks | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** | 0.002** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Subsidiaries | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** | 0.004*** |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Branches | -0.000* | -0.000 | -0.000 | -0.001** | -0.000* | -0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) | (0.000) |
| OFDI (2-dig) | 0.009*** | | | | | |
| | (0.000) | | | | | |
| OFDI (3-dig) | | 0.010*** | | | | |
| | | (0.000) | | | | |
| OFDI (4-dig) | | | 0.010*** | | | |
| | | | (0.001) | | | |
| IFDI (2-dig) | | | | 0.007*** | | |
| | | | | (0.000) | | |
| IFDI (3-dig) | | | | | 0.007*** | |
| | | | | | (0.000) | |
| IFDI (4-dig) | | | | | | 0.007*** |
| | | | | | | (0.000) |
| $R^2$ | 0.207 | 0.208 | 0.208 | 0.204 | 0.205 | 0.205 |
| Observations | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 | 87,601 |

Notes: Robust standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 2.3: Kernel density plots of firm characteristics: MNEs vs purely domestic firms




(a) Productivity




(b) Employment

# Chapter 3

# The Geography of German Subsidiaries Abroad: Importance of Destination-Specific Ties

## 3.1 Introduction

In the present chapter we explore whether German MNEs can leverage destination-specific ties available in their home region when investing abroad. We hypothesise that these ties are relatively stronger for some destinations. Hence the level of uncertainty and costs of expanding to these destinations is relatively lower and we should observe that MNEs have a higher propensity to invest in some destinations than in others. We also expect there to be considerable heterogeneity across firms in terms of who benefits from these ties, while also firm factors such as size can independently drive the directionality of outward investments.

The novelty of this study lies in conceptualising the directionality of outward investment at the level of the home region of a firm. Here we build on a large literature exploring the heterogeneity across internationalising firms and foreign destinations (Dunning, 1977, 1998; Helpman et al., 2004; Blonigen, 2005). Our

starting point is the fact that firms face barriers to expanding abroad (Zaheer, 1995; Melitz, 2003). While the previous chapter compared MNEs and purely domestic firms we now focus only on MNEs and the directionality of their investments abroad. We hypothesise that a firm that makes the choice to invest abroad faces asymmetries also with regards to where to invest. We develop a framework to show that regions have specific ties with some destinations and firms can rely on those during the expansion process. From a review of related studies it emerges that particularly destination-specific experiences of proximate firms play a role, as well as migrant networks.

We split the conceptual framework in two parts. First we look at outward destination-specific ties, i.e. those arising in a particular region in Germany. Second, we discuss inward destination-specific ties, meaning those that originate from a potential foreign destination. In the first part we relate to studies that look at prior investments of firms from the same country and destination (Head et al., 1995; Henisz and Delios, 2001; Crozet et al., 2004; Head and Mayer, 2004; Yang et al., 2015), though these generally lack a regional component with regards to the home country of these firms. We add to this the effect of outward migration in connecting places to their home country (Gao, 2003; De Simone and Manchin, 2012), while these also do not account for regional variation in the home country of migrants. For the second part of the conceptualisation we discuss the impacts of inward investment (Blomström and Kokko, 1998; Barba Navaretti et al., 2004; Smeets, 2008) and inward migration on domestic firms (Head et al., 1997; Rauch, 2001; Kugler and Rapoport, 2007; Javorcik et al., 2011). We discuss in detail how they can influence the directionality of outward investment of MNEs. For example Kugler and Rapoport (2007) claim that migrants can be an information source and draw attention on investment opportunities in their home countries. This is of particular importance for first time investors (Hernandez, 2014). To show that knowledge about foreign destinations travels at the local level we build on existing studies that show how export entries of firms within the same region have positive spillovers for prospective exporters that want to expand to the same foreign market (Silvente and Giménez, 2007; Koenig, 2009; Mayneris and Poncet, 2013; Conti et al., 2014).

We opt for the regional level following Johanson and Vahlne (1977, p.28) who highlight the tacit nature of knowledge, where the destination-specific element includes the: *"business climate, cultural patterns, structure of the market system, and, most importantly, characteristics of the individual customer firms and their personnel."* This type of tacit knowledge is not easily transferable over space (Polanyi, 1961; Audretsch and Feldman, 1996; Storper and Venables, 2004). This matters for MNEs (Malmberg et al., 1996), also in the case of Germany where intangible assets are shown to be important for regional generation of knowledge and spillovers from MNEs (Kramer et al., 2010). Without we relate to the concepts of 'global pipelines' as tacit knowledge can also be transferred globally (Bathelt et al., 2004) with significant implications for regional development (Crescenzi and Iammarino, 2017). This underlines our preference for the regional level as we also aim to provide insights for policy makers at the relevant spatial level.

In the empirical section of the chapter we estimate a number of mixed logit models for 2,201 international location choices of German MNEs. Our methodology follows earlier studies on MNE location decisions as we account for heterogeneous preferences of firms (Defever, 2006; Basile et al., 2008; Ascani et al., 2016). By introducing firm-size as a case-specific factor interacted with the destination choices we also introduce existing methods to the MNE location choice literature. Our main findings are that proximity to MNEs seems more relevant if they are also German rather than foreign-owned. As in the previous chapter this could hint at cultural proximity, or lack of embeddedness of foreign firms. Secondly, we find new evidence that the regional concentration of immigrants is significantly associated with the directionality of German investment abroad. Here we confirm earlier studies though they remain at the national level (Kugler and Rapoport, 2007; Javorcik et al., 2011; Gheasi et al., 2013). Our final finding concerns firm heterogeneity. Firm size seems to be positively associated with the probability of choosing more distant and dissimilar destination markets. In addition, not all MNEs appear to benefit from destination-specific ties, while they matter most for singe-destination investors as they are potentially first-time investors.

In the following section we review the relevant literature and establish the conceptual framework in detail. Section 3 introduces the data and discusses the

variation in our variables. In Section 4 we present the methodological advantages of the mixed logit model, while the empirical results are discussed in Section 5. Section 6 concludes.

## 3.2 Related literature and conceptualisation

This section reviews and discusses a number of studies on which we build here in conceptual and empirical terms. Our aim is to conceptualise that destination-specific ties matter for the directionality of outward investment. We first focus outward-facing ties, based on prior investments of MNEs in specific destinations and clustering of MNEs by destination. In a second step we conceptualise inward-facing ties and build on the literature on migration and foreign investment as well as the effects from foreign MNEs on local domestic firms. Finally, we review a number of studies on export spillovers to show that indeed the directionality of internationalisation can be influenced by the local availability of ties that exporters have with certain foreign destinations.

### 3.2.1 Outward destination-specific ties

Outward investments lead to the accumulation of expertise and knowledge that is destination-specific. A number of studies, mainly from the field of management science and organisational learning, have looked into how this knowledge can benefit other firms from the same home country and their international expansions. They demonstrate that it can be transferred back and shared in the home country of an MNE. Their insights are highly relevant for our study as we hypothesise that outward investments from MNEs in a specific foreign destination make that destination more accessible for surrounding firms in Germany. We conceptualise this as one of our three channels for destination-specific ties between a region in Germany and foreign destinations.

In an early study based on the entry of 31 Canadian firms in the US market, Mitchell et al. (1994) show that they benefit from the presence of other foreign

investors in the same sector. A follow-up by the same authors that uses a larger sample highlights that also previous experiences by the firm itself are a positive predictor of subsidiary survival (Shaver et al., 1997). However, these findings are contingent on whether other firms are located in a different 2-digit sector. Henisz and Delios (2001) analyse investment decisions by Japanese MNEs and show that prior investment decisions can provide crucial information as well as legitimise subsequent international expansions of other Japanese firms. In addition, their results stress the fact that prior experiences are even more relevant for firms that face higher levels of uncertainty, such as those that invest in a country for the first time. As in our study they measure prior experience by the total number of investments by other Japanese MNEs in the same foreign destination. Yang et al. (2015) demonstrate that especially previous failures of Japanese firms in China increased the survival rate of 822 Japanese subsidiaries between 1979 to 2000 in the same sector. Similar effects are shown for previous failures of the firm itself or others in the same business group. The importance of destination-specific experience at the parent-level (or 'keiretsu') has also been highlighted by Henisz and Delios (2001) and Blonigen et al. (2005).

Another group of studies shows how establishments owned by MNEs that invest abroad often cluster in specific countries and regions within these. The most prominent study has been conducted by Head et al. (1995) based on Japanese MNEs and their agglomeration in specific US states, while state-level investment promotion efforts only play a small role (Head et al., 1997). Similar evidence have been brought forward for Ireland (Barry et al., 2003), France (Crozet et al., 2004), the EU (Head and Mayer, 2004) and Germany (Spies, 2010). Taken together the studies that are discussed here are relevant as knowledge about best or worst practices in a specific foreign market seems to be passed on between firms from the same country of origin. Since the exchange of information and learning partially happens before the actual investment takes place conceptualise on where this knowledge transfer takes place (i.e. the home region) and can thus influence the directionality of investment location choices.

Finally there is a small number of studies that looks at outward migration and the association with outward investment. While the direction of causality is

not always apparent it is interesting to think about how migrants going to other places can facilitate the investment of firms from the same home country. For example Gao (2003) finds that the share of ethnic Chinese in a specific country is positively related to the amount of inward investment from that country in China. Similarly, De Simone and Manchin (2012) show that the number of migrants from new- in old members states of the EU is positively associated with subsequent investment from the latter in the former. The authors hypothesise that the main drivers are privately-held information that can reduce barriers in information, culture and regulations. Conceptually this further supports our main research question of this chapter, though we cannot empirically test for it due to the lack of data on outward migration of Germans (Buch et al., 2006).

### 3.2.2 Inward destination-specific ties

Naturally we can think about destination-specific ties also the other way around: originating in a foreign destination. Two economic actors have been discussed in the literature, mainly as data are widely available. Those are migrants and foreign firms and both will be discussed together in more detail here to show that places can build up specific ties with foreign locations. There are two important distinctions we can make. First, inward migration can enhance inward investment, and second, inward migration can facilitate outward investment. Inward investment matters for domestic firms as they can serve as additional linkages or ties with foreign destinations. More specifically they have significant impacts in terms of spillover and competition effects on domestic firms (Blomström and Kokko, 1998; Görg and Greenaway, 2004; Barba Navaretti et al., 2004; Smeets, 2008). Hence these channels here are all conceptually connected and reviewed together.

The key conceptual insights in this literature are drawn from previous studies on the directionality of international trade. For example Head et al. (1997) show that immigrants in Canada lead to increases of bilateral trade with their home country. However, adapting them to explain international investment is viable since the latter requires even larger amounts of information about the foreign destination market (Javorcik et al., 2011; De Simone and Manchin, 2012). In

a seminal study, Rauch (2001) discusses conceptually how business and social networks that span across national borders can be leveraged by firms to overcome information barriers to international trade. He defines migrant networks as *"communities of individuals or businesses that share a demographic attribute such as ethnicity or religion" [p.1178].* Following Rauch and Casella (2003) these networks can be formed by business groups, recent immigrants, or ethnic groups that settled a long time ago. Rauch (2001) also discusses specific channels as internationalising firms wanting to avoid opportunism rely on diaspora networks when international contract enforcement mechanisms are weak. These networks can enhance trust as misbehaving firms will be blacklisted. Another channel is that *"networks can be used to transmit information about current opportunities for profitable international trade (or investment)"* (Rauch, 2001, p.1184).

Regarding investment, Rauch and Trindade (2002) mention that migrants provide informal contacts, deter opportunistic behaviour and thus enhance the prospects for inward investment in China. They discuss how this matters most for countries with weaker legal institutions, and other complicating factors such as local customs, regulations and language. A study by Buch et al. (2006) analyses the relationship between inward migration and inward FDI in German federal states. They find that a higher foreign population from high-income countries is associated with a larger stock of inward investment from the same origin. The study is interesting as it is one of the few that empirically connect migration and foreign investment at the sub-national level, though in their case these remain relatively broad and are based on administrative boundaries.

Another group of studies finds a relationship between inward migration and increased probability of outward investment to the migrants' country of origin. These are particularly interesting for our case as we examine the location decisions of German MNEs abroad. In a study on the US, Kugler and Rapoport (2007) put forward that especially high-skilled migrants can be a source of information about investment opportunities in their respective home country. This is confirmed by Javorcik et al. (2011) also for the US and by Gheasi et al. (2013) for the UK context. However, in contrast to previous studies their results include inward and outward investment using pooled data for 22 countries. Also Hernandez (2014)

provides evidence on inward migration and investment in the US and adds that migrant networks are particularly of importance to first-time investors that have no destination-specific knowledge or experience. He also highlights the importance of tacit knowledge for these dynamics to occur (Polanyi, 1961; Granovetter, 1985; Kogut and Zander, 1992).

Following the literature there seems to be a clear consensus that migration has a significant effect on the directionality of investment abroad. Migrants that move to a foreign country carry specific knowledge about their home country, which can be leveraged by firms that make an international location decision. Beyond obvious language skills, the literature has highlighted how migrants can provide informal information about business culture or opportunities, as well as formal laws and regulations. In that sense migrants are a crucial part of destination-specific ties and will be incorporated in our empirical analysis. Inward investment is similar to inward migration regarding the channels and it will also form a separate empirical channel in this analysis. As inward migration and investment are conceptually similar and are also connected empirically they have been reviewed together.

### 3.2.3 Destination-specific localised externalities between firms

Firms share knowledge about how to enter and conduct business in foreign destinations. We hypothesise that this happens at the regional level and will review relevant studies here that have shown this in the case of exporting behaviours. Destination-specific externalities between foreign and domestic MNEs and the probability of domestic firms to become exporters in specific foreign markets have been shown for a number of countries. This includes Spain (Silvente and Giménez, 2007), France (Koenig et al., 2010; Poncet and Mayneris, 2013), China (Mayneris and Poncet, 2013), Russia (Cassey and Schmeiser, 2013), Italy (Conti et al., 2014) and Denmark (Choquette and Meinen, 2015). Interestingly, no study has looked at Germany, a country which is traditionally highly engaged in international markets via exports and investment abroad. Although the mechanisms are not the same for exports and investment abroad they are related and we aim to conceptually borrow

from this literature for our study. Most importantly, both involve overcoming entry barriers to internationalisation, such as gathering information about the destination market.

Silvente and Giménez (2007) apply a multinomial logit model to analyse the export destination decisions of 454 Spanish SMEs. They find that the agglomeration of domestic exporters at the level of 48 provinces positively influences the probability of firms in the same industry to export to the same destination. In a subsequent study, Koenig (2009) shows in the case of France that they are more relevant for entering destinations that are more spatially remote. The spillover variable in their study is composed at the level of 340 employment areas, similar to those we propose to use in the German case here. Mayneris and Poncet (2013) find that this effect even holds at the product level in an analysis of exporters in Chinese regions. They add that foreign MNEs act as export 'catalysts' for domestic exporters. Studying Italian exporters, Conti et al. (2014) provide evidence for service sectors as well and also highlight the larger effect for more distant foreign destinations. This idea is supported by findings from Gil-Pareja et al. (2015) who show that Spanish overseas export promotion offices are most effective outside the European Economic Area and attribute this to the higher information barriers when expanding in these markets.

Despite acknowledging the differences between internationalising via exports and investment abroad, we do see significant similarities. For example, a recent empirical study by Conconi et al. (2016) shows that most investments abroad are preceded by exports undertaken by the same firm to the same foreign country. These findings are in line with the idea of firms following sequential internationalisation patterns and increasing market engagement in specific foreign destinations (Johanson and Vahlne, 1977). Since investment abroad requires an even higher level of firm productivity than exporting (Helpman et al., 2004) this also implies that the preparation process requires more, or more specific, knowledge of the destination. Similar efforts to be undertaken by the internationalising firm include gathering information about the destination in terms of economic opportunities, as well as the formal and informal business environment. In the vein of Mion and Opromolla (2014) this can also apply to the recruitment of personnel with

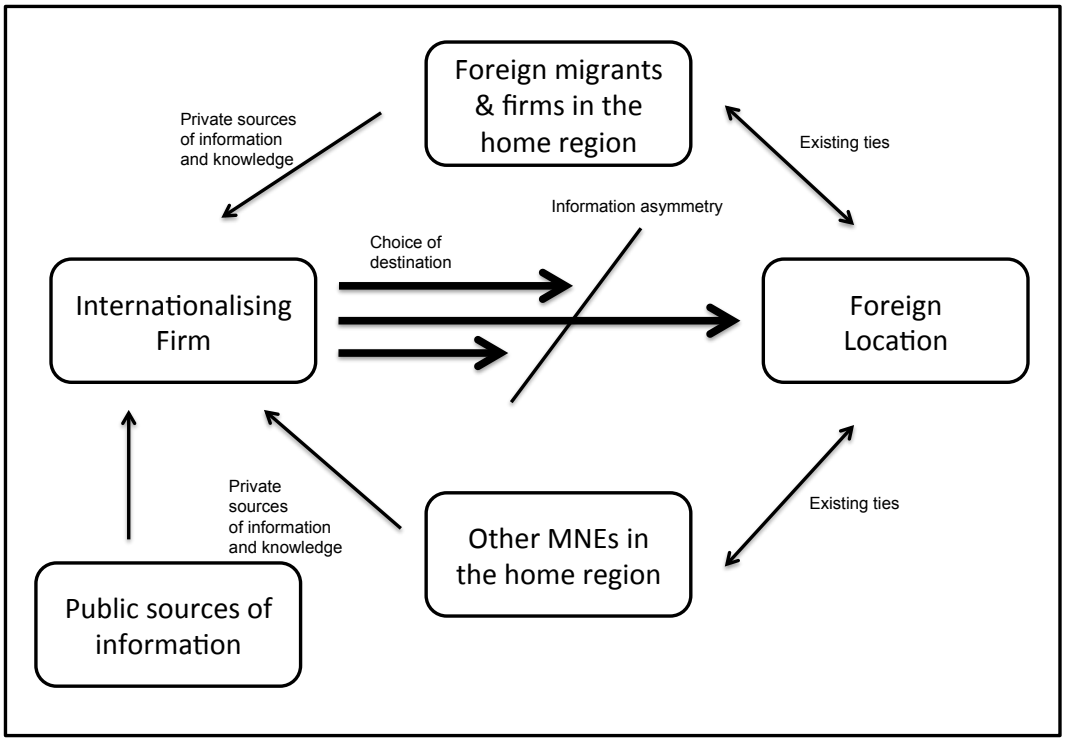
destination-specific expertise. Since these costs of internationalisation can be prohibitively high for some firms (Greenaway and Kneller, 2007) the local availability of destination-relevant knowledge at home can act as a substantial catalyst and cost-decreasing factor also in the case of investment abroad. This section has highlighted that these knowledge exchanged tend to occur at the regional level.

### 3.2.4 Integrating region-destination linkages in a conceptual framework

In this study we hypothesise that the directionality of outward investment by German firms is influenced by the availability of existing ties between the home region a German MNE is located in and a specific foreign destination. A review of the relevant literature has shown that there are various mechanisms through which these linkages arise and how they can influence the directionality of the internationalisation of firms. We conceptualised outward ties based on pre-existing investments of MNEs and outward migration, and inward ties based on inward migration and investment. Both were shown to have a strong destination-specific element. Adding insights from studies on export spillovers we could show that most of these knowledge exchanges (some of which are tacit) take place at the sub-national level. Figure 3.1 summarises these in a simple schematic conceptualisation. Following Dunning (1998) we put forward that destination-specific knowledge could be seen as a 'location-bound asset' that firms in some home regions could harness as an ownership advantage over firms located in other regions.

The starting point for our conceptualisation is the internationalising firm that is deciding on the location of its investment abroad. Naturally this process involves a lot of due diligence at the firm-level and firms will consider any sources of information available (at reasonable cost). However, as commonly highlighted in the literature, the firm faces an information asymmetry when taking this decision (Zaheer, 1995) and it is similar to but larger than for international trade (Gao, 2003; Javorcik et al., 2011). We demonstrated that this asymmetry differs by destination, depending on the amount and quality of destination-specific knowledge that a firm has. Hereby firms rely on public and private sources of

Figure 3.1: Conceptual Framework




information to gain knowledge and overcome this asymmetry (Kinoshita and Mody, 2001; De Simone and Manchin, 2012). We assume that public information is available to all firms in Germany, e.g. from investment promotion agencies (Harding and Javorcik, 2011), chambers of commerce at home and abroad or online desk research. Information cannot be equated with knowledge but we are so far only interested in the potential knowledge firms have, while actual knowledge will be heterogeneous across firms in the empirical setting. Private information and other specific knowledge on the other hand needs to be obtained from other sources and we hypothesise that this type of knowledge travels within narrower spatial units than the country-level (Jaffe et al., 1993; Audretsch and Feldman, 1996; Storper and Venables, 2004; Bode, 2004).

Following the literature discussed above, there are different information sources based on ties between a German region and a foreign destination that can be leveraged by the internationalising firm: migrants, subsidiaries in Germany owned by foreign MNEs, and German MNEs with subsidiaries abroad. The key for our study is that these differ between German regions. Thus, firms located in some regions have destination-specific information advantages over firms in other regions.

In the empirical analysis we test whether this in fact has a significant impact on the directionality of the international location decisions of firms. This notion is also closely related to the concept of 'global pipelines' which puts forward the idea some actors can provide information locally that connects a place with more distant locations. As a result, firms located in vibrant clusters have an inherent advantage of those that are not, while the types of knowledge can be tacit as well as codified (Bathelt et al., 2004). A central pipeline are foreign investments, with lasting impacts on regional connectivity and economic development (Crescenzi and Iammarino, 2017).

Another key dimension that forms part of our conceptual framework is destination-specific knowledge is more valuable for investments directed to emerging markets or markets that are more distant.[1] Kinoshita and Mody (2001) explain in more detail how the value of private information and knowledge increases when less public information is available. This is commonly the case for distant destinations. For example, the spatial distance between Berlin and Beijing and Berlin and Washington is roughly comparable, though the distance in terms of familiarity with the business environment is not. The business environment, conduct and customs as well as consumer tastes are much closer to Germany in the case of the US vis-a-vis China. This notion is confirmed by several studies that find a higher importance of ties for countries that are more distant (Koenig, 2009; Conti et al., 2014). Also the value of export promotion is larger for less known markets (Gil-Pareja et al., 2015) and the same holds for investment promotion (Harding and Javorcik, 2011). Since larger firms have access to more resources to evaluate the different destination choices and actually overcome the barriers of expanding to more distant markets we expect firm size to play a crucial role in this (Figueiredo et al., 2002; Arauzo-Carod, Maria and Manjón-Antolín, 2004). They are more likely to have the personnel, research and travel budget, as well as contacts to other firms.

[1] As discussed on the introductory chapter, distance (or proximity) can refer to a number of dimensions (Boschma, 2005).

## 3.3 Data and descriptives

### 3.3.1 German outward investors

The empirical analysis makes use of a large firm-level dataset extracted from BvD ORBIS (similar to previous chapter). We primarily utilise information on the ownership structure and firm characteristics of 1,661 German-owned MNEs.[2] Since the database is based on the latest firm accounts available to the data provider it is effectively a cross-section. Most firm accounts included in the analysis are filed in 2014[3] and they own at least 1 subsidiary abroad with a minimum ownership of 50%. In total we can identify 3,673 subsidiaries that are majority-owned by one of the 1,661 German MNEs.[4]

Table 3.1: Distribution of firms in the sample by number of employees

| | Regression sample | | Extracted sample | |
|---|---|---|---|---|
| Size class | Count | Share | Count | Share |
| Small (< 50 emp.) | 260 | 15.65 % | 641 | 29.42 % |
| Medium (50 - 249 emp.) | 1,007 | 60.63 % | 1,112 | 51.03 % |
| Large (250 - 1,000 emp.) | 325 | 19.57 % | 348 | 15.97 % |
| Very large (> 1,000 emp.) | 69 | 4.15 % | 78 | 3.58 % |
| Total | 1,661 | 100.00 % | 2,179 | 100.00 % |

Among the 1,661 MNEs we can identify a total of 1,562 unique GUOs. The empirical analysis will explicitly control for the case that firms within the same

[2] Based on the definition provided by ORBIS as firms with a global ultimate owner (GUO) located in Germany. It refers to the owner with the largest ownership share, and minimum 25%. Hence all firms in the sample are headquartered in Germany and are restricted to have no foreign owners.

[3] In our dataset 2.6% of firms report the last accounts in 2015, 66.9% in 2014, 28.2% in 2013, 1.7% in 2012, and 0.6% in 2011. To make sure that we have the latest accounts we restrict the dataset to active firms without involvement in insolvency proceedings.

[4] Chen and Moore (2010) use the same dataset with similar restrictions for French MNEs and obtain a sample of 1,302 firms. Also the study by Henisz and Delios (2001) is similar as their empirical setting is based on 2,705 Japanese investments in 155 countries between 1990-96.

corporate group (i.e. same German GUO) also have destination-specific investments. This is to ensure that we capture region-destination-specific ties that work through the regional channel, rather than some other firm-specific international ownership connection.[5] Table 3.1 highlights that while most firms in our final sample are medium-sized companies (61%) there is a significant heterogeneity in terms of firm size. Data restrictions as described above have an impact on the size distribution in the final sample used for the estimations. Most importantly the share of medium-sized companies is larger than in the sample that we initially extracted from ORBIS. The main reason is that we drop a number of small firms that employ less than 10 employees. Full details on the data extraction and cleaning can be found in Appendix 3.A.1.

Our analysis is interested in the association between firm size and the propensity to invest in specific destinations, which requires an additional restriction to the data. The reason is that in ORBIS some firms report consolidated accounts (including all listed companies). This means that firm characteristics are aggregated at the level of the headquarters. This could lead to problems if for example employment data are aggregated at the level of the GUO, but we want to examine firm size at the sub-business group level. Hence in this chapter we restrict the data to firms with unconsolidated accounts and accept a smaller but clearly defined sample.[6] Using unconsolidated accounts is common in the literature (Peri and Urban, 2006; Temouri et al., 2010; Chen and Moore, 2010) and means that we do not suffer from the 'headquarter bias'. In Appendix 3.A.1 we provide a detailed discussion of this and other sample-related issues.

[5] The allocation of firms to regions is possible in ORBIS as previous studies demonstrated (Peri and Urban, 2006; Redding et al., 2011; Burchardi and Hassan, 2013). Also see data section of Chapter 2 for further details if necessary.

[6] This was less of an issue in Chapter 2 as we assumed that the internationalisation decision is undertaken at the headquarter-level.

### 3.3.2 Dependent variable: Destinations of German-owned subsidiaries abroad

This study investigates the directionality of investment abroad, and hence we choose a dummy dependent variable equal to 1 if a firm owns a subsidiary in a specific destination. Similar to other studies, we group destination countries into country groups (Becker et al., 2005; Buch et al., 2006; Koenig, 2009; Conti et al., 2014).[7] The rationale for using country groups and not individual countries is that knowledge about foreign markets is actually relevant beyond the immediate country. While completely abstracting from relevant country-specific factors, such as formal and informal institutions, it seems reasonable to expect that some knowledge is, for example, applicable to Latin America or the Middle East in general. Nevertheless there is also a practical reason for our choice as we are computing measures for destination-specific ties at the regional level in Germany and using countries as destinations would result in a majority of zeroes for the choice setting.[8] As we are interested in the regional variation in Germany we need to accept this limitation.

In Table 3.2 we offer an overview over the number of subsidiaries abroad by destination, that are owned by one of the 1,661 German MNEs in our sample. Overall we can identify 3,726 subsidiaries of which 49% are located in Western Europe, followed by 28% in Central-Eastern Europe. Asia and North America host 11.9% and 5.6% of subsidiaries respectively, while 2.2% are situated in Latin America. We compare the distribution of subsidiaries in our sample to official statistics from the German Central Bank (Bundesbank) to assess its representativeness. While the distribution seems fairly comparable regarding Western Europe and Asia, it is less so for Central Eastern Europe (CEE), North- and Latin America. The latter are underrepresented, due to a significant overrepresentation

[7] Appendix 3.A.2 provides a full list of country groupings in Table 3.7.

[8] There are 258 employment areas in Germany so if we assume 200 countries as destinations this would result in 51,600 potential region-destination combinations. The variation in the sample would be minimal as most of these combinations are not actually observed and our models would not converge.

Table 3.2: Overview of locations of German-owned subsidiaries abroad by MNE size

| Destination | Subsidiaries in destination | | Bundesbank official data | Unique pairs (firm-destination) | | Employment of MNE |
|---|---|---|---|---|---|---|
| | Count | Share | Share | Count | Share | Average |
| Western Europe | 1,827 | 49.0% | 43.6% | 1,083 | 48.2% | 326 |
| Central-Eastern Europe | 1,047 | 28.1% | 16.6% | 698 | 31.5% | 295 |
| Asia | 442 | 11.9% | 13.9% | 143 | 6.7% | 647 |
| North America | 209 | 5.6% | 14.5% | 143 | 6.5% | 720 |
| Latin America | 82 | 2.2% | 5.4% | 50 | 2.2% | 1,106 |
| Rest of the World | 119 | 3.2% | 6.0% | 84 | 3.9% | 755 |
| Total | 3,726 | 100% | 100% | 2,201 | 100% | 397 |

Note: Employment mean calculated at level of German MNE (1,661 unique German owners). 'Rest of the World' destinations include Africa, Middle East, and Oceania. Bundesbank data use min. 10% ownership for outward investment.

of CEE countries. Since our sample has some restrictions this is not necessarily surprising, especially since we exclude firms with consolidated accounts and hence any listed firm. As German MNEs investing in CEE are relatively smaller, while listed firms are generally large we can speculate that this can be the source of this sampling bias. These caveats have to be kept in mind for the subsequent analysis of location choices by German MNEs. A final observation on Table 3.2 can be made regarding the average size of the MNEs that invest in the different destinations, as there appears to be considerable heterogeneity. We will discuss this further below and the empirical model will exploit this variation statistically.

Since some of the MNEs in our sample own multiple subsidiaries in some destinations abroad we only compute the number of unique MNE-destination combinations. Those will form the basis constructing the choice dataset. Overall we identify 2,201 unique combinations between MNEs and destinations and expand those by combinations that are not directly observed. Hence the resulting choice dataset has 17,608 observations (8 destinations multiplied by 2,201 observed location choices).

### 3.3.3 Main explanatory variables: Destination-specific ties and firm size

Our conceptual framework distinguished three main forms of destination-specific ties between a German region and a foreign destination. To approximate them empirically we construct covariates based on either the total or relative number of firms and immigrants in a region. Following Koenig (2009) and Choquette and Meinen (2015) we choose to compute the variables at the level of non-administrative employment areas to alleviate the issues of using administrative boundaries. In Germany there are a total of 258 employment areas and for the remainder of this study we will refer to 'employment areas' and 'regions' interchangeably. Employment areas have the advantage that they reflect the underlying economic structure of a place and hence it is more appropriate when analysing firm decisions as they are embedded in these structures. In the German case they should be preferred over counties (i.e. Kreise) (Arauzo-Carod, Maria and Manjón-Antolín, 2004).

The dataset on investment abroad by German MNEs has been discussed in section 3.1. The first destination-specific channel is based on the total outward investment by German firms in a region and we construct two measures. In a first step we compute the (log) total number of outward investments (OFDI) by foreign destination and region in Germany. In a second step the relative concentration of outward investment to the same destination abroad is approximated using a simple location quotient (LQ) formula: in (1).[9]

[9] A similar measure is deployed in Aitken et al. (1997) for the relative specialisation of regions in manufacturing exports and in Silvente and Giménez (2007) for the relative specialisation of regions in specific export destinations. Also Cook et al. (2012) use it to test how specialised a region is in specific sectors and whether this is associated with outward investment. Anecdotal observations on ORBIS also claim an over-representation of metropolitan areas. While the data provider does not describe this concern, using relative measures can also alleviate this concern, unless the over-representation in these regions only concerns wither MNEs or non-MNEs specifically.

$$\mathrm{LQ}_{rj} = \frac{\mathrm{Firms}_{rj}}{\mathrm{Firms}_{j}} / \frac{\mathrm{Firms}_{r}}{\mathrm{Firms}} \tag{3.1}$$

For the OFDI variable the first part of formula (1) expresses the share of firms in the German home region r that invest in the same destination j abroad as a share of total firms in Germany that invest in the same destination j. The second part of the formula calculates the share of total firms in a region r that invest abroad in any foreign destination, to the total number of firms that invest abroad in Germany. Dividing the first part by the second part then gives the relative specialisation of a region in terms of firms investing "relatively more" in a specific destination as compared to the national average. A number that is larger than 1 indicates a relative specialisation.

We compute two similar variables for the reverse case of foreign MNEs that are locating in German regions. Again, we consider destination-specific investment ties. The data on inward investment (IFDI) are also extracted from ORBIS and our sample contains a total of 43,431 foreign-owned firms in Germany. As in the case for outward investment we use a minimum ownership share of 50%. To avoid any confusion of the channels none of these have any German shareholder (not even at a minority stake). Missing entries on geographic locations in Germany reduces the sample by 5,443 observations. As above we distinguish the (log) total number of foreign firms in a region separated by origin as well as a location quotient (LQ). The difference to the location quotient for OFDI is that we consider foreign firms in German regions rather than German firms that expand internationally.

Finally, our third channel is based on immigrants in Germany. We use data on the home country of immigrants living in Germany to test the importance of region-destination ties approximated by migrant networks. Data are extracted from Destatis, the Federal Statistical Office of Germany and include all foreigners living in a region that do not have the German citizenship.[10] Latest data were available

[10] This includes those with a permanent or temporary residence permit, but excludes foreign personnel of armed forces. Ideally we would also include statistics on naturalised foreigners that now hold a German passport but unfortunately such data do not exist at the regional level.

for the year 2014. As with the variable for inward investment we aggregate the (log) total number as well as the location quotient at the regional level. As in Docquier and Lodigiani (2010) we use the stock of migrants, though we have no data on their skill composition or other characteristics apart from the country of origin. As in the study by Buch et al. (2006) we can only look at the stock of immigrants living in Germany as reliable data on Germans living abroad are not available. The descriptive analysis of destination-specific ties in section 3.5 provides maps and further analysis of the total and relative importance of these variables by employment area in Germany and foreign destination. Descriptive statistics for all 3 measures described here are provided in Appendix 3.A.2, Table 3.8 for the region-level and Table 3.9 for the firm-level.

Table 3.3: Summary statistics of MNE characteristics

| | Count | Mean | Std. dev. | Min. | Max. |
|---|---|---|---|---|---|
| Employees | 1,661 | 291.40 | 1041.04 | 10.00 | 23236.00 |
| Patents | 1,661 | 31.37 | 313.04 | 0.00 | 11763.00 |
| Trademarks | 1,661 | 5.26 | 16.82 | 0.00 | 300.00 |
| Subsidiaries abroad | 1,661 | 3.24 | 25.15 | 1.00 | 998.00 |
| Branches at home | 1,661 | 2.61 | 6.06 | 0.00 | 121.00 |
| Regional GDP (in bn EUR) | 1,661 | 41.77 | 49.11 | 1.45 | 153.08 |
| Regional OFDI | 1,661 | 105.47 | 154.99 | 0.00 | 530.00 |
| Regional IFDI | 1,661 | 817.97 | 1307.42 | 4.00 | 4053.00 |
| Regional immigrants | 1,661 | 131775.44 | 164658.72 | 0.00 | 505855.00 |

Finally, in our literature review and conceptualisation we discussed firm size as an important factor for choosing destinations abroad. We hypothesised that firm size play a crucial role in expanding to more distant locations, in addition to the availability of destination-specific linkages. Indeed in Table 3.2 we showed that average firm size does differ significantly across destinations. The literature on MNE location choices so far mostly relies on firm-level factors to explain which firms internationalise, rather than where they expand to. Since our sample only includes MNEs we are not too concerned about selection effects of specific

firms into internationalisation here.[11] We hypothesise that firm size is positively correlated with the 'distance' between Germany and the destination market. In other words, firms that establish subsidiaries in more distant markets are on average larger in terms of employment as they have the resources to overcome the additional barriers of operating in more distant and less familiar markets abroad. Hence our empirical analysis will explicitly test for firm size as we believe it is potentially associated with the directionality of investment abroad. Summary statistics for our control variables and additional firm-level descriptives are presented in Table 3.3.

### 3.3.4 Regional variation of destination-specific ties in Germany

The aim of this section is to provide a first intuition on the regional variation of destination-specific ties in Germany. Figure 3.2 to Figure 3.5 in Appendix 3.A.2 show maps of destination-specific ties between German regions and Western Europe, Central-Eastern Europe, North America and Asia. Since we are working with cross-sectional data most of the variation for the statistical analysis will come from spatial differences in these variables. Hence it is important to demonstrate that regional variation exists and is clearly destination-specific as well. The three maps in each figure compare the three forms of destination-specific ties that were discussed in the conceptual section. The red circles symbolise the total number of firms or immigrants and the blue shading indicates their relative number in a region using the location quotient formula.

Figure 3.2 shows the spatial distribution of destination-specific ties between German regions and Western Europe. German MNEs with subsidiaries in Western Europe are located in large metropolitan areas, as well as smaller regions in the West and South-West of Germany. Their relative concentration exhibits a less

[11] The fact that firms operating on international markets are fundamentally different than those operating only on national markets is well-established in the literature and explored in Chapter 2.

clear spatial pattern. Looking at subsidiaries owned by foreign firms from Western Europe in Germany (2 b) they are unsurprisingly concentrated in regions that share a border with Western European countries. This spatial pattern is even stronger when looking at the location of immigrants (2 c), which are absolutely and relatively concentrated in regions close to the Northern, Western and Southern borders.

Figure 3.3 considers the territorial distribution of destination-specific ties for Central and Eastern Europe. Overall both outward- and inward investment seem to be relatively concentrated in regions close to the Eastern border with Poland and the Czech Republic. The absolute number of German MNEs with establishments in CEE countries is mainly in Western Germany, in and around large metropolitan areas. Immigrants from the CEE member countries show less clear spatial patterns with an absolute concentration in large Metropoli and relative concentration in the South and South-East of Germany.

Destination-specific ties for North America are depicted in Figure 3.4. The German owners of subsidiaries in North America are based mostly in big German city agglomerations such as Frankfurt, Munich, Hamburg and Cologne, as well as regions scattered around these. Interestingly, very few of these firms are located in the former Eastern German states. Inward investment from North America again appears to be clustered around cities, especially in the region around Frankfurt and Cologne. North American immigrants live in the large cities, especially Berlin and Munich. The centre of the country shows a belt of regions stretching from the East to the West where North Americans are relatively overrepresented in the number of immigrants.

In Figure 3.5 we show the territorial patterns of destination-specific ties for Asia. Keeping in mind that 'Asia' includes a large basket of countries in our case, there seem to be some distinct patterns. Overall few regions exhibit a relative concentration of German firms that invest in Asia. These are scattered around the country and tend to be outside large metropolitan regions besides the Frankfurt metropolitan area. Most Asian-owned subsidiaries in Germany can be found in Hannover, Düsseldorf, and Frankfurt, which also show a relative concentration

with high location quotients. Asian immigrants are located in Central-Western regions around Frankfurt and Düsseldorf. However, the relative concentration of Asians is very high in the former Eastern German states.

Overall there are a few take-aways from this explorative analysis that can help guide the statistical analysis. Most importantly we have shown that there is considerable regional variation in destination-specific ties. Here it is important to distinguish two sources of variation: On the one side, there is inter-regional variation regarding destination-specific ties with a specific foreign destination. On the other side, there is intra-regional variation when it comes to destination-specific ties with different foreign destinations. Also interesting to highlight is the fact that absolute and relative measures of destination-specific ties do not necessarily coincide at the regional level. While an absolute strength of ties is clearly visible in large metropolitan areas the relative strength of ties shows that some regions clearly have stronger ties with some foreign destinations. The subsequent statistical analysis will explore whether there is a significant association between these measurements of destination-specific links and the directionality of international location decisions of German MNEs. In words we want to understand to what degree e.g. the number of North American firms or immigrants in a region in Germany is associated with the propensity of MNEs in that region to themselves invest in North America.

## 3.4 Methods

### 3.4.1 Overcoming IIA: Mixed Logit Models

To analyse the directionality of German investment abroad we estimate the individual location decisions of German MNEs in 8 destinations. We opt for a choice model setting to allow for alternatives at the firm-level, and as in related studies this precludes the estimation of the intensive margin, i.e. the number of subsidiaries an MNE might own in a destination. Empirically most multinomial studies rely on the conditional logit model (CLM) as established by McFadden

(1974), while others use the more simple binary logit.[12] As the name suggests the drawback of the latter is that only two location choices can be estimated. In multinomial choice models MNEs are assumed to make location decisions based on individual profit maximisation:

$$\pi_{ij} = \beta_i' x_{ij} + \epsilon_{ij} \tag{3.2}$$

where $\beta_i'$ is firm i's vector of coefficients over observable characteristics $x_{ij}$ for destination j and $\epsilon_{ij}$ is the iid extreme value random component. According to Train (2003) firms know their own $\beta_i$ and $\epsilon_{ij}$ for all alternative choices and base their location decision on the maximisation of $\pi_{ij}$. Following our conceptualisation the ties between a firms' home region and destination j can act as cost-decreasing (and hence profit-increasing) factors and thus influence the directionality of the location decision of MNEs investing abroad. In the context of this model they vary at the regional level and thus will be included in $x_{ij}$ as each firm is assumed to be located in one region only.[13] Here, the main challenge for researchers is that the true profits of each alternative as evaluated by the individual firm are not actually observed. Hence we have to rely on location decisions of firms that are actually realised and observable alternative-specific characteristics that we can approximate with data. This also means that the level of analysis is the realised location choice (against the alternative destinations), while MNEs in our sample can have multiple of these realised location choices (maximum 8 of course).

In principle this could be done using the standard CLM, however with one main limitation: The CLM relies on the crucial assumption that the error term

[12] See e.g. Guimaraes et al. (2000); Becker et al. (2005); Blonigen et al. (2005); Bertrand et al. (2007) and Devereux et al. (2007) for an application of the CLM and Grubert and Mutti (2000); Henisz and Delios (2001); Koenig (2009) and Choquette and Meinen (2015) for the binary logit.

[13] We acknowledge that firms could also be exposed to destination-specific ties via branches or subsidiaries in Germany, though we do not explore this empirically. Including these in the model would require a weighting based on at least number of domestic locations, and potentially distance and economic weight. Since we have no preconception on these we leave this issue for future studies to explore.

is independent across alternatives. This independence of irrelevant alternatives (IIA) means that MNEs have no unobserved preferences for some destinations and there are no unobserved correlations between the location choices in the set of alternatives. The latter means that there are no unobserved factors for a subset of the choices, e.g. Western business culture. Blonigen et al. (2005) use the CLM to analyse the location decisions of Japanese multinationals in 11 foreign destinations and concludes that there are potential issues with the IIA condition that need to be resolved.[14]

One way of overcoming this limitation is using a random parameters logit model such as the Mixed Logit Model (MXL). The empirical literature on international location choices of MNEs has recently embraced the MXL, including studies by Defever (2006, 2012), Cheng (2008), Basile et al. (2008) and Ascani et al. (2016). For the purpose of this study we will follow them closely and extend it with regards to firm-specific factors. The MXL can be regarded as a generalisation of the CLM as it can account for heterogenous preferences (or 'tastes') of firms, allowing them to choose differently over the same set of observable destination characteristics (Revelt and Train, 1998). In formula (2), the $\beta_i$ is allowed to vary across alternatives j and estimated via maximum likelihood procedures. Following Train (2003) the choice probability is the weighted average of the simple logit formula,[15] where the weighting is based on unknown $\beta$'s that vary by firm:

$$P_{ij} = \int \left[ \frac{exp(\beta_i' x_{ij})}{\sum_{l=1}^{m} exp(\beta_i' x_{ik})} \right] f(\beta|\theta) d\beta \tag{3.3}$$

where $\theta$ describes the distribution of $\beta$'s across firms. Hence, in the MLX $f(\beta|\theta)$ determines the relative weights of $\beta$'s, that now differ for each firms'

[14] Also nested logit models can be used as in Devereux and Griffith (1998); Crozet et al. (2004); Head and Mayer (2004) and Barrios (2006) though the IIA condition still needs to hold within nests and there needs to be a feasible nesting structure. Rank-ordered choice models can lead to similar results, with the caveat of ex ante imposition of a 'ranking' among alternatives. As developed by Beggs et al. (1981) it is applied in Silvente and Giménez (2007) and Kinoshita and Mody (2001).

[15] Further details on models with non-random coefficients are provided in Appendix 3.A.3.

estimated unconditional logit function. We specify $f(\beta)$ to be normally distributed ($\beta \sim N(b, W)$) since we do not know whether the expected signs of the coefficients are the same for each firm (Train, 2003). The choice probability is approximated using simulations for any given $\theta$. To do so a value of $\beta$ is drawn from $f(\beta|\theta)$ with r = 1 being the first draw. This value is then used to calculate the logit formula (3) and after a specified number of repeats we can calculate the average to obtain a simulated probability ($SP_{ij}$):

$$SP_{ij} = \frac{1}{R} \sum_{r=1}^{R} \frac{exp(\beta'^{r} x_{ij})}{\sum_{l=1}^{m} exp(\beta'^{r} x_{ik})} \tag{3.4}$$

where R specifies the total number of draws, fixed at R = 500 for this study. This simulated choice probability is subsequently inserted in the log-likelihood function to get the simulated log likelihood ($SLL$):

$$SLL = \sum_{i=1}^{N} \sum_{j=1}^{J} y_{ij} ln SP_{ij} \tag{3.5}$$

where $y_{ij} = 1$ if firm i chooses alternative j and zero otherwise.

### 3.4.2 Testing explicitly for firm heterogeneity in location decisions

Our descriptive statistics highlighted that the size of the German parent firm differs significantly by the destination of investment abroad. The arising pattern suggests that more 'distant' destinations in terms of geography, but also culture and institutions, are targeted by German MNEs that are on average larger. This observation is in line with the literature on MNEs as fixed entry costs for more distant markets are generally higher and larger firms have the resources to overcome these. By introducing firm-specific factors such as firm size we can also test if they have a statistically significant influence on the location choices of German MNEs. Since case-specific factors do not vary across cases they cannot be directly included in the MLX. To introduce them we follow the methodology

of the 'alternative-specific' CLM as described in Cameron and Trivedi (2009).[16] The model basically relies on interaction terms between case-specific variables and alternative-specific dummies. Brownstone and Train (1999) use the same method to introduce case-specific education variables in their mixed logit model of stated preferences among vehicle alternatives. Hence, while the methods exist elsewhere they have not been applied to the location choices of firms. In our case we interact case-specific firm size with indicator dummies for each foreign destination to obtain variables that now vary across and within cases.

## 3.5 Empirical results and discussion

### 3.5.1 Destination-specific ties matter for MNE location choices

We estimate our location choice model for 2,201 unique linkages between German MNEs and 8 foreign macro areas. As discussed in the methodology section we run a mixed logit model to allow for heterogeneity across firms for some of the variables included. All of our regressions include a full set of non-random destination dummies and robust standard errors that are clustered at the level of the home region of the MNE. Regression results for our main variables of interest are presented in Table 3.4 and are largely in line with our conceptualisation of how region-destination specific ties can influence the directionality of MNE investment abroad. The first part of the table presents the random coefficients that are allowed to vary across firms according to their individual preferences. The second part of the table shows the non-random coefficients consisting of a set of interaction terms between firm size and destination dummies as specified in the methodology section.

Focussing on the upper part of the table we show separate results for our main

[16] In STATA we follow the methodology of the *-asclogit-* command, which is designed to account for case-specific variables in the CLM.

Table 3.4: Estimation results: Mixed Logit Model for location choices of German MNEs

| | | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|---|
| OFDI (log total) | b | 0.233*** | | | | | |
| | | (0.0632) | | | | | |
| | s | 0.499*** | | | | | |
| | | (0.0455) | | | | | |
| | %>0 | 68.1% | | | | | |
| IFDI (log total) | b | | 0.213*** | | | | |
| | | | (0.0496) | | | | |
| | s | | 0.230*** | | | | |
| | | | (0.0447) | | | | |
| | %>0 | | 83.2% | | | | |
| Immigrants (log total) | b | | | 0.361*** | | | |
| | | | | (0.0674) | | | |
| | s | | | 0.260*** | | | |
| | | | | (0.0327) | | | |
| | %>0 | | | 91.8% | | | |
| OFDI (relative) | b | | | | 0.359*** | | |
| | | | | | (0.0637) | | |
| | s | | | | 0.138** | | |
| | | | | | (0.0567) | | |
| | %>0 | | | | 99.5% | | |
| IFDI (relative) | b | | | | | 0.0816*** | |
| | | | | | | (0.0206) | |
| | s | | | | | 0.0000761 | |
| | | | | | | (0.000130) | |
| Immigrants (relative) | b | | | | | | 0.226*** |
| | | | | | | | (0.0457) |
| | s | | | | | | -0.000395 |
| | | | | | | | (0.000733) |
| MNE experience | b | 0.0588 | 0.0514 | 0.0616 | 0.0421 | 0.0482 | 0.0575 |
| | | (0.114) | (0.109) | (0.105) | (0.0993) | (0.108) | (0.107) |
| | s | 0.00509 | -0.0190 | -0.00299 | 0.000643 | 0.00617 | 0.00576 |
| | | (0.00808) | (0.0219) | (0.00553) | (0.00514) | (0.0671) | (0.0827) |
| Firm size * Africa | | 0.506*** | 0.491*** | 0.497*** | 0.604*** | 0.497*** | 0.492*** |
| | | (0.115) | (0.126) | (0.118) | (0.159) | (0.125) | (0.122) |
| Firm size * Asia | | 0.361*** | 0.345*** | 0.352*** | 0.350*** | 0.353*** | 0.355*** |
| | | (0.0600) | (0.0606) | (0.0595) | (0.0615) | (0.0596) | (0.0601) |
| Firm size * CEE | | -0.0307 | -0.0354 | -0.0253 | -0.0281 | -0.0261 | -0.0266 |
| | | (0.0407) | (0.0394) | (0.0402) | (0.0396) | (0.0381) | (0.0389) |
| Firm size * Latin America | | 0.557*** | 0.524*** | 0.534*** | 0.434*** | 0.530*** | 0.527*** |
| | | (0.111) | (0.107) | (0.102) | (0.117) | (0.103) | (0.102) |
| Firm size * Middle East | | 0.367** | 0.302* | 0.318* | 0.399 | 0.300* | 0.319* |
| | | (0.167) | (0.182) | (0.178) | (0.254) | (0.169) | (0.180) |
| Firm size * North America | | 0.361*** | 0.358*** | 0.371*** | 0.369*** | 0.367*** | 0.368*** |
| | | (0.0634) | (0.0605) | (0.0629) | (0.0612) | (0.0585) | (0.0580) |
| Firm size * Oceania | | 0.561*** | 0.546*** | 0.596*** | 0.552*** | 0.543*** | 0.556*** |
| | | (0.109) | (0.113) | (0.119) | (0.131) | (0.113) | (0.111) |
| Destination dummies | | yes | yes | yes | yes | yes | yes |
| Log likelihood | | -2830.6 | -2847.4 | -2841.5 | -2712.2 | -2855.4 | -2852.8 |
| Cases | | 2,201 | 2,201 | 2,201 | 2,201 | 2,201 | 2,201 |
| Observations | | 17,608 | 17,608 | 17,608 | 17,608 | 17,608 | 17,608 |

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors in parentheses clustered at employment area level. 'Western Europe' used as baseline category. CEE = Central Eastern Europe.

variables as specified in the data section. We first discuss the coefficients and turn to the standard deviations in the section below. Columns (1) to (3) show the absolute measures and columns (4) to (6) the relative measures of destination-specific ties. While all turn out to be statistically significant there are differences regarding the size of the coefficient. This finding is encouraging though as each variable approximates a different source of region-destination specific ties. It means that the availability of destination-specific ties is positively associated with the specific location choice an MNE has undertaken. For the absolute indicators the strongest predictor is the total number of immigrants in a region. This means that e.g. a larger number of Asians living in a region is positively associated with the amount of outward investment from that region to Asia - as compared to other destinations. Our findings confirm previous studies (Kugler and Rapoport, 2007; Javorcik et al., 2011; Gheasi et al., 2013), though none of these distinguishes total and relative concentration of immigrants or goes below the national level. One related study in the German context shows a similar association for inward migration and inward investment (Buch et al., 2006), while we complement their findings with novel evidence for outward investment as well. The coefficients for OFDI and IFDI are comparable in magnitude, with OFDI being a bit larger.

On the side of the relative measures, the concentration of outward investment (OFDI) appears to be the most important in economic terms. Intuitively this means that a relative concentration, e.g. in the number of MNEs that invest in North America is positively related to the propensity of proximate firms to also invest in North America. Interestingly, the relative concentration of inward investment by foreign MNEs in the home region of the German MNE appears to be less important. This supports the notion that a shared nationality between firms facilitates externalities, and as in Chapter 2 we could interpret this as evidence for cultural proximity in addition to spatial proximity. As highlighted by Javorcik et al. (2011) MNEs protect their firm-specific advantages and we speculate that foreign firms are either better in doing so or they are less embedded in local networks. Investments by foreign MNEs could also be driven by market-seeking objectives and hence they potentially engage less in local business networks. Finally, the coefficient for relative concentration of immigrants is also positive and highly

significant, and in between OFDI and IFDI in terms of magnitude.

Overall we need to exercise caution when interpreting these coefficients as causal. Especially the total measures in (1) to (3) are highly correlated among each other and hence, while we confirm an association there are potential issues of omitted variable bias. The absolute number is also going to be larger in urban areas and areas with a larger market. On the other hand, the relative measures are cleaner from a theoretical perspective as it is harder to think about why regions should be 'relatively' more connected to some places than others in terms of our variables if they are only large in economic terms. This is supported by the fact that the relative measures are not highly correlated.[17] When we include them in the same model in specification (1) of Table 3.5 the general pattern holds: For the directionality of outward investment, OFDI is more important than the concentration of immigrants than IFDI (ceteris paribus). It also holds when we do not include the interaction terms between firm size and destination dummies in (2). All in all, while the coefficient for OFDI is robust in size when compared to Table 3.4, the ones for IFDI and immigrants decreases. This again highlights the overwhelming importance of outward investment of proximate firms for location choices of German MNEs.

### 3.5.2 The importance of firm size in MNE location choices

The second halves of Table 3.4 and Table 3.5 report the non-random coefficients included in the model. As outlined in the methodology section we include interaction terms between firm size and a destination dummy. This can provide us with additional insights on what is potentially driving international location choices of firms as larger firms might find it easier to overcome larger level of uncertainty (Arauzo-Carod, Maria and Manjón-Antolín, 2004). We report a total of 7 interaction terms between firm size (measured as log total employment) and 7 destinations. The estimated coefficients have to be interpreted with reference to

[17] As all three destination-specific variables are computed at the level of destinations this makes a cross-tabulation infeasible in terms of presentation.

Table 3.5: Estimation results: Mixed Logit Model: Additional results

| | | (1) all MNEs | (2) all MNEs | (3) single MNEs | (4) multi MNEs |
|---|---|---|---|---|---|
| OFDI (relative) | b | 0.350*** | 0.347*** | 0.438*** | 0.349*** |
| | | (0.0614) | (0.0624) | (0.0650) | (0.0792) |
| | s | 0.130** | 0.124** | 0.148** | 0.138** |
| | | (0.0548) | (0.0566) | (0.0596) | (0.0553) |
| IFDI (relative) | b | 0.0597*** | 0.0622*** | 0.126*** | 0.00918 |
| | | (0.0231) | (0.0220) | (0.0478) | (0.0301) |
| | s | 0.000125 | 0.000101 | 0.000616 | -0.000162 |
| | | (0.000255) | (0.000266) | (0.000795) | (0.000565) |
| Immigrants (relative) | b | 0.114*** | 0.0985** | 0.186* | 0.0358 |
| | | (0.0431) | (0.0437) | (0.0957) | (0.0559) |
| | s | -0.00142 | -0.00197 | -0.000875 | -0.00262 |
| | | (0.00294) | (0.00420) | (0.00503) | (0.00333) |
| MNE experience | b | 0.0513 | -0.0517 | -0.137 | 0.272** |
| | | (0.0995) | (0.107) | (0.235) | (0.121) |
| | s | 0.00114 | 0.00391 | -0.0213 | 0.00715 |
| | | (0.00818) | (0.0159) | (0.112) | (0.00570) |
| Firm size * Africa | | 0.588*** | | | |
| | | (0.155) | | | |
| Firm size * Asia | | 0.349*** | | | |
| | | (0.0620) | | | |
| Firm size * CEE | | -0.0317 | | | |
| | | (0.0396) | | | |
| Firm size * Latin America | | 0.438*** | | | |
| | | (0.116) | | | |
| Firm size * Middle East | | 0.373 | | | |
| | | (0.237) | | | |
| Firm size * North America | | 0.370*** | | | |
| | | (0.0609) | | | |
| Firm size * Oceania | | 0.549*** | | | |
| | | (0.129) | | | |
| Destination dummies | | yes | yes | yes | yes |
| Log likelihood | | -2708.3 | -2747.1 | -1148.1 | -1431.8 |
| Cases | | 2,201 | 2,201 | 1,298 | 903 |
| Observations | | 17,608 | 17,608 | 10,384 | 7,224 |

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors in parentheses clustered at employment area level. 'Western Europe' used as baseline category. CEE = Central Eastern Europe.

the baseline category, which is 'Western Europe' in our case. Table 3.4 reports our main variables of interest separately and a few interesting patterns emerge. When compared to the baseline category, MNEs that invest in Africa, Latin America and Oceania seem to be larger than those investing in Western Europe. A one percentage point increase in firm size increases the probability of choosing one of these destinations by around 0.5 percentage points. Here we need to keep in mind that location choices not mutually-exclusive as large firms typically invest in multiple destinations. This pattern also holds for Asia, North America and the Middle East, however the coefficients are in the range of 0.35 percentage points and the coefficients for Middle East is only weakly statistically significant.

The assumption that Africa, Latin America and Oceania are more distant and dissimilar to Western Europe would confirm such a finding from a theoretical point of view as outlined in the conceptual framework. Studies have shown that more dissimilar markets require more support for firms to expand there (Harding and Javorcik, 2011; Gil-Pareja et al., 2015). North America and Asia can be seen as more familiar to German MNEs, hence the firms investing there do not need the same size to overcome potential barriers and break into these markets. This line of argumentation is further supported by the fact that the interaction terms for firm size and Central Eastern Europe are not significant. We explain this by the geographical and institutional similarity between Western and Eastern Europe and that the European Union includes countries of both macro groups. Hence firm size is not a significant driver for investments in CEE. Looking at column (1) of Table 3.5 shows that this finding also holds when including all three relative measures of destination-ties simultaneously.

### 3.5.3 MNEs have heterogeneous preferences in their location choices abroad

As outlined in the methodology section the main advantage of using a MXL model is that it allows for heterogenous preferences of firms among the alternatives. Firms can have individual preferences for some foreign destinations and react differently to destination-specific factors. Since our proxies for destination-ties

are estimated as random coefficients we allow for the fact that some firms might not rely on them at all. In Table 3.4 we show that some estimated standard deviations for the randomly-varying parameters are in fact statistically significant. This confirms the notion that destination-specific ties are more relevant for some German MNEs than for others. A non-random coefficients model would have violated the IIA condition and failed to capture this finding.[18]

Regarding total OFDI in the home region of a German MNE presented in column (1) we can calculate that for 68.1% of MNE the estimated coefficient is larger than zero.[19] This means that for two thirds of MNEs the experiences of other MNEs in the same home region matter for choosing a foreign destination for their investments. The flip-side is that for the rest of the MNEs the parameter is below zero, meaning they seem to avoid destinations that are relatively more targeted by other German MNEs from their home region. The share of MNEs with a positive coefficient is higher for total measures of IFDI (83.2%) and immigrants (91.8%). Interestingly the relative measure of OFDI is not only the most relevant in economic terms as reported above but also relevant for almost all MNEs (99.5%). This finding again holds when including all three relative measures simultaneously in Table 3.5.

Another source of heterogeneity in our sample is whether MNEs are single-destination (and possibly first-time investors) or multi-destination MNEs. We split our sample into single- and multi-destination MNEs and report the results in columns (3) and (4) of Table 3.5. It turns out that German MNEs that only own subsidiaries in a single foreign destination have a stronger correlation with the relative proxies for destination-specific ties. This is in line with the

[18] In fact, when we estimate a conditional logit model (CLM) with the same set of variables, total OFDI is rendered insignificant. This can be explained by the relatively large estimated standard deviation in relation to the size of the coefficient reported in column (1) of Table 3.4, and thus large heterogeneity across firms. Results for the CLM are presented in Table 3.10 of Appendix 3.A.2.

[19] We obtain the share of MNEs with a positive coefficient by looking at the standard normal table. To calculate the (positive) z-score we divide a significant beta coefficient by its estimated standard deviation. In this case b = 0.233 and s = 0.499 and the corresponding z-score = 0.47.

finding by Silvente and Giménez (2007) who also report a larger coefficient for single-destination Spanish firms. Investments by MNEs that own subsidiaries in two or more destinations seem positively associated with OFDI only, while the coefficients for inward investment and immigrants are not statistically significant. We explain this finding by more significant information asymmetries and barriers to internationalisation faced by single-destination investors. Hence those firms have a larger need to rely on pre-existing destination-specific ties to overcome those. We need to note here that regressions (3) and (4) do not include the interaction terms between firm size and destination dummies. However, comparing columns (1) and (2) shows that the main coefficients of interest do not vary significantly when we exclude the interaction terms. Our underlying reason for excluding them is that MNEs investing in multiple destinations are already larger on average.[20]

A final source of heterogeneity across firms is the level of intra-business group experience in specific destinations. All models in our empirical analysis include the random coefficient 'MNE experience' to control for this. A similar variable is included by Basile et al. (2008) in a study of MNE subsidiary locations in Europe, though in our case we do not find this variable to be significant. The only exceptions are found when we split the sample into single- and multi-destination investors in columns (3) and (4) of Table 3.5. A tentative explanation we can offer is that only once a firm is established as a multi-location MNE it can fully appropriate firm-internal knowledge on foreign destinations.[21] The overall insignificance of this variable in our study can result from the fact that we rely on relatively broad country groups as destinations. It does not compromise the findings of Basile et al. (2008) as they rely on country-level data for MNE destination alternatives. If anything it enhances the significance of MNE group experience being most valuable when it is very specific.

[20] While the 1,298 single-destination MNEs have an average size of 218 employees, the comparable figure for the 363 multi-destination MNEs is 554 employees.

[21] Note that around 40% of multi-destination MNEs are part of a corporate group. This is a comparable figure to single-destination MNEs at 41%. Hence different rates between these groups cannot drive the probability of investing in multiple destinations.

## 3.6 Conclusion

The literatures on international trade and international business have a long tradition in explaining the heterogeneity of firms and their investment abroad. We conceptually integrate those with economic geography to provide new insights on how destination-specific ties at the regional level are associated with the directionality of foreign expansions by German MNEs. Our conceptual starting point is that firms face information asymmetries and uncertainty when choosing where to locate abroad. Here we put forward the idea that the home region of a firm has specific ties with foreign destinations that are relatively stronger for some destinations. These can be leveraged by some MNEs and hence alleviate the asymmetry towards some foreign destinations. By reviewing related studies on foreign expansions of firms and localised externalities we have demonstrated that particularly the proximity to other MNEs as well as migrants can be used to empirically approximate destination-specific ties.

Location choices of firms are commonly analysed in a choice-model setting and we opted for the mixed logit model, as it can deal with heterogenous preferences across firms (Defever, 2006; Basile et al., 2008; Cheng, 2008; Ascani et al., 2016). We estimate the propensity of 2,201 location choices against a set of 8 alternative destination choices. Our variables of interest are computed as the strength of ties between the home region of a firm and each potential destination. The regional level in Germany are the 258 employment areas to capture the underlying economic structure and we distinguish the absolute as well as relative strength of ties.

Our findings reveal that destination-specific ties between the home region of a firm and foreign destinations are indeed positively associated with the directionality of outward investment. Since we base our analysis on a cross-section (as most studies in the location choice literature) this can be seen as original evidence for the long-term connection of subnational regions and foreign destinations. Comparing the economic importance of different measures it appears that especially the proximity to German MNEs with destination-specific investments matters. This is followed by the concentration of immigrants from a specific foreign country group, while the concentration of inward investment appears less important. This

echoes findings from Chapter 2 as inward investors potentially prevent knowledge outflows to protect their advantages and they are potentially less locally embedded in economic structures. Our findings regarding immigrants echo earlier studies (Kugler and Rapoport, 2007; Javorcik et al., 2011; Gheasi et al., 2013) though we add to them as we can show that spatial proximity and a relative concentration at the sub-national level matter.

The second set of findings concerns the heterogeneity of firms in their propensity to rely on destination-specific ties and choose certain foreign destinations. We first exploit the properties of the MXL to show that there is case-specific variation in the data and firms do have heterogeneous preferences. Second, we confirm earlier studies as especially single-destination and potential first-time investors rely on destination-specific ties as they face higher information asymmetries than multi-destination investors (Silvente and Giménez, 2007). Third, our study does not corroborate earlier findings of within-business group experience for location choices of German MNEs (Blonigen et al., 2005; Basile et al., 2008). Finally, we follow Brownstone and Train (1999) and import existing choice-setting methods to the location choice of firms by interacting case-sensitive variables with destination dummies. This furthermore highlights that larger firms appear to be able to invest in more distant destinations. We speculate that uncertainty in these markets is higher and only larger firms have the resources to overcome them (Arauzo-Carod, Maria and Manjón-Antolín, 2004).

Beyond the firm-level literature our study is also relevant for understanding the long-term sources of regional disparities between places. By showing that regions have ties with foreign destinations that can be leveraged by expanding firms this means that the absence of such can add to the path-dependency in regional development that is endogenous to regions (Martin and Sunley, 1998). Here our study also connects to the concept of global pipelines where linkages to location outside of the region are crucial for firms and economic development (Bathelt et al., 2004; Crescenzi and Iammarino, 2017). Studies have shown that MNEs have different levels of embeddedness in local innovation systems and roles in sourcing external knowledge (Kramer and Revilla-Diez, 2012). Future work could also directly connect our measures of ties with measure for economic development

in a region- rather than firm-level study.

### *Limitations and future research*

The present study has provided some original insights, but a number of limitations need to be highlighted that can serve as starting points for future research. While we have shown that destination-specific ties are associated with location choices of German MNEs we do not claim causality here. We are aware that the actual investment location choice is usually conducted by individuals inside the MNE. Since we can only associate this decision with observable factors at the firm- and regional-level the firm itself remains a 'black box'. Nevertheless the association between region-destination-specific ties and the directionality of outward investment remains. It is reinforced by a conceptualisation that allows for various different proxies that have been shown to be significant empirically. Also the application of a random-coefficients model alleviates the concerns of firm heterogeneity, as does the inclusion of firm size. Nevertheless future studies should consider taking a dynamic approach to better control for firm-specific factors.

Second, internationalising firms can choose among different entry modes to a foreign market. Since we place the focus on investment abroad we do not explicitly control for other entry modes such as exports or joint ventures. It is possible that MNEs make choices among entry modes depending on the availability of ties. However, since we only have MNEs in our sample this is potentially a secondary concern. Basile et al. (2008) argue that any changes in the profitability of certain entry modes are likely to affect all MNEs in a similar way rather than altering the odds ratios between different destinations.

Third, we did not address the 'quality' of these ties. In fact it is likely that proximity to some MNEs matters more than others, for example some might be more open and engaged in supplier-buyer networks (Markusen and Venables, 1999; Head and Mayer, 2004) while others are not. This is also underlined in the proximity to migrants as their skill level matters (Kugler and Rapoport, 2007; Javorcik et al., 2011; Gheasi et al., 2013). Finally, we do not account for multiple or repeated investment by firms in the same destination, or firm investments

in multiple destinations. This is due to the nature of our data and choice of empirical model. Nevertheless we do control for business-group experience and show that the association holds across single- and multi-destination investors. Future studies could increase the number of foreign destinations to increase the number of destinations by firm. However, we have shown that there is a trade-off in terms of regional variation in the home country that makes a full set of all countries infeasible.

Fourth, the chapter has one additional limitation as the foreign destinations are grouped into 8 macro destinations. The reasoning is that else there would be too little variation of destination-specific ties at the regional level in Germany, which is what we are interested in.[22] There is little we can do about this in empirical terms, it should be kept in mind for the interpretation, as the ties between regions and destinations are not country-specific. Similar aggregations are also common in other studies in location decisions of MNEs (Buch et al., 2006; Koenig, 2009). To further increase the robustness of the results we follow previous studies and control for the destination-specific experience at the business group level (Henisz and Delios, 2001; Blonigen et al., 2005; Basile et al., 2008).

[22] For the same reason we cannot control for sector-specific ties.

# 3.A Appendix

## 3.A.1 Additional details on the data

Data on subsidiaries located abroad and in Germany were extracted from BvD ORBIS in May 2016. As discussed we apply a number of search criteria to include only 'active' firms that are located in Germany and have a German global ultimate owner (GUO). As the same we exclude firms that are not MNEs in the sense that they do not own a subsidiary outside of Germany. Table 3.6 below keeps track of the extracted sample and average firm size, as we go through the details of the data cleaning process to get our regression sample.

Table 3.6: Sample restrictions for German MNEs

| Sample restriction | No. of Firms | Firm size (mean) | Firm size (median) |
|---|---|---|---|
| Extracted sample | 2,179 | 240 | 98 |
| Non-missing domestic location | 2,171 | 240 | 98 |
| Min. foreign ownership | 2,016 | 248 | 101 |
| Unconsolidated accounts | 2,004 | 249 | 101 |
| Active | 1,943 | 253 | 102 |
| Min. 10 employees | 1,661 | 291 | 123 |

Starting with the extracted sample the average firm size is 240 employees. We then exclude firms with a missing location in Germany and apply that firms own minimum 50% of the foreign subsidiary. As stated in the main text, we restrict our analysis to firms for which BvD reports unconsolidated accounts Peri and Urban (2006); Temouri et al. (2010); Chen and Moore (2010); Ferragina and Mazzotta (2013). This leaves 2,004 MNEs in the sample with an average size of 253 employees. In the final two steps we only keep active firms and those with non-missing employment figures (minimum of 10 employees). Active means that the firm is not insolvent or currently undergoing insolvency proceedings. Our final sample includes 1,661 MNEs with an average size of 291 employees and median size of 123 employees. This also shows that the sample includes a number of very large firms. As some of these MNEs own subsidiaries in multiple destinations we end up with 2,201 unique firm-destination combinations that form the basis of

our choice model setting.

The issue of using 'unconsolidated' vs 'consolidated' accounts deserves some further scrutiny as it influences the selection of our sample. Generally speaking there are various reasons why some firms will publish consolidated accounts. These are mostly related to national laws, rules of the stock exchange, regulations on financial accounting, or other contractual agreements a firm might have. In Germany the requirements to file consolidated accounts are regulated in §290 of the German Commercial Code ("Handelsgesetzbuch - HGB"). In general all firms that have a controlling stake in a subsidiary have to file these accounts, however there are exceptions based on size of the firm (outlined in HGB §293, section 1). If the two of the three following conditions are met on day of filing the accounts a firm can choose not to file consolidated accounts: 1. consolidated balance sheet total below 24 million euro; 2. consolidated annual turnover below 48 million euro; and 3. consolidated number of employees below 250. None of these exceptions apply if the firm is a listed company (outlined in HGB §293, section 5). For our sample this means that larger firms that do not fall into these categories will not be included. However, there are further exceptions when a firm is a non-incorporated firm or partnership ("Personengesellschaft") and two of the three following conditions are met on day of filing the accounts: 1. consolidated balance sheet total below 65 million euro; consolidated turnover below 130 million euro; and consolidated employment below 5,000. Finally, since BvD collects the data through various sources there can be other reasons why our sample does also include firms that are larger than the minimum requirements to get an exemption.

### 3.A.2 Additional tables and figures

Table 3.7: Countries included in 8 country group destinations

| |
|---|
| Western Europe |
| Switzerland, Netherlands, United Kingdom, France, Austria, Belgium, Italy, Sweden, Denmark, Spain, Ireland, Finland, Norway, Portugal, Greece, Luxembourg. |
| Central-Eastern Europe |
| Turkey, Poland, Hungary, Macedonia, Malta, Bosnia and Herzegovina, Serbia, Romania, Bulgaria, Romania, Lithuania, Latvia, Estonia, Belarus, Albania, Cyprus, Croatia, Montenegro, Slovakia, Slovenia, Ukraine, Czech Republic, Georgia. |
| North America |
| Canada, USA |
| Latin America |
| Mexico, Brazil, Panama, Uruguay, Chile, Belize, Argentina, Ecuador, Colombia, Dominican Republic, Paraguay, Peru, Bolivia, Venezuela |
| Asia |
| China, Russia, India, Hong Kong, South Korea, Taiwan, Singapore, Malaysia, Thailand, Azerbaijan, Indonesia, Philippines, Vietnam, Japan, Kazakhstan, Sri Lanka, Pakistan, Bangladesh, Brunei, Macau, Uzbekistan |
| Africa |
| South Africa, Mauritius, Liberia, Nigeria, Kenya, Rwanda, Tanzania, Botswana, Morocco, Burkina Faso, Algeria, Egypt |
| Middle East |
| Israel, UAE, Saudi Arabia, Iran, Kuwait, Qatar, Lebanon, Bahrain, Jordan, Oman, Tunisia, Armenia. |
| Oceania |
| Australia, New Zealand |

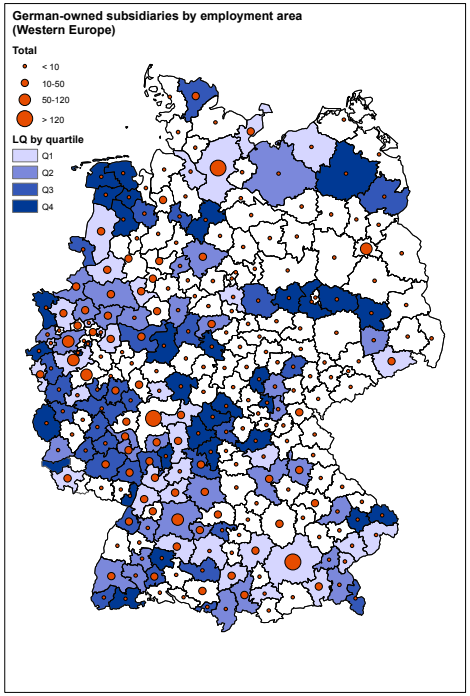
Table 3.8: Average level of destination-specific ties at regional level

| | count | mean | sd | min | max |
|---|---|---|---|---|---|
| OFDI to EU | 231 | 11.39 | 26.87 | 0.00 | 287.00 |
| OFDI to CE | 231 | 6.44 | 12.23 | 0.00 | 107.00 |
| OFDI to NA | 231 | 1.11 | 3.49 | 0.00 | 37.00 |
| OFDI to LA | 231 | 0.59 | 2.17 | 0.00 | 17.00 |
| OFDI to AF | 231 | 0.17 | 0.98 | 0.00 | 12.00 |
| OFDI to AS | 231 | 2.49 | 15.19 | 0.00 | 220.00 |
| OFDI to ME | 231 | 0.18 | 0.92 | 0.00 | 9.00 |
| OFDI to OC | 231 | 0.32 | 1.08 | 0.00 | 11.00 |
| IFDI from EU | 231 | 101.10 | 294.49 | 1.00 | 2344.00 |
| IFDI from CE | 231 | 20.96 | 78.70 | 0.00 | 829.00 |
| IFDI from NA | 231 | 12.86 | 52.31 | 0.00 | 510.00 |
| IFDI from LA | 231 | 0.65 | 2.57 | 0.00 | 27.00 |
| IFDI from AF | 231 | 0.61 | 2.19 | 0.00 | 20.00 |
| IFDI from AS | 231 | 16.13 | 70.79 | 0.00 | 740.00 |
| IFDI from ME | 231 | 3.92 | 17.08 | 0.00 | 174.00 |
| IFDI from OC | 231 | 0.72 | 2.74 | 0.00 | 24.00 |
| Immigrants from EU | 231 | 8041.87 | 18338.31 | 0.00 | 156898.00 |
| Immigrants from CE | 231 | 17980.37 | 36002.68 | 0.00 | 252947.00 |
| Immigrants from NA | 231 | 528.99 | 1632.64 | 0.00 | 18215.00 |
| Immigrants from LA | 231 | 439.68 | 1213.55 | 0.00 | 11308.00 |
| Immigrants from AS | 231 | 2527.09 | 5967.31 | 0.00 | 53103.00 |
| Immigrants from AF | 231 | 825.52 | 2102.19 | 0.00 | 17242.00 |
| Immigrants from ME | 231 | 1812.97 | 4020.75 | 0.00 | 31743.00 |
| Immigrants from OC | 231 | 58.39 | 242.54 | 0.00 | 2997.00 |

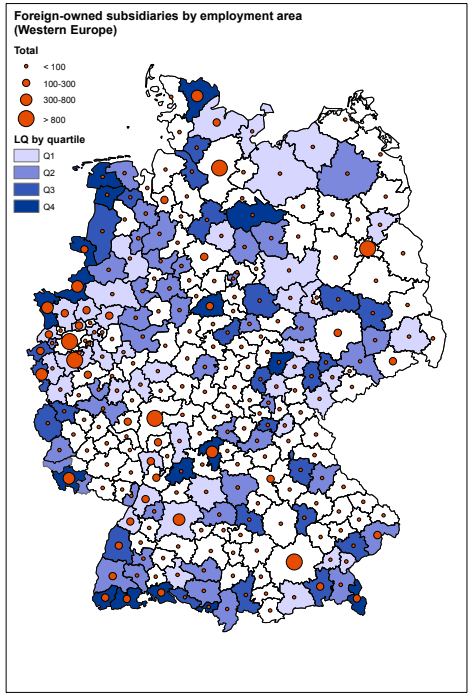
Table 3.9: Average level of destination-specific ties at firm level

| | count | mean | sd | min | max |
|---|---|---|---|---|---|
| OFDI to EU | 1,675 | 52.77 | 77.40 | 0.00 | 288.00 |
| OFDI to CE | 1,675 | 25.37 | 32.22 | 0.00 | 107.00 |
| OFDI to NA | 1,675 | 5.66 | 9.66 | 0.00 | 37.00 |
| OFDI to LA | 1,675 | 2.95 | 5.21 | 0.00 | 17.00 |
| OFDI to AF | 1,675 | 1.36 | 3.07 | 0.00 | 12.00 |
| OFDI to AS | 1,675 | 14.87 | 41.56 | 0.00 | 220.00 |
| OFDI to ME | 1,675 | 1.07 | 2.54 | 0.00 | 9.00 |
| OFDI to OC | 1,675 | 1.66 | 2.99 | 0.00 | 11.00 |
| IFDI from EU | 1,675 | 495.35 | 764.07 | 1.00 | 2344.00 |
| IFDI from CE | 1,675 | 113.59 | 208.46 | 0.00 | 829.00 |
| IFDI from NA | 1,675 | 81.44 | 149.08 | 0.00 | 510.00 |
| IFDI from LA | 1,675 | 4.07 | 7.21 | 0.00 | 27.00 |
| IFDI from AF | 1,675 | 3.53 | 6.24 | 0.00 | 20.00 |
| IFDI from AS | 1,675 | 95.12 | 179.47 | 0.00 | 740.00 |
| IFDI from ME | 1,675 | 23.90 | 42.92 | 0.00 | 174.00 |
| IFDI from OC | 1,675 | 4.11 | 7.32 | 0.00 | 24.00 |
| Immigrants from EU | 1,675 | 35090.56 | 47900.83 | 0.00 | 156898.00 |
| Immigrants from CE | 1,675 | 70126.52 | 84507.04 | 0.00 | 252947.00 |
| Immigrants from NA | 1,675 | 2540.71 | 4063.74 | 0.00 | 18215.00 |
| Immigrants from LA | 1,675 | 2146.69 | 3109.98 | 0.00 | 11308.00 |
| Immigrants from AS | 1,675 | 10755.25 | 14433.11 | 0.00 | 53103.00 |
| Immigrants from AF | 1,675 | 3497.83 | 4717.15 | 0.00 | 17242.00 |
| Immigrants from ME | 1,675 | 7471.12 | 10147.07 | 0.00 | 31743.00 |
| Immigrants from OC | 1,675 | 337.60 | 618.48 | 0.00 | 2997.00 |

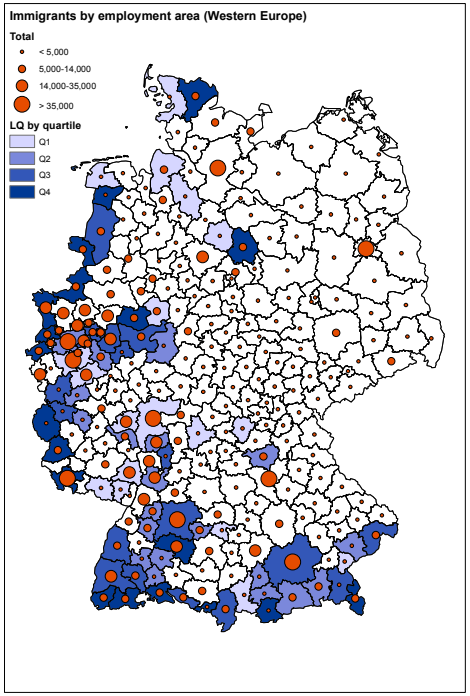
Figure 3.2: Map of destination-specific knowledge in German regions: Western Europe




(a) OFDI

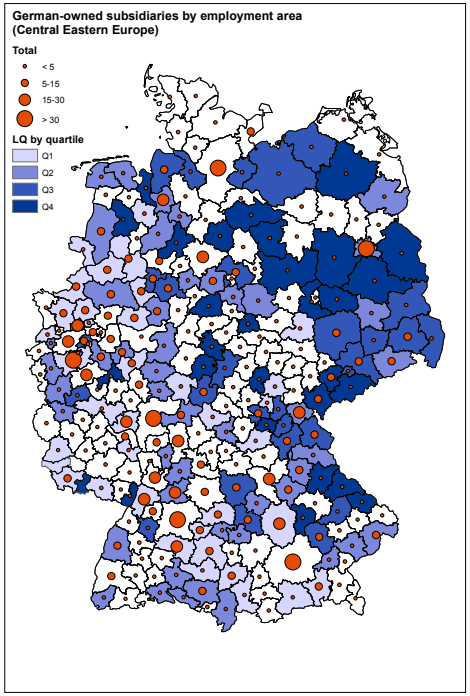



(b) IFDI

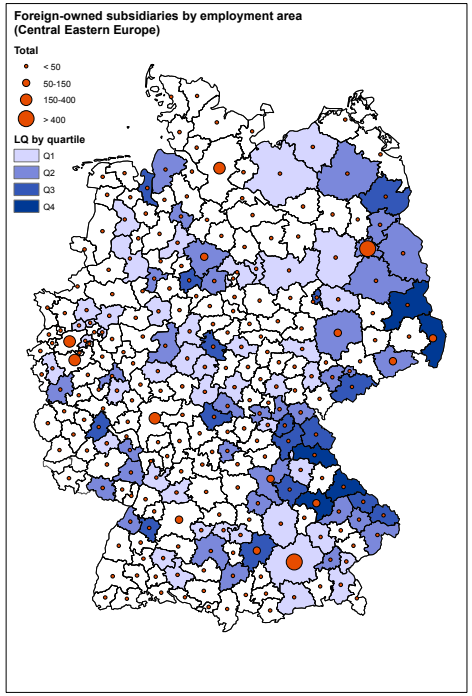



(c) Immigration

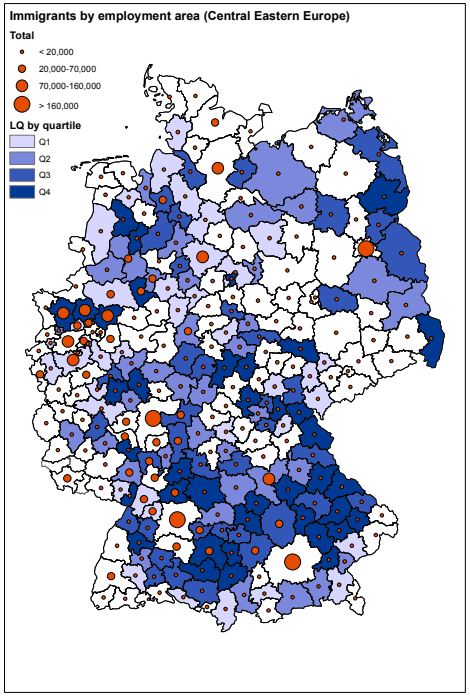
Figure 3.3: Map of destination-specific knowledge in German regions: Central-Eastern Europe




(a) OFDI

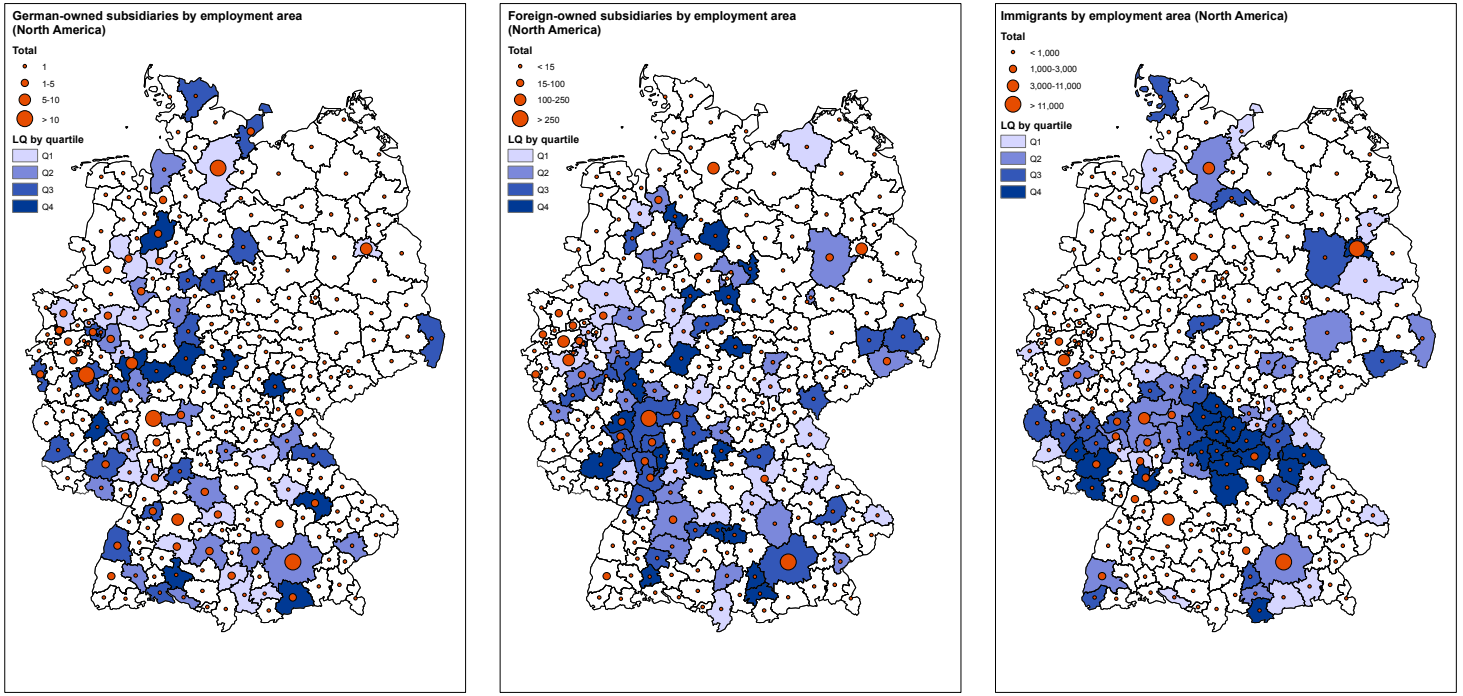



(b) IFDI



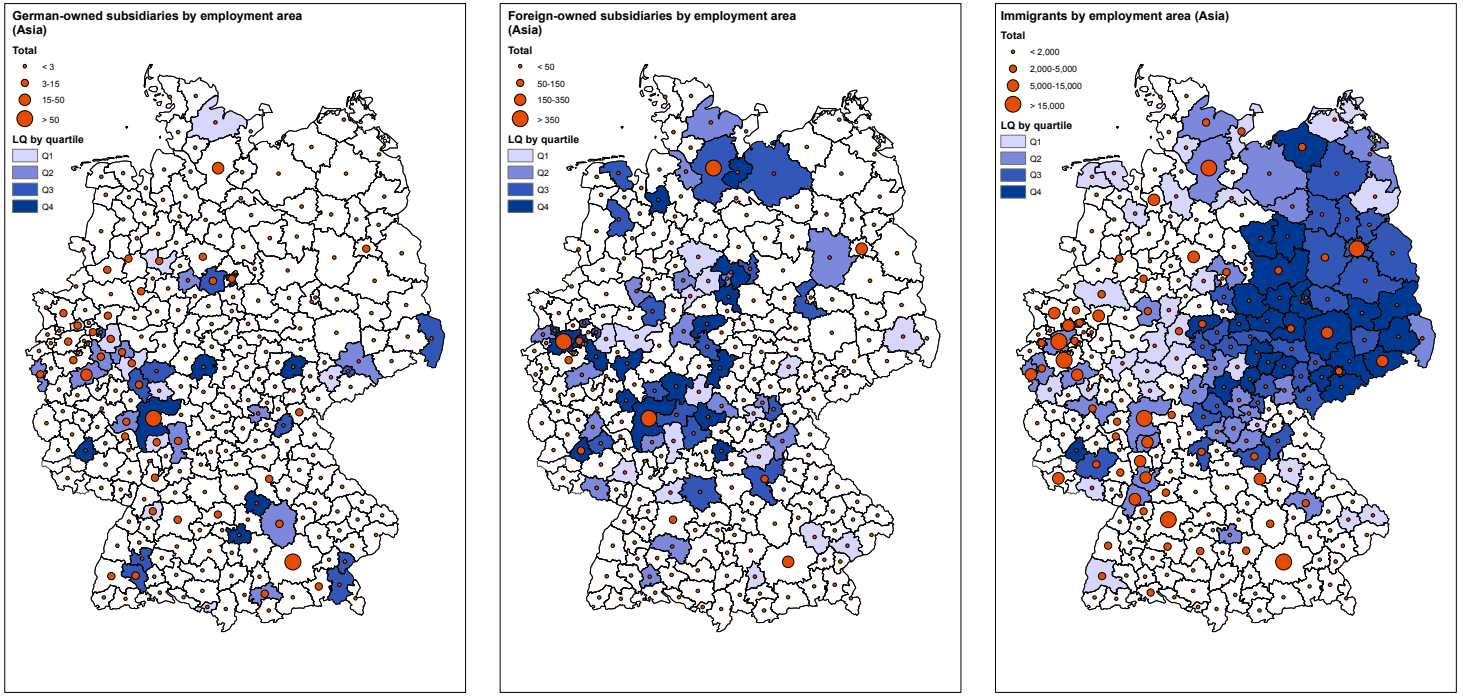

(c) Immigration

Figure 3.4: Map of destination-specific knowledge in German regions: North America




(a) OFDI (b) IFDI (c) Immigration

Figure 3.5: Map of destination-specific knowledge in German regions: Asia




(a) OFDI (b) IFDI (c) Immigration

Table 3.10: Additional results: Conditional Logit Model (CLM)

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| OFDI (log total) | 0.0531 | | | | | |
| | (0.0594) | | | | | |
| IFDI (log total) | | 0.140*** | | | | |
| | | (0.0537) | | | | |
| Immigrants (log total) | | | 0.260*** | | | |
| | | | (0.0629) | | | |
| OFDI (relative) | | | | 0.291*** | | |
| | | | | (0.0420) | | |
| IFDI (relative) | | | | | 0.0816*** | |
| | | | | | (0.0206) | |
| Immigrants (relative) | | | | | | 0.226*** |
| | | | | | | (0.0457) |
| MNE experience | 0.0426 | 0.0500 | 0.0576 | 0.0224 | 0.0482 | 0.0575 |
| | (0.107) | (0.107) | (0.107) | (0.101) | (0.108) | (0.107) |
| Firm size * Africa | 0.498*** | 0.492*** | 0.494*** | 0.549*** | 0.497*** | 0.492*** |
| | (0.123) | (0.122) | (0.123) | (0.133) | (0.125) | (0.122) |
| Firm size * Asia | 0.352*** | 0.353*** | 0.356*** | 0.339*** | 0.353*** | 0.355*** |
| | (0.0594) | (0.0596) | (0.0599) | (0.0583) | (0.0596) | (0.0601) |
| Firm size * CEE | -0.0241 | -0.0269 | -0.0268 | -0.0271 | -0.0261 | -0.0266 |
| | (0.0387) | (0.0378) | (0.0390) | (0.0389) | (0.0381) | (0.0389) |
| Firm size * Latin America | 0.524*** | 0.524*** | 0.530*** | 0.396*** | 0.530*** | 0.527*** |
| | (0.101) | (0.103) | (0.103) | (0.130) | (0.103) | (0.102) |
| Firm size * Middle East | 0.317* | 0.306* | 0.320* | 0.364 | 0.300* | 0.319* |
| | (0.183) | (0.175) | (0.179) | (0.225) | (0.169) | (0.180) |
| Firm size * North America | 0.368*** | 0.367*** | 0.369*** | 0.363*** | 0.367*** | 0.368*** |
| | (0.0586) | (0.0586) | (0.0574) | (0.0590) | (0.0585) | (0.0580) |
| Firm size * Oceania | 0.552*** | 0.546*** | 0.569*** | 0.563*** | 0.543*** | 0.556*** |
| | (0.113) | (0.111) | (0.116) | (0.130) | (0.113) | (0.111) |
| Destination dummies | yes | yes | yes | yes | yes | yes |
| Log likelihood | -2859.3 | -2855.4 | -2852.2 | -2721.8 | -2855.4 | -2852.8 |
| Cases | 2201 | 2201 | 2201 | 2201 | 2201 | 2201 |
| Observations | 17608 | 17608 | 17608 | 17608 | 17608 | 17608 |

Notes: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$; Standard errors in parentheses clustered at employment area level. 'Western Europe' used as baseline category. CEE = Central Eastern Europe.

### 3.A.3 Random vs. non-random coefficients logit model

Firms choosing the location for subsidiaries abroad can choose among many alternative destinations. One way to model this is using a multinomial model that can account for various alternative choices. The standard form in the literature is a Conditional Logit Model (CLM), which only accounts for alternative-specific variables (e.g. GDP of foreign destination). The advantage of this type of model is that the estimated coefficients are relatively easy to interpret. However it cannot account for case-specific factors (e.g. firm size or productivity). The Multinomial Logit Model (MLM) on the other hand can account for these case-specific, but alternative-invariant factors. Thus it is possible to estimate the impact of firm-specific variables varying by alternative. However, here the main drawback is that the coefficients need to be interpreted with direct reference to the base category and that it precludes the inclusion of alternative-specific regressors. A model that allows for alternative- and case-specific factors is the Alternative-Specific Conditional Logit Model.[23] As in our modification of the Mixed Logit Model (MXL) it relies on interaction terms between case-specific variables and alternative-specific indicator dummies to generate variation across alternatives as required by the CLM. Sometimes this is also referred to as a 'mixed logit model', though we prefer to use this term for the Random Coefficients Logit Model as used in this study (Cameron and Trivedi, 2005). The key limitation of these types of models is that they cannot account for random, unobserved factors that make a priori similar firms take different location decisions. This is also referred to as 'independence of irrelevant alternatives' (IIA), which is a condition that is violated in the CLM and MLM, but also Nested Logit Models within the different nests. The key problem for our study is thus that firms are assumed to have the same (unobserved) preferences when choosing among alternatives. Hence we rely on a random coefficients model that can overcome this limitation, the MXL.

[23] See *asclogit* in Stata.

# Chapter 4

# Domestic and Foreign Spatial Patterns of Industry Sectors: Exploring Global Locations of German MNEs

## 4.1 Introduction

The global reorganisation of value chains has profound impacts on the spatial organisation of firms and the structure of their respective industry sectors (Helpman, 2006; Los et al., 2015). In addition, organising input-output linkages across borders is a complex process that is highly heterogeneous across sectors. It depends on balancing the costs of production in a place with the benefits of locating in proximity with other firms in the same or other sectors (Baldwin and Venables, 2013). Also the adoption of modern technology to coordinate across space plays a key role (Baldwin and Evenett, 2015; Brakman et al., 2015). In other words, there is a trade-off between exploiting agglomeration economies such as increasing returns and the level of transaction costs as determined by proximity to the market. While the spatial pattern of industry sectors has been explored in detail within individual countries, the global spatial pattern in relation to the domestic one

remains understudied, though both are directly interlinked. We choose the case of Germany, a country that is highly competitive especially in manufacturing, with established trade and investment relations in all parts of the world. Beyond direct implications for strategic considerations at the level of the firm this is a highly relevant study as the geography of economic activity is directly related to regional economic development. Here we also relate our findings to recent discussions on offshoring of production facilities and implications for local labour markets (Marin, 2004; Sinn, 2006; Buch et al., 2007; Bade et al., 2015).

Regarding the literature, this chapter pulls together studies on the agglomeration behaviour of sectors and studies on the global location patterns of firms. Theoretical arguments on the agglomeration of economic activity date back to Marshall (1890) who highlighted the importance of knowledge spillovers, shared labour pools, and supplier-buyer relationships. The empirical literature has lately caught up due to the availability of better data, as well as measurement and computing techniques. Duranton and Overman (2005) - hereafter DO - developed the influential K-density measure to analyse the concentration of sectors based on a continuous understanding of space. Hereby they can overcome the bias in previous studies that relied on discrete spatial unites (Openshaw and Taylor, 1979; Arbia et al., 2008; Briant et al., 2010). K-densities have been applied in an increasing number of studies to scrutinise the domestic concentration patterns of sectors (Ellison et al., 2010; Nakajima et al., 2012; Vitali et al., 2013; Barlet et al., 2013; Behrens and Bougna, 2015; Brakman et al., 2017). For the analysis of global location decisions of firms we relate to studies in management science and international strategy. Most importantly, in this literature firms are assumed to make location decisions while accounting for their competitors' choices (Alcácer et al., 2013, 2015). As a result foreign subsidiaries are often found to co-locate by sector and nationality (Smith and Florida, 1994; Head et al., 1995; Crozet et al., 2004; Blonigen et al., 2005), while some firms prefer to locate away from their peers (Alcácer and Chung, 2007; Mariotti et al., 2010).

However, the empirical literature on sector agglomeration and global location decisions of multinational enterprises (MNEs) have not been integrated. The only notable exception is Alfaro and Chen (2014) who analyse the location

decisions of MNEs with respect to the geography of domestic firms. This literature gap is somewhat surprising, as there is a large potential for both literature strands to mutually-benefit from each other. Regarding this connection between agglomeration studies and MNEs, Duranton and Kerr (2015, p.14) state that *"the natural starting point here is richer work with multi-national firms and the operations of their many establishments"*. Similarly, Alcácer and Zhao (2016) advocate for the use of geocoded establishment-level data in cross-country settings as the concentration of economic activity takes many different forms and shapes. This is where our study aims to contribute as we look at the global location pattern of German-owned establishments and directly compare it to their domestic geography.

Our empirical analysis is based on detailed firm-level data from ORBIS provided by Bureau van Dijk. We use Google Maps to retrieve the exact geocode for around 220,000 German-owned manufacturing establishments in 2015.[1] We use the K-density measure to compute concentration patterns of 4-digit manufacturing sectors in Germany and globally. After describing the spatial pattern of sectors at home and abroad we integrate both and explore sector heterogeneity based on sector characteristics coming from the German Federal Statistical Office. By exploring the sector geography in Germany we complement a few existing studies (Vitali et al., 2013; Koh and Riedel, 2014; Bade et al., 2015), while an analysis of detailed global concentration patterns is largely novel. Our findings show that low and medium-low technology sectors have a much higher level of spatial concentration at the global level. We hypothesise that this can be explained by a lack of experience in international markets and thus higher uncertainty, as well as a lower diffusion of technology to organise complex production processes across space. However it can also suggest a more recent expansion, which is connected to outsourcing going along with European integration (Marin, 2004, 2006; Combes and Overman, 2004; Becker et al., 2005; Los et al., 2015; Ascani et al., 2016). In

[1] Note that the use of ORBIS for economic geography studies has increased recently (Temouri et al., 2010; Redding et al., 2011; Vitali et al., 2013; Driffield et al., 2016; Wójcik et al., 2017), while the dataset also forms the basis for the World Investment Report (UNCTAD, 2017).

line with Bade et al. (2015), stylised findings support the notion that domestically more concentrated sectors (and further concentrating) have experienced a decline in domestic employment.

While our study is the first to directly compare the domestic and global spatial pattern of sectors based on locations of German MNEs it is limited to manufacturing sectors only. Our reasoning is that service sectors have a fundamentally different geography, while we are aware that they constitute the major part of most developed economies. Nevertheless, we highlight in section 4.3 that manufacturing is key to German competitiveness. Its geography is also shown to be of high interest in other contexts such as the UK and US, with important implications for regional resilience and development (Moretti, 2013; Storper, 2013; Bryson et al., 2013; Christopherson et al., 2014; Martin et al., 2016). Hence we think that some of the insights can be transferred to other countries with globally active manufacturing MNEs. We also note that around 80% of German manufacturing firms offer services as well (European Commission, 2016), which are included in our analysis as long as they are co-located in manufacturing establishments.

The structure of the chapter is as follows. In the next section we review related studies on agglomeration of industries and global location patterns of MNEs. Section 3 discusses the international competitiveness of German manufacturing including some descriptive data. Our empirical methods based on spatial concentration indices are described and discussed in Section 4 and the empirical results follow in Section 5. We conclude with Section 6, highlighting some implications for future research.

## 4.2 Literature

We organise the review of the relevant literatures in two parts. First we summarise major empirical studies analysing agglomeration patterns of industries based on continuous spatial indicators. Second we provide an overview of relevant studies that explore the spatial pattern of MNEs outside of their home country. In doing so we also outline the research gap we aim to fill as both strands have not been integrated in their conceptual and methodological approaches.

### 4.2.1 The agglomeration of industry sectors

The concentration of sectors has a longstanding history of being the subject of theoretical and empirical studies and it is a central research theme in economics. While there are almost as many differentiated research questions as publications, there are two main themes that make this a relevant area of research. First, spatial concentration has implications on firms (and workers) due to agglomeration economies (knowledge spillovers, labour turnover, supplier-buyer linkages) and related congestion costs (rising factor costs, pollution). At the same time the concentration of sectors also has profound implications for regional economic development. These themes have been reviewed and summarised by various prominent scholars (Martin, 1999; Rosenthal and Strange, 2001; Fujita and Thisse, 2002; Henderson and Thisse, 2004).[2]

On the empirical frontier the seminal study by Duranton and Overman (2002, 2005) sparked a line of research using the K-density measure to analyse the concentration of industry sectors. The original analysis was conducted on the UK and the authors found that 52% of 234 manufacturing sectors are significantly concentrated at some distance up to 180 km. However, most concentration was found to take place in smaller distances up to 30 km. Subsequent studies mainly

[2] A good discussion on why empirical research on agglomeration patterns matters can also be found in Behrens (2016).

applied this method to manufacturing sectors in other developed economies.[3] In Japan around 50% of sectors are found to exhibit concentration (Nakajima et al., 2012), while the figure for France is 63% (Barlet et al., 2013). A study on Canada finds concentration for 40 - 60% of sectors (Behrens and Bougna, 2015). In a rare analysis of an emerging economy Brakman et al. (2017) show that firms in more than 75% of sectors in China are agglomerated among themselves. K-densities have also been computed for the case of Germany and we are aware of three studies that look beyond a single sector.[4] In the first application Vitali et al. (2013) compute K-densities for Germany and five other European countries. While their analysis is mainly comparative it shows that in 2005 close to half of 4-digit manufacturing sectors in Germany are concentrated. Interestingly the level of concentration is found to be lower than in other European countries.

Second, in a more detailed study exclusively on Germany, Koh and Riedel (2014) show that in 1999 71% of 254 manufacturing sectors were significantly concentrated. Previous studies are confirmed as most concentration occurs between 0 - 30 km. They found that mainly traditional production activities such as textiles but also metal production were among the most concentrated sectors. Regarding sector characteristics they find a positive correlation between concentration and the age of a sector and the opposite for average skill level of workers. However, due to issues of data confidentiality their estimation does not use Euclidian distances between establishments but rather assumes they are located on the centroid of a municipality (*Gemeinde*). Despite the fact that there are more than 11,000 municipalities in Germany, the centroids of larger regions are by definition on

[3] Applications to service sectors are more scarce. However, for France Barlet et al. (2013) show that business services tend to be more often concentrated than manufacturing and at shorter distances of up to 4 km. Koh and Riedel (2014) find that in Germany service sectors are less likely to be concentrated.

[4] Scholl et al. (2016) and Scholl and Brenner (2016) compute K-densities for the micro technology sector.

average further away from other centroids.[5] Our study aims to improve on this by using the actual geocodes of establishments.

In a third application, Bade et al. (2015) study the concentration of business functions within manufacturing sectors in West Germany for the years 1992 and 2007 separately. Their study suggests that 17 out of 28, or 60% of sectors are significantly concentrated. The most relevant finding for our study is that integrating (i.e. spatially concentrating over time) sectors seem to have experienced a decline in domestic employment and the number of establishments.[6] At the same time firms in these sectors invested more abroad. Overall the authors interpret this as a trend of concentration in Germany accompanied by fragmentation at the global level. Nevertheless the study also has few key weaknesses, mainly because they only look at a limited number of sectors including a few outliers to their interpretations.[7] Finally, as Koh and Riedel (2014) they assign geocodes to establishments based on the centroid of a municipality they are based in.[8] Despite all this they provide a few relevant findings by showing how the global and local spatial pattern of sectors can be related.

In terms of characteristics of concentrated (or dispersed) sectors the literature has tested many different factors, in line with the theoretical predictions of

[5] For example, Berlin forms a single municipality with around 3.5 million inhabitants and an area of almost 900 $km^2$. Similar issues concern other large cities such as Hamburg, Munich and Cologne, each containing more than a million inhabitants in a single municipality.

[6] Interestingly, they report that within-sector business functions concentrated further over time in some 'integrating' sectors, and dispersed in a number 'fragmenting' sectors.

[7] Their central hypothesis regarding offshoring activities is based on merely 8 integrating sectors of which only half actually show a decrease in employment (or number of establishments) and an increase in outward investment.

[8] They improve it slightly, as two establishments in the same municipality are assigned a distance to each other of 2/3 of the maximum circular radius of that municipality. However, this can lead to problems if large municipalities host many establishments in the same sector as it mechanically returns a strong concentration at the 2/3 distance band.

agglomeration going back to Marshall (1890).[9] A key concept are forward- and backward linkages and Duranton and Overman (2008) find vertical integration between sectors to increase chances of co-location. Analogue to this, Behrens et al. (2015) show how sectors that source an increasing share of inputs abroad disperse over time, while interpreting this as 'import competition'. In the same study a higher share of exports in turnover is demonstrated to favour spatial concentration, in line with the literature on export spillovers (Koenig, 2009; Cassey et al., 2016). Behrens and Bougna (2015) do not find the overall level of intermediate purchases to be important for concentration. Specialised labour pools are found to increase concentration e.g. when measured by the skill level of workers (Koh and Riedel, 2014) though this correlates highly with establishment productivity. Labour intensity was not found to be important by Combes and Overman (2004), though Bade et al. (2015) highlighted that sectors reducing employment are likely to offshore production to locations abroad. Hence there seems to be some link between labour intensity, agglomeration and offshoring. Evidence on knowledge spillovers or a sectors' technology intensity tend to confirm a positive association with agglomeration (Brülhart, 1998; Haaland et al., 1999; Combes and Overman, 2004). Related to this is the idea that older sectors use technologies that already diffused over space. Hence older sectors have a lower necessity to co-locate to exploit knowledge spillovers (Desmet and Rossi-Hansberg, 2009). At the same time older sectors can have a higher level of competition (Klepper, 2007) leading to a decrease in concentration if local competitors go out of business. Other studies find no relevance of sector age (Behrens and Bougna, 2015; Brenner and Kauermann, 2016) and again others show a positive association with concentration (Koh and Riedel, 2014).

[9] The literature generally distinguishes between- and within sector spillovers (Hoover, 1948) and while some highlight the urbanisation economies (Jacobs, 1969; Glaeser et al., 1992) we mainly refer to localisation economies in this study (Arrow, 1962; Romer, 1986; Henderson, 1986; Porter, 1990).

### 4.2.2 Global location patterns of MNEs

Studying the global expansion of German industry sectors implies exploring location decisions of MNEs abroad. The literature dealing with location choices of firms is vast and hence we focus on a subset of studies exploring the role of agglomeration economies and competitor location decisions, including co-location by nationality or sector. In the field of management science Juan Alcácer and co-authors show that the location decisions of MNEs cannot be explained by location characteristics alone as firms are strategic and closely account for the location behaviour of their competitors (Alcácer et al., 2013, 2015). They hypothesise that if location characteristics would be the only explanatory factor, all competing firms would co-locate, which is empirically not the case. Hence their theoretical and empirical findings are in line with earlier considerations by Hymer (1960) and Knickerbocker (1973) who also highlighted the strategic element surrounding investment decisions.

In a comprehensive literature review on the link between agglomeration economies and the location of international investment, Jones (2017) concludes that MNEs mainly locate in domestic agglomerations. This is also the case in a study by Duranton and Overman (2008) who analyse firm locations in the UK. On the other hand agglomerations of foreign firms matter for location choices of MNEs if the foreign investors come from the same home country. This phenomenon is well-established in various literature streams (Head et al., 1995; Henisz and Delios, 2001; Lu, 2002; Blonigen et al., 2005) and also confirmed by the findings in Chapter 3 of this thesis. The importance of foreign and domestic agglomerations for location choices of MNEs is explored in detail by Mariotti et al. (2010). Their study demonstrates that MNEs are concerned about knowledge spillovers and some prefer to locate away from local competitors if the perceived risk of unintended knowledge outflows are too high. They conclude that co-location among MNEs is more common as potential knowledge inflows compensate for outflows. Alcácer and Chung (2007) explore this phenomenon more directly by distinguishing firms by their access to technology. They show that less advanced firms tend to locate in industrial agglomerations, while more advanced firms prefer

to locate themselves away from direct competitors to avoid unintended outflows of knowledge. The latter point also resonates in a few studies showing that firms in high-tech sectors have a higher ability to organise their production over larger distances (Brakman et al., 2015; Rezk et al., 2016; Alcácer et al., 2016). Finally, Smith and Florida (1994) show that foreign affiliates from the same country tend to spatially concentrate if they rely on backward- and forward linkages. Following research by Alcácer and Delgado (2016) high-tech firms in the biopharmaceutical sector are more likely to rely on intra-firm rather than inter-firm linkages. Hence external agglomerations seem less relevant.

### 4.2.3 MNEs: The missing link between the domestic and global geography of sectors

This selective review of the literature on the agglomeration of sectors and global location choices of MNEs holds a few important insights for the present study. While there are a number of ways forward from here (some of which we discuss below), our research aim is clear: We want explore the global concentration patterns of establishments owned by German MNEs and compare it to their domestic geography. Hereby we draw on the findings highlighted above, including the role of technology, a shared sector and nationality, input-output linkages, offshoring and integration in global value chains. We believe that this can provide new insights on the link between the domestic and global spatial pattern of sectors. More specifically, we discussed how firms account for the location choices of competitors and exhibit a tendency to co-locate by nationality when going abroad. This makes it plausible that German firms expanding via establishing business units abroad are influenced by the location decisions of other German firms, mainly in their respective industry sector. While we certainly expect that German MNEs do not spread evenly in the global economic landscape the question left to explore is whether we can qualify this heterogeneity further based on sectoral

comparisons.[10]

Some sector characteristics will be explored in more detail as they stood out from the literature. Building on Bade et al. (2015) labour market dynamics seem to take a central role as they find that sectors with declining employment in Germany tend to concentrate further over time while investing heavily abroad. This also resonates in the studies on offshoring in the German context (Marin, 2004, 2006; Becker et al., 2005; Buch et al., 2007). As sectors are increasingly embedded in global value chains (Helpman, 2006) we furthermore expect the share of intermediate inputs that a sector sources domestically and globally to be related to this. The second key factor that seems to emerge from the literature is the role of technology. Internationalisation tends to be driven by more technology-intensive firms (Cantwell, 1995, 2017) and less technologically-advanced firms tend to locate in agglomerations as they have little knowledge to lose (Alcácer and Chung, 2007). As more high-tech firms are capable of organising production across space (Baldwin and Evenett, 2015; Brakman et al., 2015; Rezk et al., 2016; Alcácer et al., 2016) we hypothesise that they drive the global geography of foreign expansions from a country. Hereby we do not say that higher technology sectors do not clusters and lower technology sectors do not disperse. However on average establishments of lower technology sectors should only be able to establish themselves in a few places and hence will cluster there. We will return to these points when we discuss the empirical results.

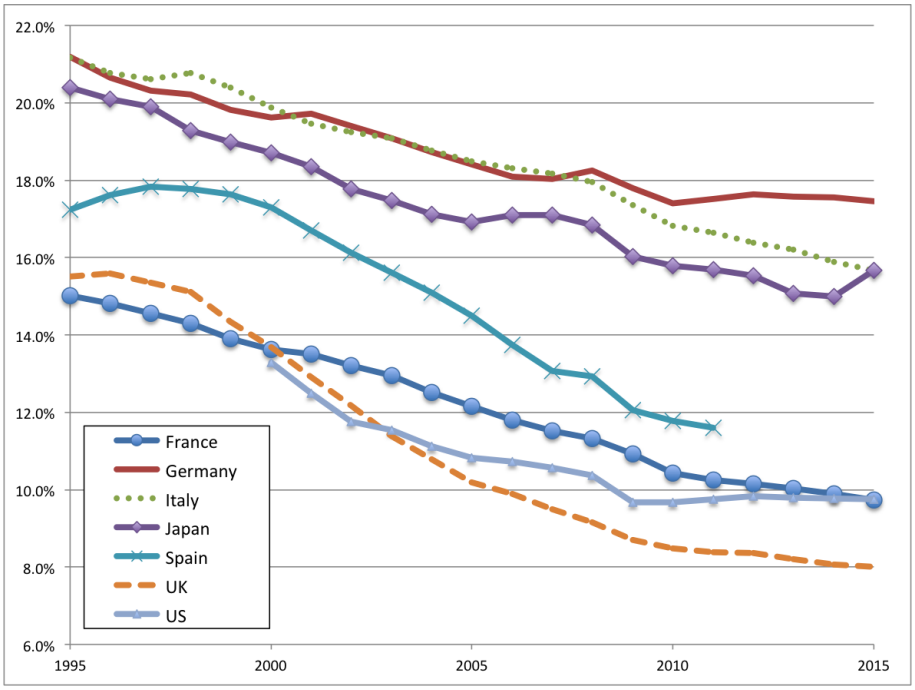
## 4.3 Germany's manufacturing sector

The aim of this section is to provide an overview of the German manufacturing industry and its international competitiveness. We will draw on official data from the German Statistical Office as well as data and reports from international organisations such as OECD, UNCTAD and the EU. In a first step we explore the

[10] We return to this crucial point in the empirical section as the global geography of a specific sector will be compared (benchmarked) against the global geography of German establishments in general.

importance of manufacturing as a backbone of the German economy and major source of the country's trade surplus. To do so we will offer a comparison with other major industrialised economies. The remainder of the section discusses individual sectors in more detail, paying particular attention to sector-level technology-intensity, export performance and employment.

Figure 4.1: Share of manufacturing in total employment for selected countries, 1995-2015. (Source: calculation based on OECD data)



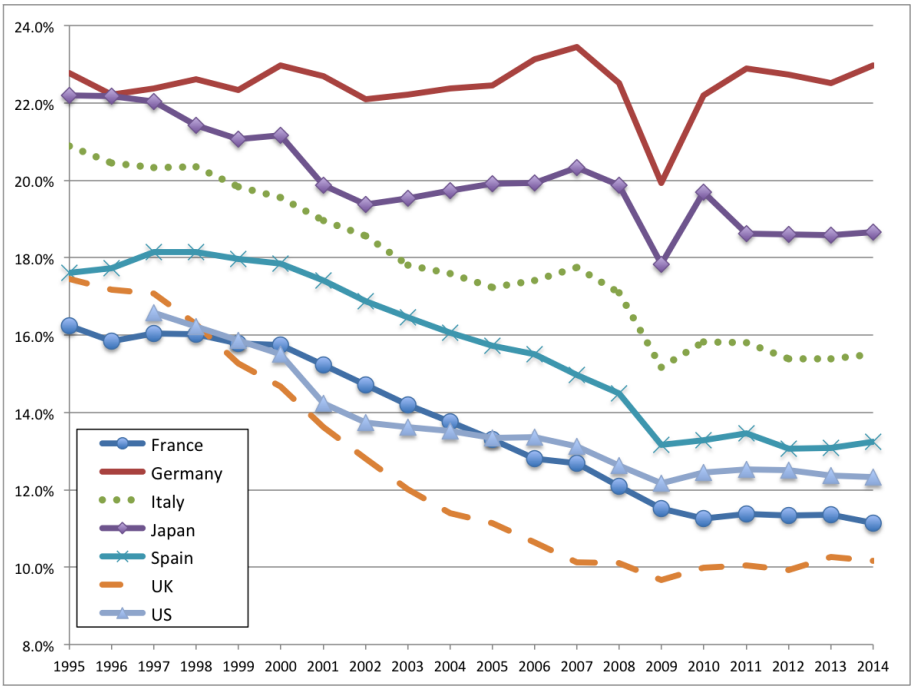

### 4.3.1 International competitiveness

The manufacturing sector is traditionally of high importance to the German economy and the backbone of the country's international competitiveness (The Economist, 2012; Hancké and Coulter, 2013; European Commission, 2015; Bade et al., 2015). This becomes particularly evident when comparing the importance of manufacturing for national employment, gross value added or exports across major industrialised countries. As our study focusses on manufacturing it is crucial to understand these drivers of competitiveness when comparing the spatial expansion at home and abroad.

Figure 4.1 shows the share of manufacturing in total employment across 7

industrialised countries from 1995 - 2015. Though the trend is decreasing, the importance of manufacturing in total employment is still high in Germany at 17.4% in 2015. The two countries that come closest to this value are Italy and Japan with almost 16%. Other countries such as France, the US and the UK all have less than 10%. Interestingly, after the financial crisis the share of manufacturing jobs remained stable in Germany and the US, but declined in the other countries. A similar trend is also observed by the OECD (2016) and provides a first hint at the competitiveness of the German manufacturing sector, as well as favourable labour market policies and institutions allowing for flexible adjustments (Lallement, 2011).

Figure 4.2: Share of manufacturing in total GVA for selected countries, 1995-2015 (Source: calculation based on OECD data)




In Figure 4.2 we plot the share of manufacturing in total GVA for the same set of countries and time period. A similar picture arises with Germany having the highest share of manufacturing at 23% in 2015. This is more than 4 percentage points higher than the share of Japan, and 7.5 percentage points above Italy. It means that while we showed that both have a comparable share of manufacturing employment they seem to trail Germany in terms of productivity. We observe that the share of manufacturing in total national GVA has been decreasing for

all countries except Germany for our period of analysis.[11] This phenomenon has also been highlighted by the European Commission (2015) and again underlines the strength of German manufacturing firms. A final interesting observation on Figure 4.2 is that German manufacturers were hit very hard by the financial crisis in 2009 as the drop of the share in GVA is the highest in absolute and relative terms. Nevertheless the sector rebounded quickly to its pre-crisis trend. This could be seen as a key weakness of an economy. However, others have argued that a global interconnectedness (Chen and Alfaro, 2012; Crescenzi and Iammarino, 2017) and strong manufacturing base (Bryson et al., 2013; Christopherson et al., 2014) can be sources of economic resilience.[12] Looking at absolute figures we can see that in 2009 total GVA in Germany dropped by almost €100 billion, of which €80 billion were lost in manufacturing sectors. We will explore the latter point further below by looking into cross-border trade.

The competitiveness of German manufacturing is probably most visible when comparing goods exports across industrialised countries as in Figure 4.3. Panel (a) shows the percentage of manufacturing goods in total exports reached almost 84% in Germany in 2015. Again, Italy and Japan are close, while the other countries have around 70%. The share of manufacturing exports in the UK declined to 55.5% in recent years. This rapid declining trend is also visible in the case of Japan. However, looking at shares on its own can be misleading as a decreasing share in exported goods can also be driven by an increase in service exports. Hence we compare total exports in panel (c). Two 'superstar' exporters stand out: the United States and Germany, with the former reaching more than $1,500 billion exports in 2015 and the latter more than $1,300 billion. Considering that the population of Germany is around one quarter of the US this is one of the strongest evidence for the competitiveness of German manufacturing goods on

[11] Of course this can either be driven by a decrease in manufacturing or by a relative increase in non-manufacturing GVA. Hence we only refer to the relative importance of manufacturing for an economy.

[12] We acknowledge that 'resilience' remains a somewhat fuzzy concept and is something that is hard to build or replicate (Martin and Sunley, 2015). Here we only use it in the sense of bouncing back from a shock such as a recession.

international markets.

Looking at the import side, panels (b) and (d) show that Germany imports relatively more services than it exports. The country's manufacturing imports reached 77.7% of total imports in 2015 placing the country in the midfield compared to the others. Total goods imports amounted to more than $1,000 billion in 2015 as shown in panel (d), which is less than half than the US. Hence Germany is also a significant buyer of manufactured goods, hinting at its integration in global value chains. Since value chain integration is one of the drivers we consider in this study it is worthy to explore this further. Indeed, following data from the OECD the share of manufacturing in total intermediate consumption is around 43.6% in Germany.[13] Germany's high share of manufacturing in total exports is also not a recent phenomenon but reaches back to the early 90s (see Figure 4.19 in Appendix 4.A.1). Looking at a longer timespan reveals another interesting fact as total exports only started to grow exponentially in the early 2000s, when Germany overtook the US as the largest exporter for almost 10 years. Imports on the other hand only grew modestly.

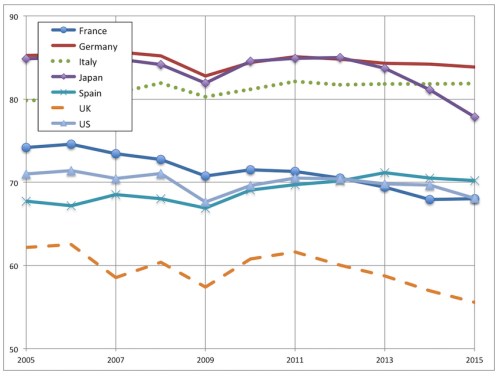
A final point on manufacturing is that the sector is also a key contributor to innovation in Germany. A report by the European Commission (2017) showed that manufacturing business R&D amounted to 1.7% of GDP in 2014, most of which is driven by the medium technology sector. This is the highest share in the EU and a key driver of productivity growth in manufacturing. The Commission also highlights that around 80% of German manufacturers offer services as well, contributing around 16% to the value-added of manufacturing (European Commission, 2016). We will explore the technological profiles of manufacturing sectors in more detail in the following section.

### 4.3.2 Spatial patterns and trends in Germany

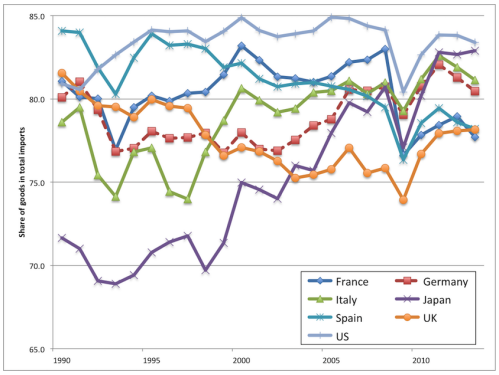
To get a first intuition of the importance of specific sectors within manufacturing we review major international reports on the German economy. This aggregate

[13] See Figure 4.18 in Appendix 4.A.1 for further comparisons of intermediate consumption.

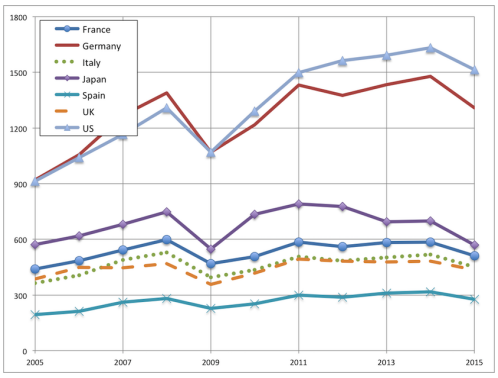
Figure 4.3: Relative vs. absolute manufacturing exports and imports for selected countries, 2005-2015. (Source: calculation based on UNCTAD data)



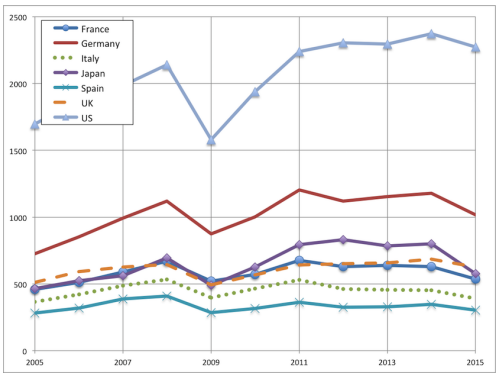

(a) Share in total exports




(b) Share in total imports




(c) Total goods exports (bn $)




(d) Total goods imports (bn $)

analysis is then complemented with a data-driven comparison of 2-digit sectors across groups of technology intensities. Following the OECD (2016), Germany has a traditional comparative advantage in the production of chemicals, as well as transport-, electronic- and optical equipment. These sectors are also emphasised in the annal report on the economic development of Germany prepared by the German council of economic experts ("Sachverständigenrat"), based on their importance in manufacturing and for the German economy. In addition the Council also mentions the sectors of basic- and fabricated metals, and machine-building (Sachverständigenrat, 2015). The competitiveness of the German automotive industry is also highlighted by the IMF (2016) and found to be based on its superior productivity, export performance and investments in R&D. In addition to automotive the European Commission (2015, 2017) highlights the traditional strength of the German pharmaceutical industry, machine-building, chemicals, electrical equipment, and basic metals. The same reports also show that most business R&D is conducted by large firms in the medium-high technology sector and the R&D share of SMEs is declining due to a lack of adequate financial and human capital.

Table 4.1: Characteristics of 2-digit manufacturing sectors in Germany (2015). Source: Destatis

| Code | Description | Emp. share | Turn. share | Average wage | Turn. per emp. | Emp. per unit | For. turn. share | Exp. share (volume) | Tech. | Competitive advantage mentioned in: |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | Manufacture of food products | 0.08 | 0.08 | 28,817 | 292,503 | 96.5 | 0.22 | 0.04 | LO | |
| 11 | Manufacture of beverages | 0.01 | 0.01 | 41,590 | 326,715 | 111.2 | 0.12 | 0.00 | LO | |
| 12 | Manufacture of tobacco prod. | 0.00 | 0.01 | 60,348 | 1,265,185 | 378.9 | 0.12 | 0.00 | LO | |
| 13 | Manufacture of textiles | 0.01 | 0.01 | 33,698 | 188,409 | 88.7 | 0.47 | 0.01 | LO | |
| 14 | Manufacture of wearing apparel | 0.01 | 0.00 | 34,018 | 242,113 | 116.0 | 0.37 | 0.01 | LO | |
| 15 | Manufacture of leather and related prod. | 0.00 | 0.00 | 34,029 | 185,431 | 144.9 | 0.30 | 0.01 | LO | |
| 16 | Manuf. of wood, prod. of wood and cork etc. | 0.01 | 0.01 | 33,093 | 243,450 | 69.0 | 0.23 | 0.01 | LO | |
| 17 | Manufacture of paper and paper prod. | 0.02 | 0.02 | 40,975 | 284,651 | 143.1 | 0.40 | 0.02 | LO | |
| 18 | Printing and reprod. of recorded media | 0.02 | 0.01 | 34,447 | 152,287 | 74.8 | 0.14 | | LO | |
| 19 | Manufacture of coke and refined petroleum prod. | 0.00 | 0.04 | 70,983 | 3,669,835 | 278.0 | 0.10 | 0.00 | ML | |
| 20 | Manufacture of chemicals and chemical prod. | 0.05 | 0.08 | 57,702 | 428,560 | 205.1 | 0.59 | 0.10 | MH | GCEE (2015), OECD (2016), EC (2017) |
| 21 | Manuf. of basic pharmaceutical prod. and prep. | 0.02 | 0.03 | 58,864 | 406,334 | 333.5 | 0.65 | 0.07 | HI | EC (2017) |
| 22 | Manufacture of rubber and plastic prod. | 0.06 | 0.04 | 37,905 | 197,476 | 120.3 | 0.38 | 0.04 | ML | |
| 23 | Manufacture of other non-metallic mineral prod. | 0.03 | 0.02 | 38,944 | 203,852 | 59.7 | 0.26 | 0.01 | ML | |
| 24 | Manufacture of basic metals | 0.04 | 0.05 | 47,763 | 376,697 | 238.8 | 0.41 | 0.05 | ML | GCEE (2015), EC (2017) |
| 25 | Manuf. of fabricated metal prod., ex. Machinery | 0.11 | 0.06 | 38,820 | 166,001 | 85.3 | 0.31 | 0.04 | ML | GCEE (2015) |
| 26 | Manuf. of computer, electronic and optical prod. | 0.05 | 0.04 | 52,102 | 257,301 | 153.5 | 0.59 | 0.10 | HI | GCEE (2015), OECD (2016) |
| 27 | Manufacture of electrical equip. | 0.07 | 0.05 | 49,291 | 224,631 | 183.4 | 0.50 | 0.07 | MH | GCEE (2015), OECD (2016), EC (2017) |
| 28 | Manufacture of machinery and equip. n.e.c. | 0.17 | 0.13 | 51,169 | 230,172 | 165.9 | 0.60 | 0.17 | MH | GCEE (2015), EC (2017) |
| 29 | Manuf. of motor vehicles, trailers, semi-trailers | 0.13 | 0.23 | 62,206 | 500,697 | 613.3 | 0.65 | 0.18 | MH | OECD (2016), IMF (2016), EC (2017) |
| 30 | Manufacture of other transport equip. | 0.02 | 0.02 | 60,320 | 342,251 | 384.3 | 0.64 | 0.06 | MH | GCEE (2015), OECD (2016) |
| 31 | Manufacture of furniture | 0.02 | 0.01 | 35,689 | 189,339 | 100.4 | 0.30 | 0.01 | LO | |
| 32 | Other manufacturing | 0.03 | 0.02 | 38,559 | 176,985 | 94.7 | 0.52 | | LO | |
| 33 | Repair and installation of machinery and equip. | 0.03 | 0.02 | 47,845 | 174,046 | 86.3 | 0.26 | | ML | |

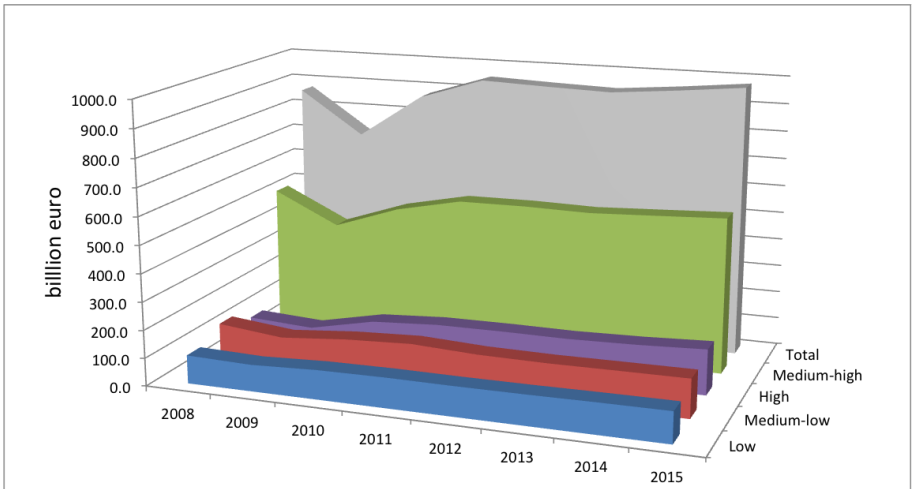
Notes: Employment and Turnover shares refer to share in total manufacturing. Wage, turnover and employment per unit calculated as 2-digit sector-level averages. Technology intensity classifications: HI = high; MH = medium-high; ML = medium-low; LO = low. Foreign turnover share defined as share of turnover from exporting or selling to clearly identified exporters.

Table 4.1 lists all 25 manufacturing sectors at the 2-digit level with some corresponding economic figures from the German Federal Statistical Office. Perhaps not surprisingly, all reviewed reports almost exclusively mention sectors classified with either high or medium-high technology-intensity, based on the technology classification by Eurostat and the OECD. Since these more technology-intensive sectors seem to drive German competitiveness we will place a specific focus on them during our analysis.

In Figure 4.4 we examine the development of exports and employment by technology groups between 2008-15. Panel (a) shows an overall increase in exports of more than 10% since 2008 to €977 billion in 2015. This is mainly driven by a strong growth of exported high-tech goods as those increased by almost 60% from €98 to €164 billion. In terms of composition high and medium-high technology sectors expanded their share in total exports from 72% to 74% over the period of analysis (11% to 17% for high-tech alone). Medium-low tech exports decreased by around 3% to almost €140 billion, while low-tech exports increased by more than 8% to €111 billion.

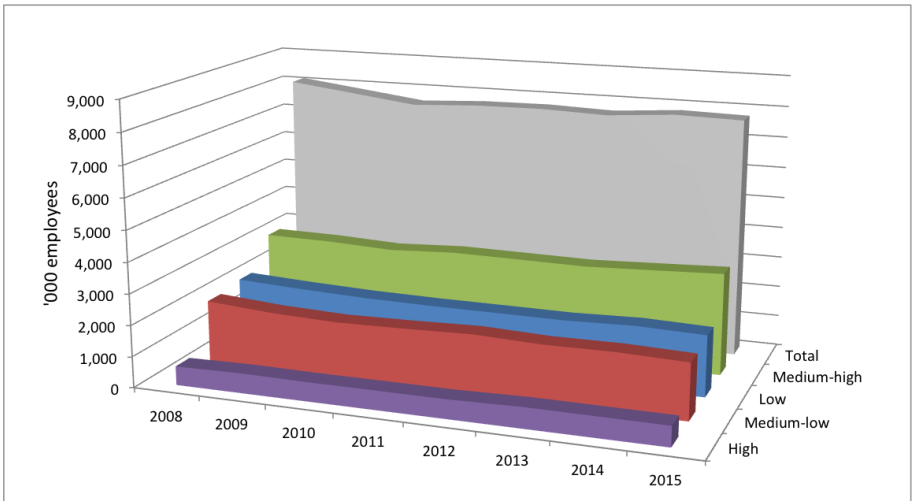
Regarding the trends in manufacturing employment, panel (b) shows that around 3.3 million, or 43% of manufacturing employees work in medium-high technology sectors. This represents an increase of around 3% since 2008. Over the same time period, total employment in high tech sectors expanded by almost 7% and now accounts for around 8.4% of manufacturing employment. Looking at employment in medium-low and low-technology sectors shows a decrease over these 8 years, from 4.3 million in 2008 to only 3.8 million in 2015. Together this hints at a potential polarisation in employment patterns between sectors that boast higher- vs lower levels of technology. We will discuss this further when looking at the geography of these sectors.

Figure 4.4: Trends in manufacturing exports and employment by technology group in Germany, 2008-15. (Source: calculation based on Destatis and Eurostat data for exports and employment, respectively)




| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| Low | 101.9 | 95.6 | 105.3 | 107.9 | 106.9 | 107.8 | 110.2 | 111.3 |
| Medium-low | 144.5 | 119.7 | 139.6 | 150.0 | 138.6 | 136.1 | 138.2 | 139.6 |
| High | 98.1 | 84.5 | 133.4 | 147.4 | 149.0 | 147.9 | 153.6 | 164.2 |
| Medium-high | 525.8 | 413.9 | 494.5 | 543.6 | 545.4 | 541.0 | 551.4 | 562.3 |
| Total | 870.3 | 713.7 | 872.8 | 948.9 | 939.9 | 932.8 | 953.4 | 977.3 |

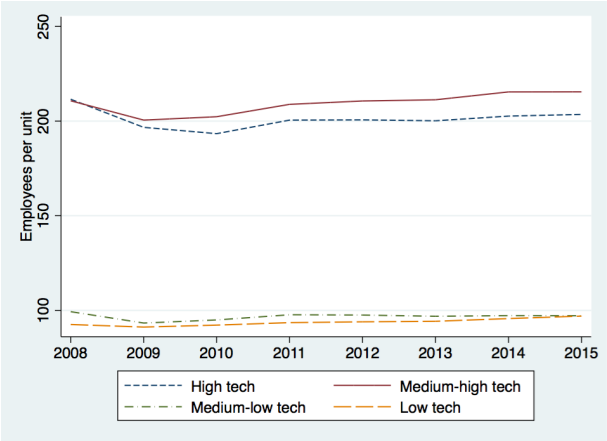
(a) Manufacturing exports (in billion €)



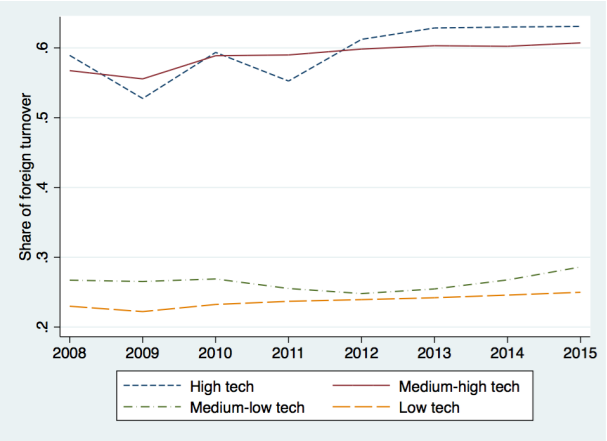

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
|---|---|---|---|---|---|---|---|---|
| High | 606 | 639 | 618 | 619 | 617 | 667 | 659 | 650 |
| Medium-low | 2,085 | 1,927 | 1,851 | 1,888 | 1,946 | 1,864 | 1,881 | 1,813 |
| Low | 2,212 | 2,105 | 2,028 | 1,995 | 1,987 | 1,975 | 2,037 | 1,975 |
| Medium-high | 3,197 | 3,167 | 3,076 | 3,180 | 3,155 | 3,128 | 3,214 | 3,306 |
| Total | 8,100 | 7,838 | 7,573 | 7,682 | 7,705 | 7,634 | 7,791 | 7,744 |

(b) Manufacturing employment (in '000)

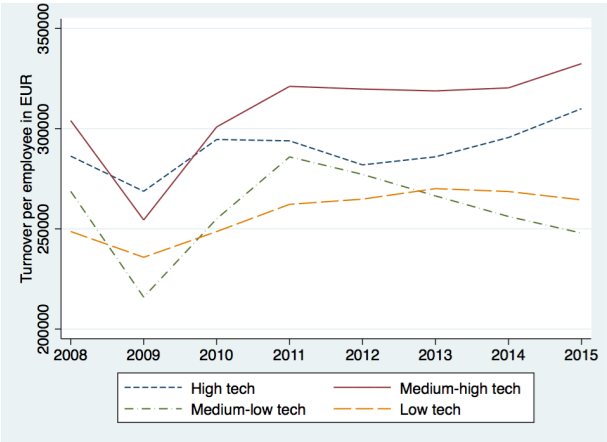
Figure 4.5: Comparison of sectors by technology intensity, 2008-15. (Source: calculation based on Destatis data)



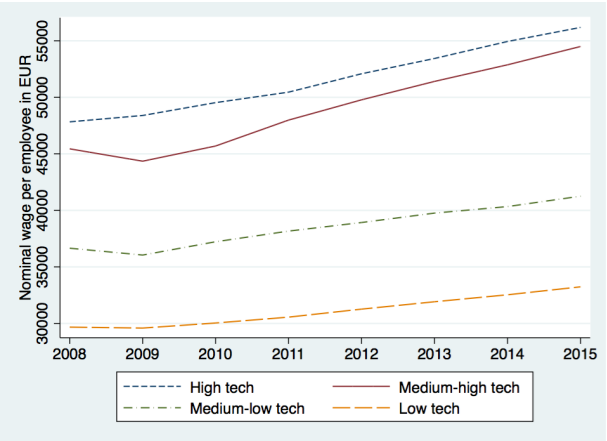

(a) Employment per unit




(b) Share of foreign turnover




(c) Turnover per employee




(d) Wage per employee

When comparing exports by technology intensity across countries, Germany's high share of medium-high technology sectors in total manufacturing exports is only exceeded by Japan (see panel b, Figure 4.20, Appendix 4.A.1). The share of high-technology sectors in exports is lower than in the US, France, and the UK as shown in panel (a), but higher than Japan, Italy and Spain. Low and medium-low sectors in Germany have low shares in exports when compared to other industrialised countries. Only France has a lower share in medium-low technology exports (see panel c), and only Japan has a lower share in low-technology exports (panel d). To avoid confusion regarding shares we also plotted the total values of manufacturing exports by technology intensity in Figure 4.21 see Appendix 4.A.1). It shows us that Germany is the second largest exporter in high, medium-low and low-technology sectors behind the US. However Germany consistently exports more in medium-high sectors. Again the overall picture that arises from this comparison is that Germany has a comparative advantage in medium-high and to some degree high-technology sectors.

Based on Figure 4.5 we can see that firms in high and medium-high (HI-MH) technology sectors are on average larger, more export-intensive, more productive and pay higher wages.[14] In Panel (a) the average employment per business unit is plotted for the period 2008 - 2015. HI-MH sectors on average employ 200 people per unit, which is more than twice as many than low and medium-low (LO-ML) technology sectors. A similar picture arises when looking at the share of foreign turnover, which is around 60% of total turnover for HI-MH sectors and only around 25-28% for LO-ML sectors.[15] Despite small fluctuations both of these indicators are relatively stable over our time period. In Panels (c) and (d) we can see that also the level of productivity measured as turnover per employee, and wage per employee is significantly higher for more technology-intensive sectors. Average productivity was higher than 325,000 EUR for MH and 310,000 EUR for

[14] Calculated as sector-level averages, rather than actual firm-level characteristics.

[15] The indicator calculates the share of export revenue in total turnover. This includes sales to domestic firms if those are clearly identified as exporters, but excludes sales of foreign affiliates abroad. This definition is not apparent on the website of Destatis, but following an information request has been confirmed in written to the author by the agency itself.

HI sectors. The gap is also increasing after 2011, with LO sectors approaching 260,000 EUR and ML below 250,000 EUR. The picture for wages is even more stark as though they are increasing in all sectors on average they do so at a faster rate and starting level for higher technology sectors. The average gross wage in HI-MH sectors was around 55,000 EUR, 41,000 EUR in ML and only 33,000 EUR in LO sectors.

The analysis of Germany's competitive advantage showed distinct patterns for high and medium-high technology sectors in terms of economic strength and levels of engagement in international markets. A brief look at the baseline economic characteristics of the largest 4-digit sector in each 2-digit class shows that our selection includes significant heterogeneity across key economic indicators.[16] Sector characteristics include absolute figures such as the share in employment or turnover, as well as sector-level average wages and productivity measured as turnover per employee. For example we find that the largest sector in terms of total employment and turnover is 'Manufacture of motor vehicles (2910)', as firms in this sector employ around 7.6% of all workers in Germany while generating almost 18% of total turnover.

## 4.4 Methods and data

Empirical studies in spatial economics have used a number of indicators to describe spatial concentration of economic activity. This section will provide a brief overview of popular concentration measures found in the literature and discuss their benefits and drawbacks. Here the focus is placed on measures using a continuous rather than discrete approach to geographical space, that can ensure the most unbiased comparison across different geographies. In the second part we explain the K-density measure - our main quantitative indicator - in detail. We will also address practical issues of estimating K-densities and refer to existing studies

[16] See Table 4.6, Appendix 4.A.1 for an overview of the largest 4-digit sector per 2-digit classification. We computed the largest sector as a 50-50 weighting between total employment and total turnover.

in the German and other contexts. A key point of discussion is the construction of appropriate counterfactuals, i.e. the baseline geography against which we compare our selected sectors.

### 4.4.1 Discussion of popular spatial indicators

Traditionally economic agents have been aggregated at discrete units of space such as countries, regions, or travel-to-work areas. The problem with these types of measures, such as Gini, Herfindahl, or the Ellison-Glaeser (EG) index, is their imposition of a spatial structure on the data.[17] This means that they cannot account for different spatial patterns independent of the chosen spatial scale making them less suitable for cross-country comparisons. In the literature this well-known issue is commonly described as the modifiable areal unit problem, or MAUP (Openshaw and Taylor, 1979; Arbia, 1989). Briant et al. (2010) show empirically that spatial concentration measures are sensitive to data aggregation at some territorial unit. More recent spatial indices based on point-pattern analysis can overcome the issue of MAUP by comparing spatial patterns based on continuous spatial scales (Arbia, 2001; Marcon and Puech, 2003; Duranton and Overman, 2005). The best use of continuous measures lies in detecting the exact distances at which establishments in a sector are significantly concentrated or dispersed. However, the researcher furthermore needs to choose among absolute measures such as Ripley's K (or 'K-function'), or relative measures such as the K-density (Duranton and Overman, 2005) or M-function (Marcon and Puech, 2010). An excellent review of these is provided in Marcon and Puech (2017). We discuss those in more detail below as their construction is similar to K-densities, though significant differences exist, which is why we opt for using K-densities.

Ripley's K has been proposed in the seminal work by Ripley (1976, 1977). It measures the spatial concentration or dispersion of points for distances 0 to r as

[17] For applications of the highly influential EG index see for example Rosenthal and Strange (2001); Henderson (2003); Alecke et al. (2006); Barrios et al. (2009); Dauth et al. (2016) and Faggio et al. (2017).

compared to complete spatial randomness (CSR). The function can be calculated by counting the average number of neighbouring firms within circles of increasing radius around a firm. Hence it is a cumulative function. After calculating the average number of firms within a defined circle these can be compared to a random circle to construct confidence intervals using Monte Carlo simulations. K(r) can be normalised using Besag's L-transformation where CSR is represented as a 45 degree line (Besag, 1977): $L(r) = \sqrt{\frac{K(r)}{\pi}}$. It can be further simplified by deducting r to get a benchmark value of 0 as in Marcon and Puech (2003): $L(r) = \sqrt{\frac{K(r)}{\pi}} - r$. The interpretation is straightforward as any positive value indicates clustering and any negative value dispersion - given that they lie outside of the confidence intervals for the null hypothesis of CSR.

However, relative measures have distinct advantages over Ripley's K as they can weight points. Giuliani et al. (2014) refer to this as an issue of 'clustering of firms' as compared to 'clustering of economic activity'. Furthermore, relative measures can control for a more meaningful benchmark than CSR (e.g. overall manufacturing). CSR assumes a reference geography based on a random distribution of points in space (spatial Poisson process). In a real empirical setting this is always unrealistic as economic activity is never randomly distributed in space (Marshall, 1890; Krugman, 1991). To overcome this limitation Diggle and Chetwynd (1991) have proposed the D-function to 'control' for a baseline geography using the K-function based on a separate set of points: $D = K_c - K_0$. This can be the distribution of manufacturing or a higher sectoral aggregation (Marcon and Puech, 2003; Kosfeld et al., 2011). Following Marcon and Puech (2017) the issue of D-functions - in addition to the inability to apply weights to points - are that values are not comparable over increasing distances and when controls differ. Issues also remain regarding the proper use of confidence bands, which are not jointly but individually generated for $K_c$ and $K_0$ using Monte Carlo simulations. Also the M-function is a cumulative measure of concentration and proposed to be complementary to K-densities, as it meets the criteria of a good spatial indicator proposed by Duranton and Overman (2005). However, the interpretation is tricky, as concentration is not measured *at* but *up to* a specific distance, making it less reliable for predictions at different spatial scales following its developers (Marcon

and Puech, 2010). Empirical studies using the M-function remain scarce though it has increasingly been adopted in fields outside of economics (Marcon and Puech, 2017).

### 4.4.2 Weapon of choice: K-densities

As discussed above, the K-density index (or 'Kd-function') is the most widely-adopted probability density function in economics. Developed by Duranton and Overman (2002, 2005) it returns the probability of significant sector concentration at specified increasing distance bands. In a first step the bilateral Euclidian distances $d_{i,j}$ between plants i and j in a sector are computed. Considering n plants it follows that there are $\frac{n(n-1)}{2}$ unique pairs in each sector. Since the actual distance in terms of accessibility between plants is not taken into account here the distances are smoothed with a Gaussian kernel following the bandwidth of Silverman (1986) or more recently Sheather and Jones (1991). K-densities are then computed with the following formula:

$$\hat{K} = \frac{1}{n(n-1)h} \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} f\left(\frac{d - d_{i,j}}{h}\right) \tag{4.1}$$

with $h$ being the bandwidth and f being the kernel function. The first part of the function ensures that Kd is normalised to sum to 1.

A common way of summarising K-densities for sectors is to sum the area at all distances above the confidence band (Duranton and Overman, 2005; Koh and Riedel, 2014). The resulting index can provide a sense of 'scale' in terms of how concentrated a sector is overall and makes comparability easy. Behrens and Bougna (2015) refer to this index as the 'cumulative density function (CDF)', which we adopt here. The index has a value between 0 and 1 and can easily be interpreted. For example, in Germany the CDF value for manufacturing of pharmaceuticals is 0.04. This means that a random draw of two firms from the sector has a 4% chance that they are co-located within the chosen maximum distance band.

In the German case most studies use discrete spatial units such as municipalities (Gemeinden) or counties (Kreise) to assess the spatial patterns of sectors (Sternberg and Litzenberger, 2004; Brenner, 2006; Maurseth and Frank, 2009; Brachert et al., 2011; Gutberlet, 2014). Also Brenner and Kauermann (2016) rely on county-level data but highlight that official data sources do not provide geocoded data though those would be preferable from an empirical viewpoint. Indeed, an empirical comparison of continuous indices to the Ellison-Glaeser index confirms that MAUP is an issue also in Germany (Koh and Riedel, 2014). As the literature section has highlighted, in the German context the number of studies using K-densities are limited (Vitali et al., 2013; Koh and Riedel, 2014; Bade et al., 2015) mainly due to issues of data availability.

### 4.4.3 Data

As in previous chapters, our main datasource is ORBIS and we access firm accounts for the year 2015. The database fulfils our main two data requirements as it holds detailed identifiers on the location and industry sector of an establishment. Sector codes are available at the 4-digit NACE (Rev. 2) classification and allow to distinguish between primary and secondary economic activities of firms. While firms can have multiple sectors as their secondary activity, they only have one primary. To avoid double counting the focus of our analysis are primary activities.[18] We extract all establishments located in Germany that have a non-missing 4-digit sector code and fall into the category of manufacturing. As we want to describe the full geography of a sector this also includes foreign-owned establishments. We do not add any further restrictions with regards to employment or other characteristics. The simple reason is that many of these are missing in ORBIS (especially for smaller firms) and hence we would seriously underestimate the geography of a sector. As we are mostly interested in the spatial pattern of a sector we compromise on that and follow related studies by using the location and

[18] An extension including the secondary activities is in preparation but had to be left for future research. We discuss this in more detail in the concluding remarks as well as Appendix 4.A.3.

Table 4.2: Number of geocoded establishments at home and abroad by establishment size

| | Total | By establishment employment | | |
|---|---|---|---|---|
| | | 10+ | 1-10 | Missing |
| Establishments at home | 217,115 | 67,420 | 74,791 | 74,904 |
| | (100%) | (100%) | (100%) | (100%) |
| successfully geocoded: | 214,665 | 66,718 | 73,972 | 73,875 |
| | (98.9%) | (99.0%) | (98.9%) | (98.6%) |
| high quality: | 211,722 | 65,745 | 73,304 | 72,673 |
| | (97.5%) | (97.5%) | (98.0%) | (97.0%) |
| Establishments abroad | 13,941 | 5,671 | 1,589 | 6,681 |
| | (100%) | (100%) | (100%) | (100%) |
| successfully geocoded: | 11,968 | 4,588 | 1,362 | 6,018 |
| | (83.9%) | (80.1%) | (85.7%) | (90.0%) |
| high quality: | 10,300 | 3,910 | 1,232 | 5,158 |
| | (73.9%) | (68.9%) | (77.5%) | (77.2%) |

sector classification of an establishment (Vitali et al., 2013; Koh and Riedel, 2014) rather than employing a weighting of the actual establishments. Implications of using weighted vs. unweighted establishments are discussed by Nakajima et al. (2012) but the main issue is that larger plants potentially have larger impact on sector concentrations. This provides us with a sample of 217,115 manufacturing establishments in Germany and 13,941 of German-owned establishments globally (outside of Germany).[19]

The actual geocoding of establishments is based on addresses reported in ORBIS. We process them via a Python script that accesses the application programming interface (API) of Google Maps.[20] The quality of the geocoding depends on the strictness of the selection criteria but it is generally higher for

[19] We only consider ultimately-owned establishments and a minimum of 25% ownership. See chapter 2 for more details on the definition of ultimate ownership.

[20] The .py script can be made available upon request and further details on the process are available at:

*https://developers.google.com/maps/documentation/geocoding/intro*

addresses within Germany than abroad.[21] The success rate of finding geocodes for establishments in Germany approaches 99% and drops to 97.5% if we only keep high quality ones, i.e. those found to be accurate at the building or street level. Similarly, the figures are 83.9% and 73.9% outside of Germany. Table 4.2 reports the quality of the geocoding exercise including the number of establishments.

A breakdown by establishment size does not show significant differences within Germany in terms of geocoding success rates or quality. However, success rates abroad are slightly lower for large establishments. We speculate that one potential reason could be that those are more likely to be located in China, which shows a lower success rate than other countries. Generally we do not expect this to bias our results as the benchmark is always the spatial pattern of overall manufacturing. Also Vitali et al. (2013) rely on ORBIS to compute K-densities for Germany though their sample only contains around 62,500 firms for the year 2006. A potential reason for this lower number compared to our sample is that they do not geocode the firms themselves based on the address but rely on entries of postcodes in the database itself. Our data have two advantages apart from being able to access more a recent year. First, we can also include establishments that might report a street, number and city but no postcode and hence can still be geocoded with our method. Second, we are able to get more precise geocodes, as postcodes can still be relatively large or refer to a post office box rather than the actual location of a firm.[22] In another application using ORBIS data, Giuliani et al. (2014) estimate the spatial concentration of high and medium-high technology sectors though only for two regions in Italy.

A tabulation of the number of establishments by country and country groups (see Table 4.7, Appendix 4.A.1) shows that in our sample most of the German-owned establishments abroad are located in the United States (30% of total), followed by three Central-Eastern European countries (Czech Republic, Poland,

[21] For example, we can require the search to match all criteria (street, number, postcode, city, federal state, country) or just some of them.

[22] For example, 'Berlin-Mitte (10115)' has more than 20,000 inhabitants at an area size of 2.4 km2 or 'Munich-Maxvorstadt (80333)' is home to 11,000 people at 1.62 km2.

Romania, each around 7-8%) before a number of Western European countries (Switzerland, Austria, Italy, UK and France - each around 3%).[23] Overall the top 8 countries host more than two thirds of all establishments, whereas the Top 20 combine almost 90%. When looking at groups of countries in the lower part of Table 4.7 we see that North America and Central Eastern Europe each host around one third of German establishments, followed by Western Europe with almost 27%. A few additional interesting patterns emerge if we look at the share of establishments by technology intensity class. The US hosts around 30% of all German manufacturing establishments abroad, while these include more than half of German high-tech establishments. The Czech Republic and Poland host disproportionally many medium-low tech businesses and Poland and Romania above average low-tech establishments.[24] Switzerland and Canada also seem to be hubs of German high-tech firms. The spread of medium-high tech firms is similar to the overall distribution of manufacturing, not least because 42% of all establishments fall within this technology group. Nevertheless, Italy, Switzerland and China host a disproportionally larger share of those. The sectoral dimension is reported in Appendix 4.A.1, with Table 4.9 and Table 4.10 showing the number of establishments for the top 20 sectors with the most establishments in Germany and abroad, respectively.

### 4.4.4 Practical estimation issues

A few practical issues remain when computing K-densities and the researcher has to make choices. We will discuss the main issues here and motivate our choices based on the literature and specificities of our case.

One key point of discussion is the maximum distance band for the analysis

[23] The figures are slightly lower than in Table 4.2 as we drop establishments with insufficient information on their 4-digit sector.

[24] Wassmann et al. (2016) explore the cooperation between German firms in low- and medium-low technology sectors and firms in the Czech Republic in more detail. They conclude that partnerships are unlikely to be driven to enhance innovative capabilities but rather by cost considerations.

and the empirical literature has put forward several suggestions. Duranton and Overman (2005) propose to use a maximum of 180 km in their study on the UK, being the median distance between all points. Without providing a rationale Scholl and Brenner (2016) use 360 km for Germany and Arbia et al. (2008) 250 km for Italy. Marcon and Puech (2003) use 400 km for France, as this is half the maximum distance between two points. Kosfeld et al. (2011) argue that such large distance bands are problematic for irregularly shaped areas such as Germany as towards the edges the function is dominated by edge corrections. Hence the authors prefer to use one-fourth of the maximum distance between 2 points, which is 215 km in their case. Bade et al. (2015) use 140 km and argue that this is less than the distance between major German cities. We follow the latter studies and apply a maximum distance band of 200 km.

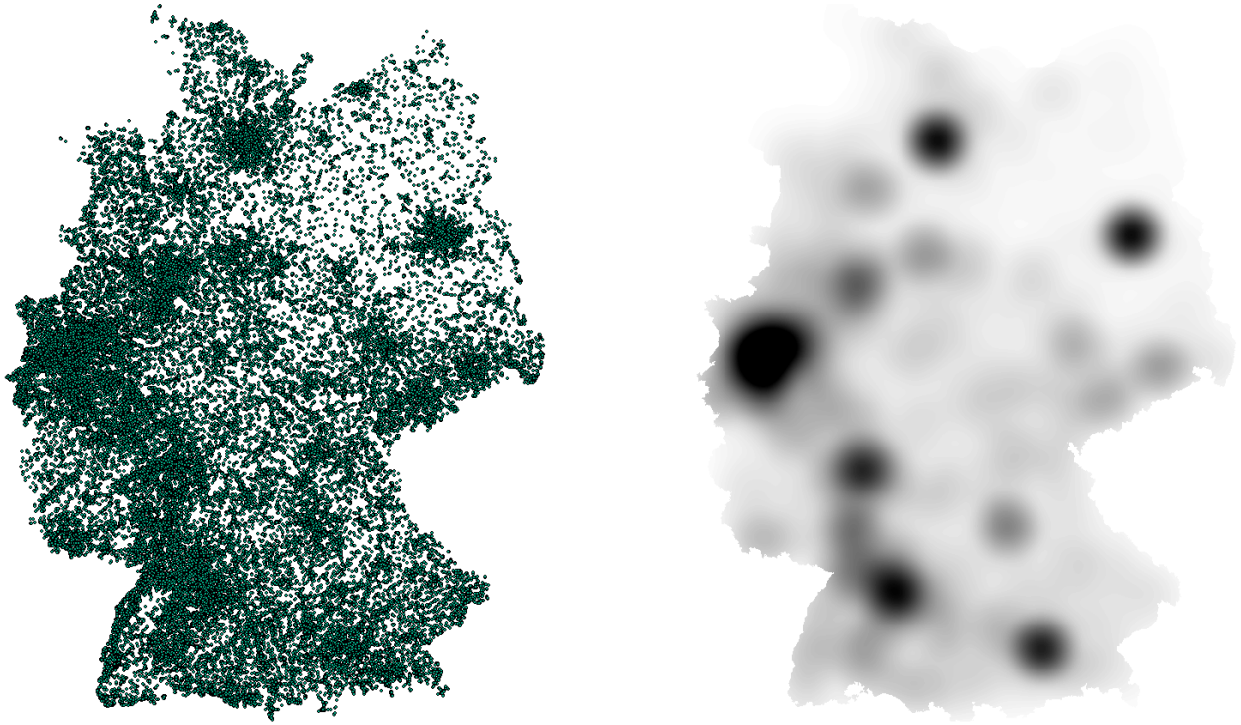
Another central question is the choice of a benchmark for the Monte Carlo simulations and the literature has found no consensus as each benchmark can tell a different story. However, it remains a crucial choice that should be explained in a transparent way. What has become clear is that using complete spatial randomness (CSR) is not very insightful as firm activity is never randomly spread across space. This is also confirmed when looking at the spatial distribution of manufacturing in Germany in Figure 4.6. The map plots the locations of our full sample within Germany and also smoothes them using a kernel density 'heat-map' in panel b. It is obvious that firm locations are not random, as they are still often determined by the proximity to historical coal mining sites (Gutberlet, 2014). Most studies have relied on the overall manufacturing pattern as their benchmark and we adopt this approach as well.

Here another choice needs to be made regarding the level of sectoral aggregation, while in most cases the 4-digit level is preferred (Duranton and Overman, 2005; Nakajima et al., 2012; Barlet et al., 2013). The agglomeration literature on Germany has considered different levels so far, while studies that apply continuous spatial indicators used 2-digit (Bade et al., 2015) and 4-digit aggregations (Vitali

et al., 2013; Koh and Riedel, 2014).[25] In an interesting extension of their study Duranton and Overman (2005) also use the 3-digit sector instead of overall manufacturing to control for the baseline spatial pattern of a 4-digit sector. They find that 4-digit sectors are still fundamentally different though 3-digit sectors explain the spatial pattern of a 4-digit sector better than overall manufacturing. Following previous studies we opt for using the 4-digit level.

[25] Kosfeld et al. (2011) and Brenner and Kauermann (2016) aggregate various 2-digit sectors and going beyond that Alecke et al. (2006) analyse tech-clustering for 3-digit manufacturing sectors. Other studies look at overall spatial patterns of manufacturing and do not focus on certain sectors in more detail (Sternberg and Litzenberger, 2004; Brenner, 2006; Brachert et al., 2011). Again others look into sub-sectors of a single broad sector classification such as ICT (Scholl and Brenner, 2016) or micro-technology (Maurseth and Frank, 2009; Scholl et al., 2016).

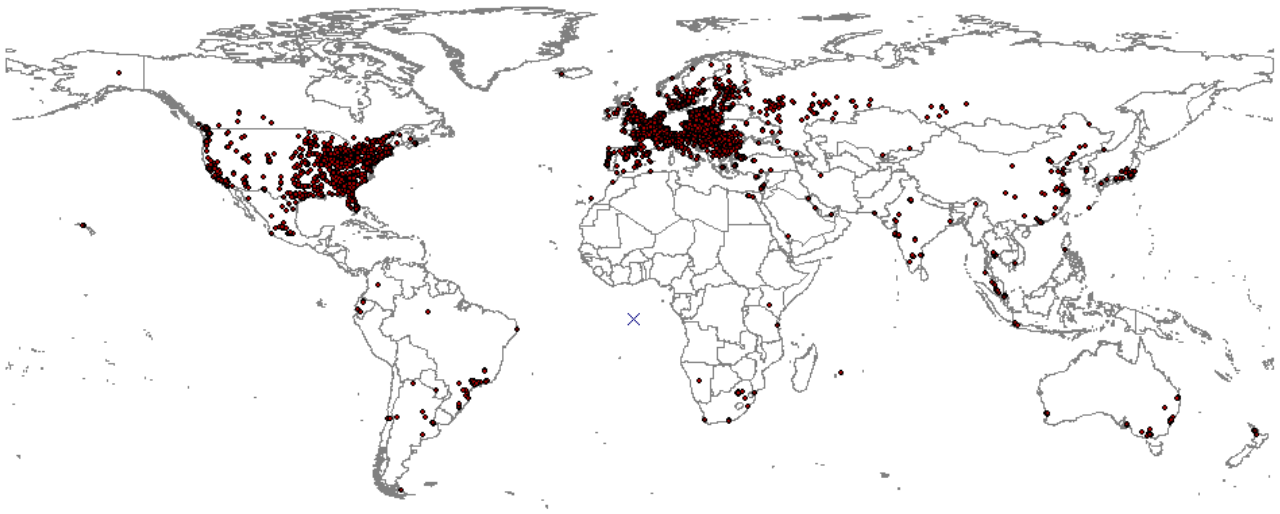
Figure 4.6: Spatial pattern of manufacturing in Germany: Point pattern and kernel density maps.



(a) Point pattern

(b) Kernel density

Figure 4.7: Spatial pattern of German-owned manufacturing firms globally.



We technically construct the confidence interval based on 'random labelling'. This means that the location of all manufacturing establishments is kept as a baseline while the sector is randomly allocated across these for the Monte Carlo draws. For example, if we have 500 automotive plants in Germany the Monte Carlo simulation is based on randomly allocating them across all potential locations that are occupied by any other manufacturing plant (as opposed to drawing from CSR). This method is appropriate if one wants to control for spatial factors that affect location choices of plants from different sectors in a similar way. The latter point is discussed in great detail in Arbia et al. (2008). In parts of the literature it is furthermore common to work with subsamples of sectors. For example Kosfeld et al. (2011) restrict their analysis to 500 and Marcon and Puech (2010) to 1,000 randomly selected establishments per sector. We think that this can be problematic as our counterfactual is based on randomising across all potential locations (random labelling) and less dense areas will be underrepresented. Hence we choose to work with the full sample, despite longer computing times.

Choosing the benchmark for the global spatial pattern of a sector is trickier and there are few applications in the empirical literature. Our preferred choice is the global geography of all German-owned manufacturing firms as shown in Figure 4.7. We acknowledge that there is a tradeoff here, as we could also compare the expansion of German MNEs to the global geography of their respective 4-digit sector (regardless of who owns the establishments). There are several reasons why we choose not to do so. First, MNEs to not spread evenly in space and hence countries are not equally targeted by investments of German MNEs. This means also that most sectors would be mechanically concentrated if we were to compare them to the global geography of their respective sector. The counter hypothesis is that German MNEs actually do follow the global geography of their respective 4-digit sector. We think that this is unlikely and based on studies on location choices of MNEs (discussed in Section 2) we know that other factors besides sectoral characteristics are highly relevant, including a shared home country, institutional frameworks, market size, and plain spatial distance (Blonigen, 2005). This makes it unlikely that German MNEs only follow the global spatial pattern of their respective sector. Second, the location choices of

MNEs are distinctly different from purely domestic firms as shown by Mariotti et al. (2010). Hence using domestic plants, i.e. not owned by an MNE, would not be an appropriate benchmark either, though they are crucial to understanding a sectors' global geography. This would leave the option of using MNE-owned plants in the same 4-digit sector as an alternative benchmark. While this does not address the first issue of uneven spread, it can better control for sector-specific global patterns. Unfortunately geocoding all plants globally that are owned by an MNE as in Alfaro and Chen (2014) is not feasible within the scope of this study.[26] We need to keep this in mind when interpreting global K-densities, as significant localisation patterns always must be interpreted with regards to the chosen benchmark. In our case this is the global geography of all German-owned manufacturing establishments.

Finally, the calculation of the index relies on computing bilateral distances between all establishments in the sample. As mentioned above we have a maximum of $\frac{n(n-1)}{2}$ unique bilateral pairs. For the estimation this illustrates in a straightforward way that computing time for these indices increases exponential to n. Euclidian distances have been found to correlate highly with other forms of distance and are hence the go-to measure. However, a well-known limitation is that they are merely an approximation of 'true' distance. Since distance (or the antonym 'proximity') comes in many dimensions (Boschma, 2005), it is difficult to argue which one to use in the case of co-location. We are aware that it might introduce bias in sectors where transport costs are significant (e.g. construction) and Euclidian distances can underestimates the 'true' distance more than in other sectors (Buczkowska et al., 2015). Unfortunately we do not have the means to compute a full distance matrix between all manufacturing establishments based on travel times though this would be possible in theory. In addition, Duranton and Overman (2005) highlight another drawback of doing this, as low-density areas with few roads can have travel times longer than the Euclidian distance, while high-density areas with many roads can actually approach Euclidian distance.

[26] While this is technically possible we do not have the resources or computing capacity to deal with such large data requests and leave it for future studies to address.

Nevertheless, since dense areas are also prone to congestion effects they choose to ignore the issue due to opposing effects. To overcome some of these issues including measurement error, the spatial literature applies a Gaussian kernel function with an optimal bandwidth following Sheather and Jones (1991) or previously Silverman (1986). The highest value for the kernel is at the location of the firm and it decreases until the defined search radius. As discussed above in our case we use a value of 1 for each firm, though also a weighting by employment or turnover would be possible.

## 4.5 Results

This section will discuss the location patterns of firms and resulting concentration of sectors within Germany and globally. We make use of the K-density measure as well as other descriptive tools such as maps, and scatter plots. The aim is to focus on interesting similarities and differences between sectors but we will also highlight some individual cases per technology group.

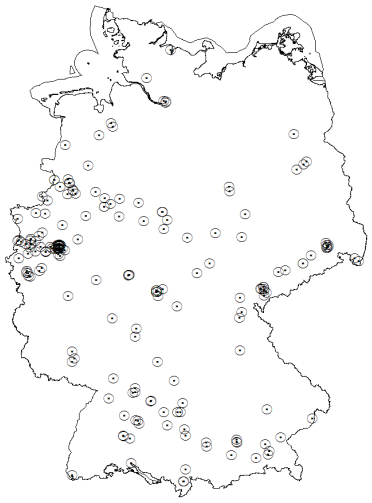
### 4.5.1 Location patterns in Germany

Before discussing the results for all 225 manufacturing sectors in our sample we focus on 4 sectors in more detail to demonstrate how the findings per sector look like in detail before we compare them.[27] We report maps for each of them in Figure 4.8 and the corresponding K-density function is plotted in Figure 4.9. Panel a represents the low-tech sector, panel b medium-low, panel c medium-high and panel d a high-tech sector.

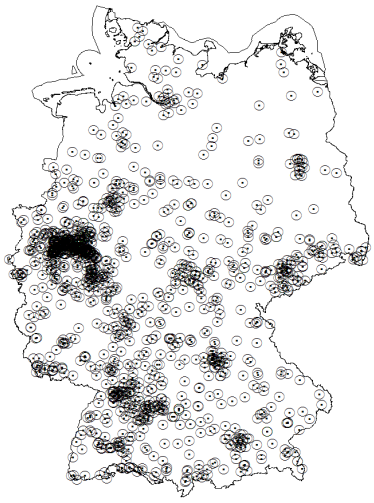
When looking at the maps we can see that each of the sectors exhibits a distinct geographical pattern, though the general manufacturing hotspots as in Figure 4.6 remain visible. Nevertheless, apart from a first intuition on where significant clusters are located, these maps hold relatively little information

[27] We choose the most concentrated sector per technology group among the large sectors as outlined in Table 4.6, Appendix 4.A.1.

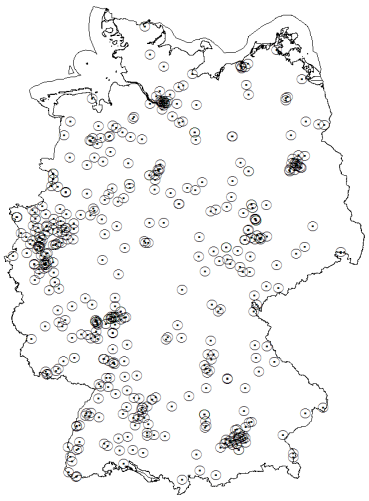
Figure 4.8: Density maps for selected sectors in Germany



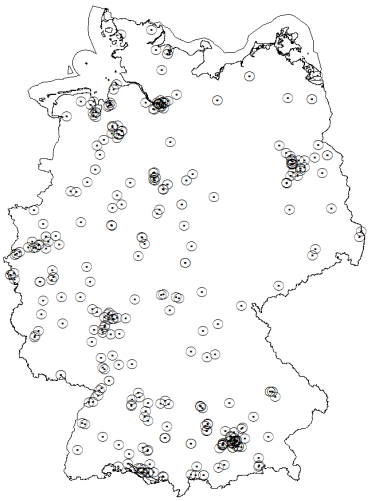
(a) Industrial textiles (N=199)



(b) Forging of metal (N=1,460)

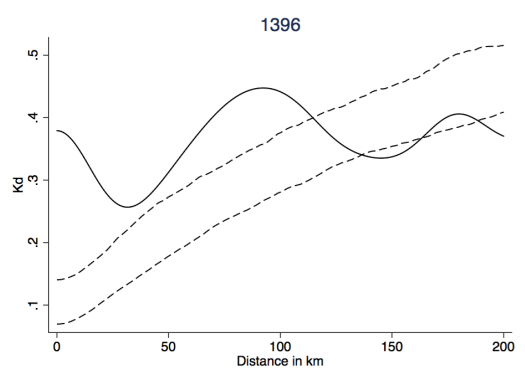


(c) Organic basic chemicals (N=481)

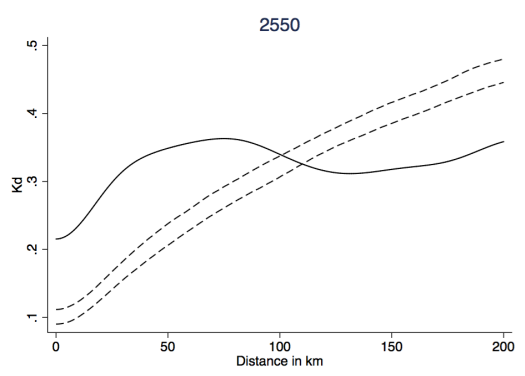


(d) Aerospace (N=345)

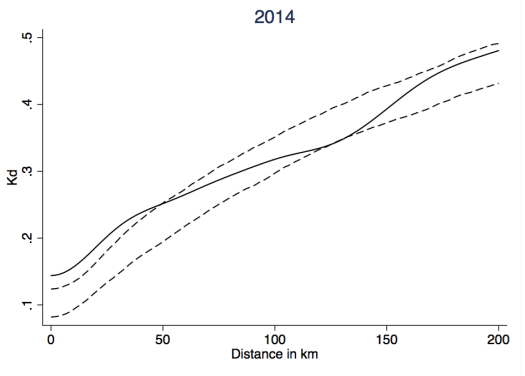
Figure 4.9: K-densities for selected sectors in Germany



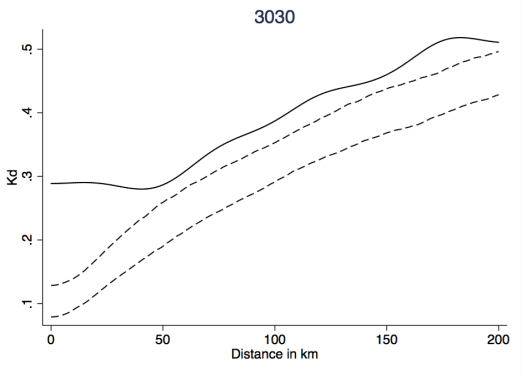

(a) Industrial textiles (N=199)




(b) Forging of metal (N=1,460)




(c) Organic basic chemicals (N=481)



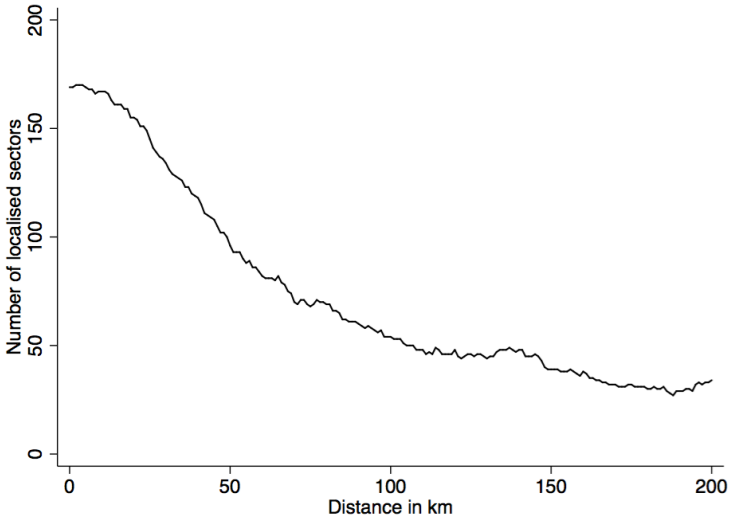

(d) Aerospace (N=345)

regarding the degree of concentration. For example, while the sector 'Forging, pressing, stamping, roll-forming of metal' appears to be the most concentrated it also has the most establishments (n=1,460). Hence we look at the plot of the K-density measure in Figure 4.9 for the same four sectors, as this controls for the number of establishments in a sector. On the y-axis we measure Kd and on the x-axis the distance band. The solid line represents the value of Kd at each distance and the dashed lines the confidence interval computed by the Monte Carlo draws. The function shows that 'Industrial textiles' (panel a) seems to be concentrated at very low distances up to 5 km exhibit a second concentration peak at around 90 km. 'Forging of metal' (panel b) is most concentrated around 60 - 70 km and less so at larger distances. This sector is also a good example why it makes sense to mainly focus on concentration as at larger distances sectors are mechanically 'dispersed' if they are highly concentrated at lower distances.[28] In other words, more co-located firms at short distances implies less firms at larger distances (i.e. dispersion). It also shows why very large distances that would include several large clusters lead to additional peaks in the plotted Kd as in the case of 'Industrial textiles'. The medium-high tech sector 'Organic basic chemicals' is more concentrated at distances up to 40 km though appears to mainly follow the general distribution of manufacturing. Finally, the high-tech 'Aerospace' sector (panel d) is concentrated at low distances but also at larger distances up to 200 km.

These figures provide us with a first intuition regarding the distances at which firms in the same sector are significantly co-located and where the main clusters are located in Germany. However it does not answer the question of intensity, i.e. how concentrated a sector is overall. As discussed in the Methods section, the literature measures overall concentration levels using the cumulative density function (CDF). Looking at Figure 4.9 the CDF value is represented by the area above the upper dashed line and below the solid line (the area of significant

[28] Since the underlying density formula is normalised this means that if there are a lot of co-located establishments within a sector at small distances, then by definition they will be relatively dispersed at larger distances.

Figure 4.10: Number of significantly concentrated sectors by distance band at home

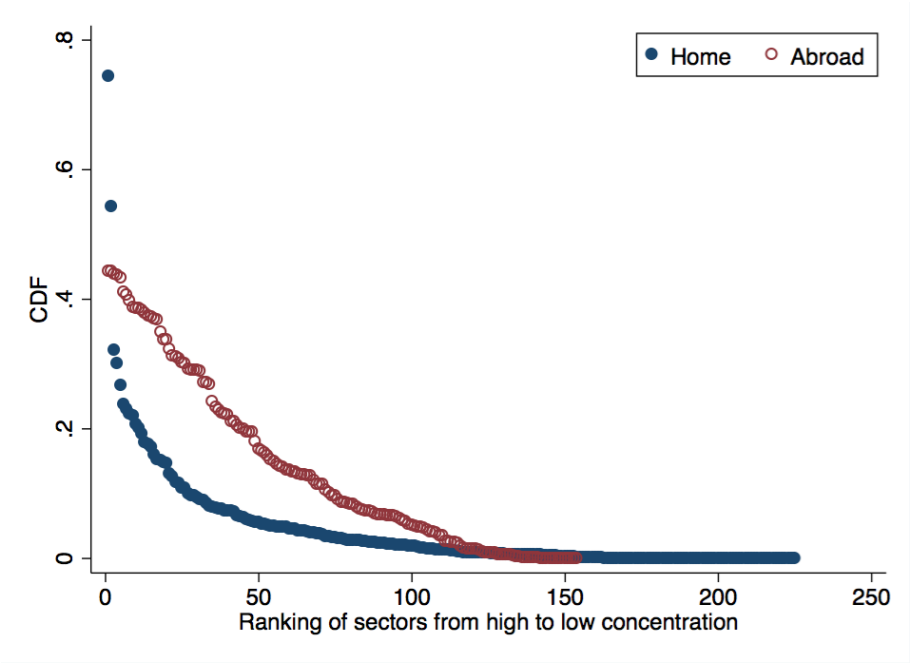



concentration). It emerges that 'Aerospace' is the most concentrated of the four sectors with a value of 0.1, meaning there is a 10% chance that two randomly drawn firms from this sector are co-located within 200 km of each other. The respective values for 'Industrial textiles', 'Forging of metal' and 'Organic basic chemicals' are 9.7%, 9.4% and 0.9%, respectively.

After gaining a better understanding of the spatial indicators using the example of four large sectors we expand the analysis to the whole economy. We compute K-densities for all 225 manufacturing sectors in Germany. The least number of establishments per sector are 28 in the case of 'Manufacture of margarine and similar edible fats' and the most establishments are in 'Manufacture of bread, fresh pastry goods, cakes' (i.e. bakeries). On average each sector has 882 establishments and the median is 353. Figure 4.10 shows the number of sectors that are significantly concentrated at each distance band from 0 to 200 km. Hence the y-axis shows a count of significantly concentrated sectors. As in previous studies we find that most concentration within sectors in a single country takes place at low distances of up to 30 km (Duranton and Overman, 2005; Koh and Riedel, 2014; Behrens and Bougna, 2015). Indeed around 170 (or 75%) of the sectors in our sample show significant localisation up to this distance. After 30 km this number decreases sharply to around 85 sectors (or 38%) at 50 km. From

then on the number of localised sectors decreases at a slower rate to around 50 sectors (22%) still exhibiting significant localisation around 200 km.

Figure 4.11: Ranking of sectors by cumulative K-density at home and abroad




In a next step we compute the CDF for each sector and plot a rank of the sectors from most to least concentrated in Figure 4.11. We do this for sectors and their spatial patterns in Germany (full dots) and globally (hollow dots). In this section we focus on the former, while the subsequent section discusses the latter when we return to this graph. Looking at the ranking of sectors by concentration shows that a few sectors are highly concentrated and the level of concentration decreases almost in an exponential way. The most localised sector in Germany is 'Manufacture of cutlery (2571)' at a value of 0.74, meaning that two randomly drawn establishments in this sector have a 74% chance to be co-located within 200 km. It is interesting to note that also Vitali et al. (2013) and Koh and Riedel (2014) find the same sector to be the most concentrated in their studies. Other sectors that are ranked in the top 10 for the other two studies as well as in ours are the production of 'Watches and clocks', 'Jewellery', and 'Wine'. Comparing

sectors among the Top 20 across these studies reveals that most are the same.[29] Comparing our results to Duranton and Overman (2005) also provides some interesting insights as some of the these sectors are also highly concentrated in the UK, including manufacturing of 'Cutlery', 'Textiles' and 'Sound recording'. However, in Germany there are a number of concentrated low or medium-low technology sectors in the areas of basic metals as significant suppliers for the automotive industry ('Cold rolling of narrow strip', 'Cold drawing of wire', 'Cold forming or folding', 'Cold drawing of bars').[30]

We now explore the heterogeneity of sectors further in terms of their concentration patterns at home, i.e. in Germany. To do so we compute the full matrix of pairwise correlation coefficients between sector characteristics and our measure of concentration.[31] Sector characteristics are based on official Data from Destatis, OECD or ORBIS itself. A full list of variables including description and data sources can be found in Table 4.8, Appendix 4.A.1.

Results are reported in Table 4.4 including the 5% significance level indicated by a star attached to the coefficient. Looking at column 1 of the correlation matrix it appears that very few of our variables are associated with concentration. However, larger sectors (more total establishments and employees) are less likely to exhibit concentration and sectors that buy more intermediate inputs from their own sector are more likely to be concentrated. The latter finding is not surprising following the importance of same-sector input-output linkages highlighted in the agglomeration literature. Other variables that are negatively correlated with sector concentration in Germany are firm size, wages, and labour intensity. However none of them is statistically significant.

[29] An interesting in-depth description of the most concentrated sectors in Germany including significant clusters and some historical background is undertaken by Koh and Riedel (2014) but beyond the purpose of our chapter.

[30] A full list of the 25 most concentrated sectors in Germany is provided in Table 4.11, Appendix 4.A.1.

[31] We opt for pairwise correlations as some sectors are not internationalised and hence have no value for concentration abroad. Using standard correlations would reduce our sample by these observations. Hence these correlations can also been seen as simple univariate regressions.

Our findings also do not support the notion that import competition is associated with lower spatial concentration which has been established by Behrens and Bougna (2015) for the case of Canada. However we do not take a dynamic view here and hence over time this can still be a relevant phenomenon. The agglomeration literature has furthermore highlighted a spatial concentration of exporters (Greenaway et al., 2004; Greenaway and Kneller, 2008; Koenig, 2009; Koenig et al., 2010). While we do not have establishment-level data on exports here there at least seems to be no association between the share of exports in turnover and the level of spatial concentration within 4-digit sectors. However, we do not claim that export spillovers are not relevant in the German context as we lack an empirical source to compare our results to.[32]

Finally, in Germany a sectors' technology-intensity is not significantly correlated with its level of concentration. We explore with further by comparing the average level of concentration by technology group in Table 4.3 and a few interesting observations emerge. First, high-tech sectors seem to be the most concentrated sectors on average in our data. This resonates well in the literature on the distance decay in knowledge spillovers, making knowledge a key factor in agglomeration economies (Jaffe et al., 1993; Audretsch and Feldman, 1996; Rosenthal and Strange, 2001), which is also found in the case of Germany (Bode, 2004). Second, medium-high technology sectors are by far the least concentrated. On average there is only a 1.4% chance that two randomly drawn firms in these sectors are co-located within 200 km as compared to 4.3% for the whole sample. This leads us to the tentative observation that medium-high tech sectors are more dispersed and spread out within Germany. Possibly this is not surprising as our review of manufacturing sectors in Germany led to the conclusion that medium-high technology sectors are the backbone of the German economy. Now we have the micro evidence that seem to suggest that quite literally firms in these

[32] One extension of our study would be to test the micro-patterns of plant- or establishment level information on exports. Such data exist in the German context, e.g. from ORBIS. It is surprising that no previous study has studies this phenomenon in the German context, a country that is always praised for its strength in exports.

Table 4.3: Average level of domestic and global concentration by technology group

| | Domestic | | Global | |
|---|---|---|---|---|
| Tech | Count | Concentration | Count | Concentration |
| Low | 82 | 0.044 | 52 | 0.190 |
| Medium-low | 74 | 0.058 | 43 | 0.154 |
| Medium-high | 56 | 0.014 | 48 | 0.082 |
| High | 13 | 0.072 | 11 | 0.060 |
| All | 225 | 0.043 | 154 | 0.137 |

Notes: Concentration = average concentration across sectors.

sectors are providing the skeleton of the overall spread of manufacturing. From a macroeconomic viewpoint this could be an interesting finding for policymakers, with potential implications for territorial cohesion, though a more detailed analysis is needed to draw definite conclusions. Low and medium-low technology sectors are roughly in line with the average level of concentration across all sectors, with the latter being slightly more concentrated. Our findings here are novel for the case of Germany, which also makes it more difficult to benchmark them. However, in their pan-European study Vitali et al. (2013) state that science-based sectors are less concentrated on average and our findings seem to contradict this, at least for the German case.[33] We will return to this tabulation in the next section where we discuss the global geography of sectors.

[33] Note that their study relies on the Pavitt taxonomy, which is not the same as our definition of technology groups.

Table 4.4: Pairwise correlation coefficients for sector variables

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Concentration (home) | 1.000 | | | | | | | | | | | | | | |
| 2 | Concentration (abroad) | -0.058 | 1.000 | | | | | | | | | | | | | |
| 3 | Concentration (entrants) | 0.890* | -0.106 | 1.000 | | | | | | | | | | | | |
| 4 | Total establishments | -0.211* | 0.244* | -0.207* | 1.000 | | | | | | | | | | | |
| 5 | Total employees | -0.194* | 0.020 | -0.200* | 0.524* | 1.000 | | | | | | | | | | |
| 6 | Labour intensity | -0.096 | -0.030 | -0.090 | 0.248* | 0.103 | 1.000 | | | | | | | | | |
| 7 | Productivity | 0.078 | -0.093 | 0.062 | -0.253* | 0.038 | -0.745* | 1.000 | | | | | | | | |
| 8 | Exports | -0.035 | -0.346* | -0.090 | -0.243* | 0.142 | 0.169 | 0.056 | 1.000 | | | | | | | |
| 9 | Size | -0.048 | -0.082 | -0.053 | -0.108 | 0.689* | -0.134 | 0.260* | 0.248* | 1.000 | | | | | | |
| 10 | Human capital | -0.138 | -0.403* | -0.114 | -0.226* | 0.266* | 0.062 | 0.304* | 0.639* | 0.397* | 1.000 | | | | | |
| 11 | Technology-intensity | -0.094 | -0.360* | -0.072 | 0.005 | 0.233* | 0.291* | -0.036 | 0.619* | 0.176* | 0.737* | 1.000 | | | | |
| 12 | Intermediates (own sector) | -0.119 | -0.037 | -0.124 | -0.081 | 0.089 | -0.314* | 0.270* | 0.069 | 0.164* | 0.282* | 0.076 | 1.000 | | | |
| 13 | Intermediates (domestic) | -0.008 | 0.131 | -0.017 | -0.108 | -0.062 | -0.539* | 0.403* | -0.287* | 0.063 | -0.087 | -0.352* | 0.684* | 1.000 | | |
| 14 | Intermediates (import) | -0.006 | -0.123 | 0.015 | -0.089 | 0.071 | -0.070 | 0.088 | 0.216* | 0.089 | 0.179* | 0.109 | -0.035 | -0.373* | 1.000 | |
| 15 | Intermediates (total) | -0.006 | 0.072 | -0.004 | -0.168* | -0.031 | -0.618* | 0.482* | -0.187* | 0.113 | 0.002 | -0.316* | 0.698* | 0.856* | 0.160 | 1.000 |

Notes: The * indicates a p-value $< 0.05$.

### 4.5.2 Location patterns of German firms abroad

Before comparing the spatial pattern of all German manufacturing establishments globally we again first discuss four sectors in more detail.[34] The maps are reported in Figure 4.12 and the corresponding K-density plots in Figure 4.13. Panels A to D show the low to high-tech sectors, respectively.[35]

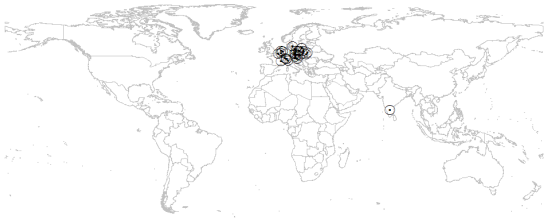
A look at the maps confirms that the hotspots of manufacturing activities by German MNEs are the United States and Europe. However, also significant differences across sectors are visible. Most markedly, establishments in the low-tech sector 'Corrugated paper' are exclusively located in Europe (mainly Poland and Czech Republic). This confirms the intuition of the data section that lower technology sectors mainly expand in Eastern Europe.[36] Again, looking at the plot of Kd in Figure 4.13 reveals the spatial pattern of a sector at specific distances. If we look at the envelope or confidence interval first we can see that the overall manufacturing pattern exhibits two concentration peaks, one around 10 km and a second around 100 km. In other words, most concentration takes place at low distances at around 10-20 km. At the same time however, also at larger distances establishments seem to be co-located, possibly due to proximity of clusters to each other. Looking at the solid line (Kd) then shows that 'Corrugated paper' is significantly concentrated at low distances. On the other hand the other three sectors plotted here significantly cluster around 30 - 50 km. Again, we need to keep in mind that the benchmark for each sector is overall distribution of German-owned manufacturing establishments globally. Hence, significant concentration of a sector needs to be read as *more concentrated than German-owned manufacturing activity globally*.

[34] As above we take the most concentrated sector of each technology group from Table 4.6.

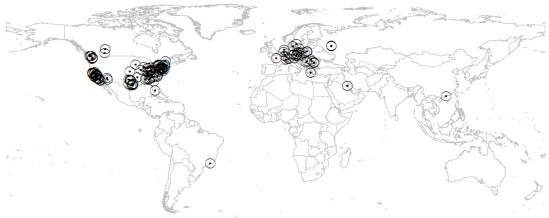
[35] Appendix 4.A.1, Figure 4.22 reproduces these maps for Europe only.

[36] Wassmann et al. (2016) discuss cost considerations as a driver for cooperation of firms in low and medium-low technology sectors in the Czech Republic particularly, though cooperation can involve various dimensions, including production.

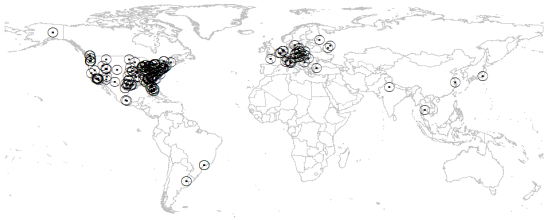
Figure 4.12: Maps of most concentrated sectors by technology group globally.



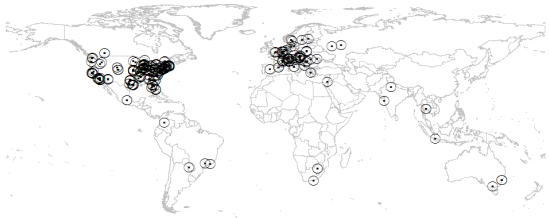
(a) Corrugated paper (N=29)



(b) Concrete & building material (N=174)

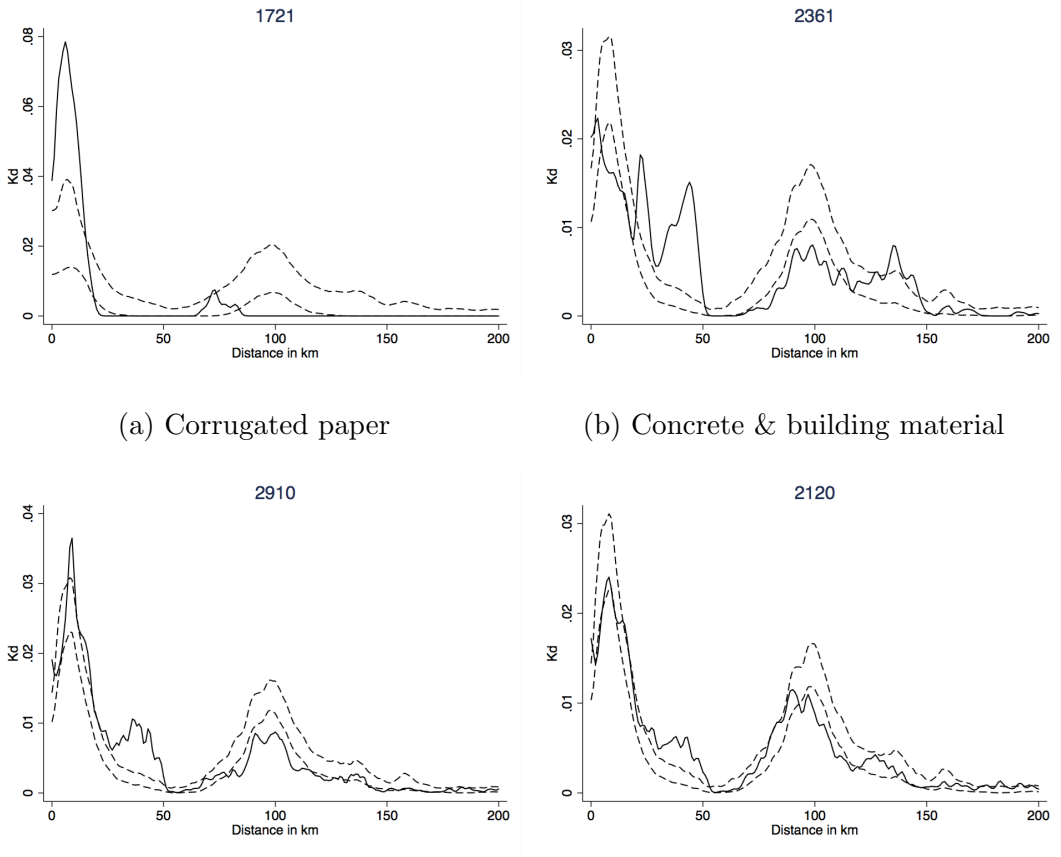


(c) Automotive (N=287)



(d) Pharmaceuticals (N=291)

Figure 4.13: K-densities for selected sectors globally




(a) Corrugated paper

(b) Concrete & building material

(c) Automotive

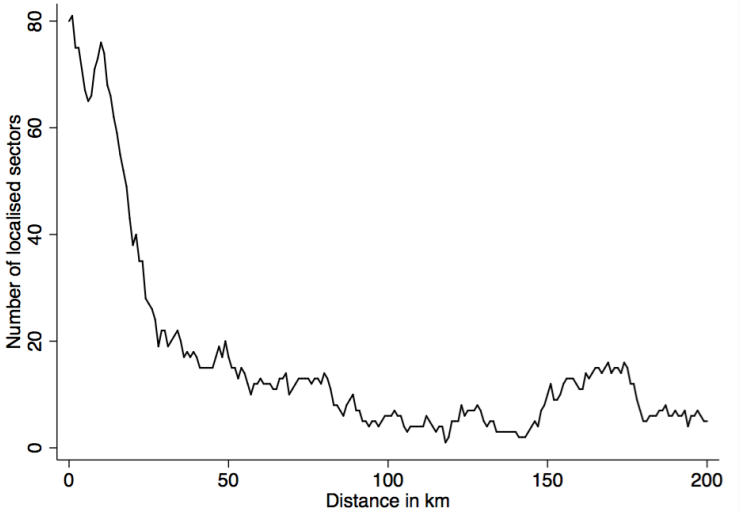
(d) Pharmaceuticals

When plotting the total number of sectors that are significantly concentrated at each distance band in Figure 4.14 we confirm that according to our data also at a global scale most concentration within sectors happens at low distances. In fact the number of concentrated sectors decreases rapidly after 20 km and much more so than within Germany where a more gradual decline is visible. One reason for the lower number of sectors that are concentrated abroad is that only 154 sector are actually internationalised with more than 10 establishments outside of Germany.[37] Hence at low distances up to 20 km still around 50% of internationalised sectors are significantly concentrated. The key take-away from the graph in the context

[37] Of the 71 sectors with less than 10 establishments outside of Germany in our data, 30 are low-tech, 31 medium-low, 8 medium-high and 2 high tech. The high tech sectors are 'Manufacture of magnetic and optic media (2680)' and 'Manufacture of electronic components (2611)'.

of our study is that there seem to be a few highly concentrated sectors at the global scale and this number drops abruptly rather than continuously as in the case for the domestic spatial patterns (shown above in Figure 4.10).

Figure 4.14: Number of significantly concentrated sectors by distance band abroad




Next we again look at Figure 4.11 where the CDF values for each sector are ranked from most to least concentrated, though focussing on the hollow dots that represent the global concentration of sectors. One of the most striking features is that though less sectors are concentrated abroad the level of concentration is generally higher. This is not surprising as a clustering by nationality and sector has been previously found in the literature (Head et al., 1995; Henisz and Delios, 2001; Crozet et al., 2004; Head and Mayer, 2004) and we are able to confirm it using very detailed information on the location of establishments. The most concentrated sector abroad is 'Manufacture of other knitted and crocheted apparel' with a value of 0.44. This is significant considering that at the global level there is a 44% chance that 2 randomly selected establishments in this sector are co-located within 200 km. Other highly concentrated sectors are 'Machining'; 'Manufacture of builders ware from plastic'; and 'Sawmilling and planing of wood'. A full list of the Top 25 most concentrated sectors abroad can be found in Table 4.12 in the Appendix 4.A.1. As no other study has previously explored the micro-patterns of internationalisation from a single country across a large number of sectors we

cannot compare our findings and leave it for future studies to explore this further.

In terms of sector heterogeneity a few interesting stylised facts emerge from the pairwise correlations (see Table 4.4). Sectors with a high human capital intensity are less concentrated abroad. This means that establishments with higher average skills tend to locate less closely to each other compared to overall German manufacturing globally. Further, sectors that generate a higher share of their turnover via exports (from Germany) are less concentrated globally. A possible explanation could be that establishments in these sectors operate as suppliers to spatially proximate buyers in the same sector. In fact the correlation coefficient of own sector intermediates for firms in these sectors is positive (r = 0.069) but insignificant.

Finally, lower technology sectors are significantly more concentrated abroad than higher technology sectors, confirming our central hypothesis established in Section 2. Our tabulation in Table 4.3 supports this as the average CDF for low-tech sectors is 0.19 and slightly lower for medium low at 0.154. Medium-high tech sectors have an average concentration of 0.082 and high-tech sectors only 0.06. This suggests that the global pattern of German manufacturing is driven by high and medium-high tech sectors, while sectors with a lower technology-intensity concentrate in few spatial clusters. Here we relate to the issue of firms and the need to possess specific capabilities or resources to overcome the uncertainty of locating in 'distant' markets. Our empirical findings show that firms active in less technologically advanced sectors are less able to spread globally and rather cluster in a few locations mainly in culturally and economically proximate Easters EU countries (Marin, 2004). This can be supported by the fact that higher technology intensity is positively associated with average firm size, level of human capital and export activity (see Table 4.4). All of these tend to be seen as determinants of firm internationalisation as highlighted e.g. in the international business literature on firm capabilities, advantages and international expansion (Hymer, 1960; Dunning, 1993; Markusen, 1995), as well as the concept of the product-life-cycle (Vernon, 1966). Especially Cantwell (1995) argues that international expansion is mainly driven by technological leaders. This location behaviour in Eastern Europe can also be explained by the possibility of German firms to relocate production facilities

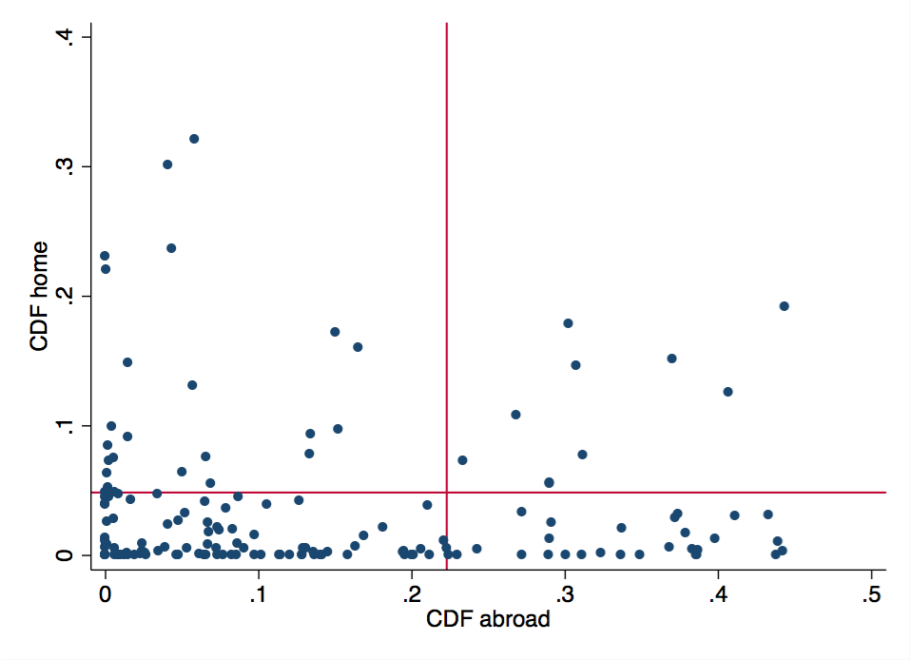
within an integrated economic area such as the EU in the absence of tariff and non-tariff barriers. Jovanović (2009) calls this an 'investment diversion effect' as firms "spatially rearrange production facilities" [p.277]. At the same time this can lead to trade creation effects if final or intermediate products are re-imported to Germany.

### 4.5.3 First insights from the integration of domestic and global spatial patterns of sectors

In the final step of this explorative empirical exercise we will directly compare the spatial pattern of industry sectors at home and globally. The natural question to ask would be whether sectors that are more concentrated at home are also more concentrated abroad. However, the spatial patterns of sectors are much more complex than that. Reviewing relevant studies as well as the empirical exploration of sector heterogeneity here has revealed that sectors are very difficult to put in 'boxes' with simple labels describing the factors associated with concentration or dispersion. A further complicating factor is that we only have a snapshot in time though studies have highlighted that the integration in global value chains has dynamic effects on the geography of sectors (Behrens and Bougna, 2015; Bade et al., 2015). However, we will address the latter point using information on the age of a sector and the spatial pattern of entering establishments as compared to established incumbents in the same sector.

A simple scatter plot of a sectors' concentration at home and abroad is provided in Figure 4.15. The horizontal and vertical lines separate the top quartile of the most concentrated sectors in each geography. The figure shows that the majority of sectors are not very concentrated at home or abroad, though, as highlighted above, the level of sector concentration is higher abroad. On the other hand a number of sectors are highly concentrated either at home or abroad, while only very few are both. To get a better understanding the role of technology we split the graph by technology group (see Figure 4.23, Appendix 4.A.1). This shows us that sectors with concentration at home and abroad are exclusively low and medium-low tech sectors (e.g. Basic food processing, Basic textiles and Basic

Figure 4.15: Scatter plot of concentration at home vs. abroad




metals). Medium-high sectors are among the least concentrated at home as well as abroad, with a few outliers abroad (Manufacture of: Wiring devices; Fluid power equipment; Plastics and rubber machinery; Electrical equipment for automotive). Sectors classified as high-tech are above average concentrated at home with one outlier abroad (Manufacture of loaded electric boards).

To better understand these 4 broad groups of sectors we explore the heterogeneity across sectors based on their characteristics. We group sectors based on the 4 quadrants visible in Figure 4.15. Following Bade et al. (2015) we are particularly interested in a potential 'integration', i.e. spatial concentration of sectors at home and the relation to international expansion. To test this further we focus specifically on employment growth in Germany since 2008 and the spatial pattern of entering compared to incumbent establishments. The spatial pattern of entering establishments is obtained by computing K-densities for all establishments that are incorporated after 2008 and using the spatial pattern of older incumbents in the same 4-digit sector as a benchmark (instead of overall manufacturing). The entry date is based on the incorporation date that ORBIS provides for each establishment. This method is well-established as we follow Nakajima et al. (2012),

Behrens and Bougna (2015) and Brakman et al. (2017).[38] Descriptives for the four quadrants and the full sample are presented in Table 4.5, including the level of concentration of entrants vs incumbents.

The first quadrant (high concentration at home and low concentration abroad) is characterised by a decline in employment at home since 2008 (-4.3%). At the same time on average these sectors have become more concentrated over time as indicated by the higher concentration of entrants as compared to incumbents in the same sector.[39] This interpretation of reducing employment at home, while integrating spatially is in line with the findings by Bade et al. (2015), though they look at specific business functions and more aggregated sectors. Also related is the study by Mitze (2014) who shows that import competition can have negative economic implications for some regions in Germany. In fact, sectors in this quadrant rely the most on imported intermediates in their final products. At the same time they are also among the youngest and most productive on average.

Sectors in the second quadrant are concentrated at home and abroad. On average they experienced a decrease in domestic employment, turnover and exports since 2008. At the same time they have a much a lower technology intensity and the average age of the establishments is the highest at 33.1 years. This group of sectors is also the least productive, with relatively old firms, low levels of human capital and firms rely more on intermediate inputs for the final product. The latter are also more likely to be purchased from their own sector. We can classify this group as concentrated domestically and globally, and increasingly so as entrants are likely to enhance concentration further. It is possible that firms in these sectors have off-shored some production facilities since on average employment in

[38] A full description of the computation of entrants vs. incumbents is provided in Appendix 4.A.2.

[39] Keep in mind that concentration of entrants needs to be interpreted with regards to the spatial pattern of establishments in the same 4-digit sector. Hence a 'significant' concentration means *more concentrated than incumbents in the same sector.*

Germany decreased significantly (-11%) since 2008 as did exports (-5%).[40] Since they rely on own-sector intermediates it is possible that they also form clusters when investing abroad. All in all it appears as if co-locating with firms in the same (low-tech) sector has an adverse economic impact on sectors. However, we cannot disentangle correlation from causation here and these sectors might be particularly threatened by globalisation or the financial crisis aftermath.

In the third quadrant we look at concentrated sectors abroad with little domestic concentration. Overall they generate a significantly lower share of their turnover from exports than sectors in the other three quadrants (only 28% compared to 40-45%). At the same time they also source less inputs via imports. This implies that firms are less integrated in global value chains or that produced goods are potentially difficult to ship and meant for local consumption.[41] This group can be classified as fragmented at home but concentrated abroad. Establishments in this sector are also significantly smaller and comparable to the second quadrant in terms of productivity and technology-intensity, though growth in turnover since 2008 has been considerable.

The fourth and final quadrant includes those sectors with little concentration in Germany as well as globally. Here we do not include sectors that are not internationalised at all, and hence only those with a minimum of 10 establishments located outside of Germany. Most sectors (i.e. 91) can be located in this quadrant and those are mainly medium-high tech with a relatively high level of productivity. At the same time they have the highest establishment size and level of exports as well as human capital. In terms of dynamics these sectors are not concentrating much further over time, while employment growth is the highest on average at 1.7%. Also turnover is increasing though this is not driven by domestically generated sales.

[40] Unfortunately official German data do not cover sales and exports from facilities abroad and the coverage in ORBIS is also incomplete preventing us to compute exports directly at the plant level.

[41] Among these sectors are Food processing (meat, vegetables, bread), Basic textiles, and Inputs for building construction (glass, concrete, stone, metal structures, wood and carpentry).

Table 4.5: Comparison of sector characteristics by concentration at home and abroad

| | Based on quadrants in Figure 4.15 | | | | |
|---|---|---|---|---|---|
| Sector characteristic | Top left | Top right | Bottom left | Bottom right | Full sample |
| Employment (growth) | -4.34 | -10.95 | 1.72 | 0.51 | -0.27 |
| Turnover (growth) | 2.66 | -12.71 | 5.83 | 9.43 | 4.81 |
| Domestic turn. (growth) | 2.80 | -16.74 | 1.76 | 6.61 | 1.59 |
| Exports (growth) | 10.36 | -5.03 | 11.03 | 14.60 | 10.52 |
| Concentration of entrants | 0.09 | 0.07 | 0.01 | 0.01 | 0.03 |
| Labour intensity | 0.17 | 0.18 | 0.18 | 0.18 | 0.18 |
| Productivity | 444.97 | 229.00 | 290.65 | 235.43 | 300.30 |
| Exports | 0.40 | 0.40 | 0.45 | 0.28 | 0.41 |
| Size | 152.97 | 148.75 | 231.41 | 110.16 | 190.98 |
| Human capital | 42.86 | 37.35 | 46.59 | 36.22 | 43.46 |
| Technology-intensity | 2.17 | 1.40 | 2.31 | 1.72 | 2.12 |
| Intermediates (own sector) | 15.14 | 17.48 | 16.56 | 15.41 | 16.18 |
| Intermediates (domestic) | 47.52 | 53.39 | 49.44 | 51.69 | 49.82 |
| Intermediates (imports) | 20.93 | 18.76 | 18.90 | 17.94 | 19.03 |
| Intermediates (total) | 68.98 | 72.70 | 68.81 | 70.14 | 69.34 |
| Sector age | 27.95 | 33.09 | 28.37 | 30.76 | 29.06 |
| N | 24 | 10 | 91 | 29 | 154 |

Notes: Technology-intensity ranges from 1 (lowest) to 4 (highest).

Figure 4.16: Summary of findings based on spatial patterns and sector characteristics

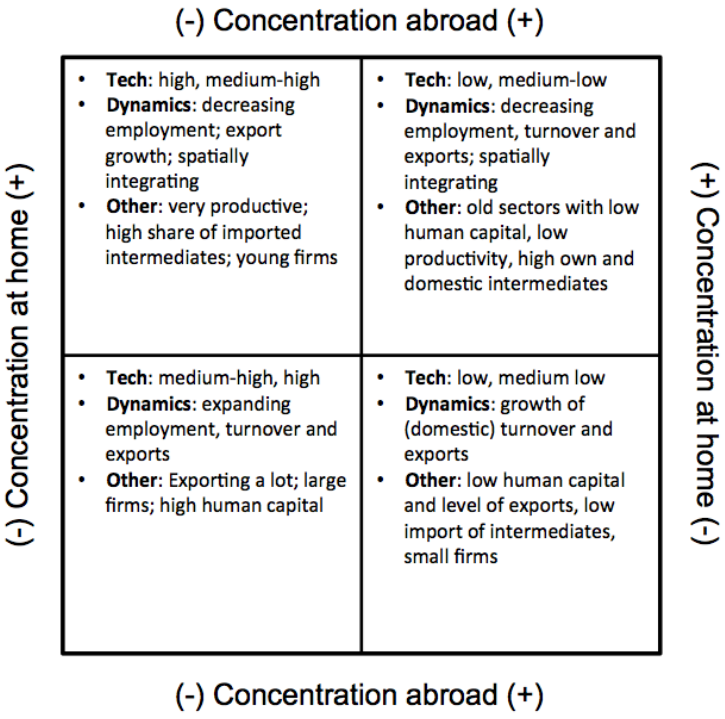
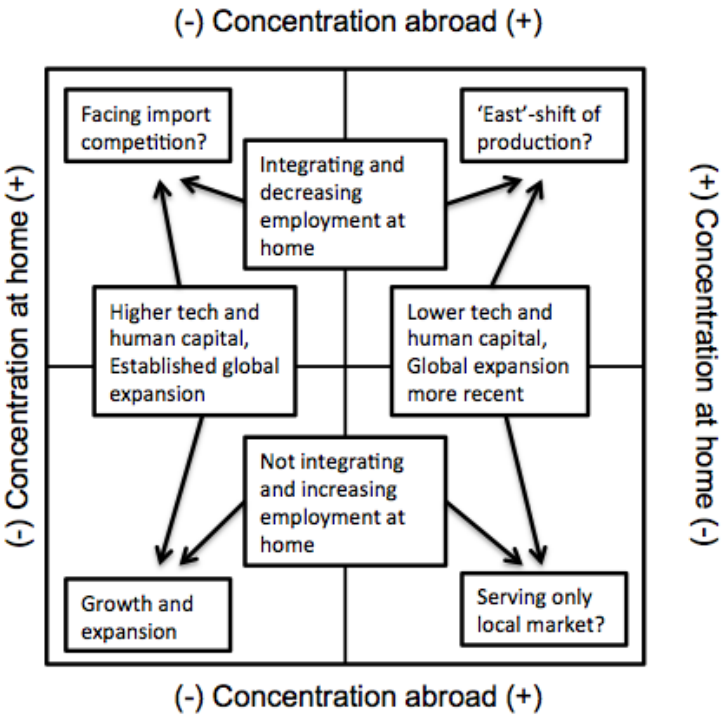


Figure 4.17: Stylisation of findings ('typology' of sectors)




We summarise our findings from this sector group comparison in Figure 4.16 and attempt to group sectors in a basic stylised typology of sectors in Figure 4.17. Here we acknowledge the difficulty to group sectors but we believe our categories are broad enough, keeping in mind that there will be significant outliers as well. As stated above, almost all concentrated sectors abroad are classified as low or medium-low technology with lower than average human capital and productivity. They are also almost exclusively located in Europe, and disproportionally in Central Eastern Europe. While our data do not support a more detailed analysis we speculate that these sectors internationalised relatively later possibly in line with European integration of CEE countries. The fact that they cluster could be related to a finding by Rugraff (2013) who observes that foreign MNEs in the Czech Republic do not engage much with local suppliers. Our data support this insofar as these sectors have an above average use of intermediates supplied by other domestic suppliers. A key difference between the upper and lower right quadrants is that establishments in the upper one experienced employment and turnover decrease in Germany, while spatially concentrating further. One reason could be that establishments outside of clusters closed down in recent years and

potentially got relocated abroad, in line with the study by Bade et al. (2015). Establishments in the lower right quadrant on the other hand are smaller and also import and export less. We speculate that they serve local markets, e.g. as suppliers or sellers of final goods.

Sectors on the left side of the typology graph are not concentrated abroad and more high or medium-high tech on average. They also tend to have a higher average level of human capital, productivity and size. In section 3 we demonstrated that they have significant presence in North America (as well as CEE) and generally tend to define the spatial pattern of German-owned manufacturing abroad. Also our findings in Chapter 3 hint in the same direction as larger firms were more likely to locate in North America. A key difference between the quadrants is that sectors in the upper one are more concentrated at home and continue to concentrate spatially. As sectors in the top right quadrant they are reducing employment in Germany though. The high share of imported intermediate goods supports the notion that suppliers to firms in these sectors may face import competition. Sectors in the bottom left quadrant are still growing strongly and exporting heavily. As discussed these are mainly medium-high tech sectors found to be the 'backbone' of the German economy, which could be an interesting finding for policymakers alike. Figure 4.17 is an attempt to stylise these findings further though these categories remain preliminary and in the best serve as a broad starting point for future research to look into.

## 4.6 Conclusion

This study has been explorative in nature. To the best of our knowledge it represents the first attempt to use geocoded data to directly compare the domestic and global spatial patterns of industry sectors for any country. After a brief review of Germany's competitiveness in manufacturing we discussed our choice of spatial indicators and highlighted key sources of heterogeneity in the spatial pattern of sectors at home and abroad. In a final step we integrated both and discussed a few stylised observations that observed from this exercise. As an increasing number of

studies looks at the domestic spatial pattern, less do so at a global scale and we think this is surprising if we accept that both are (increasingly) interconnected. Our study is a first attempt to nudge research in that direction. Below we first highlight our empirical findings and connect to the literature and then discuss some limitations and implications for future research.

### *Summary of findings and contribution to the literature*

Our empirical analysis shed new light on a number of aspects related to the domestic and global geography of industry sectors. First, while a number of studies explore the domestic spatial patterns across sectors, similar exercises at the global level are hard to find. Based on our analysis we have observed that also at the global level there is significant heterogeneity across the spatial pattern of sectors: While only around two thirds of sectors were globally active via foreign investment, the overall level of concentration is generally higher than at the domestic level (firms cluster by nationality and sector). Nevertheless we observe that there are a few very concentrated sectors, which also can be described as low- or medium-low in terms of technology-intensity. This stands in stark contrast to the higher level of concentration of high tech sectors within Germany. Previous studies have discussed how MNEs tend to locate away from domestic firms (Alcácer and Chung, 2007; Mariotti et al., 2010). Nevertheless they do not really highlight the importance of technology and we think that firms in lower technology sectors have more incentives to cluster abroad as they possibly face higher uncertainty due to lower levels of innovation and productivity (Cantwell, 1995; Alcácer and Chung, 2007; Cantwell, 2017). High tech firms on the other hand are more able to coordinate across space (Baldwin and Evenett, 2015; Brakman et al., 2015; Rezk et al., 2016).

Second, our study shows that these clusters of lower technology sectors are mainly in CEE countries, which are part of German MNEs regional value chains (Marin, 2004; Becker et al., 2005; Buch et al., 2007; Baldwin, 2013). This also resonated with research on other parts in the world such as the Pearl River Delta, where a significant spatial division of labour in relation to labour costs

and technology-intensity of products has been documented in detail (Revilla Diez et al., 2008; Meyer et al., 2012; Schiller et al., 2015). Marin (2004) also likened the dynamics to the 'maquiladoras' at US-Mexican border, which tend to export most of their products (Aitken et al., 1997). However, while the reasons and scope for German outsourcing have been explored elsewhere (Marin, 2004; Becker et al., 2005; Buch et al., 2007) we add the spatial picture as lower technology sectors seem to be more concentrated. This matters as it has been highlighted that foreign MNEs e.g. in the case of the Czech Republic, do not engage with local firms (Rugraff, 2013), which is a crucial element for knowledge and productivity spillovers to occur (Javorcik, 2004).

Third, medium-high tech sectors were not very concentrated at home or globally. At the same time our review of German manufacturing competitiveness highlighted their crucial importance for the German economy, often described as the 'backbone'. We confirm that these sectors quite literally drive the spatial structure or geography of German manufacturing at home as well as globally (as they are less concentrated). From a policy perspective this could be an interesting insight as less concentration could be related to territorial cohesion, though we would ideally need a comparison across countries that have more centralised economic structures (France, UK) as well as developing countries. Regarding the literature we add to both of the main streams that provided us with conceptual and empirical inspirations. The first looks at the agglomeration of sectors and relevant drivers of concentration between establishments (Duranton and Overman, 2005; Nakajima et al., 2012; Koh and Riedel, 2014; Behrens and Bougna, 2015; Bade et al., 2015; Brakman et al., 2017). We think that adding the technological dimension immensely improves the analytical power of these studies. Since technological intensity has been found to matter to explain concentration (Brülhart, 1998; Haaland et al., 1999; Combes and Overman, 2004) it is important to distinguish it in more than high- vs. low and also separate domestic and global concentrations as we highlighted in detail. The second stream of related studies highlights the strategic nature of international expansions and that firms closely account for location decisions of competitors from the same sector and country (Mariotti et al., 2010; Alcácer et al., 2013; Alfaro and Chen, 2014; Alcácer et al.,

2015; Alcácer and Delgado, 2016). We add that the level of technology plays a role as well as lower technology firms might be less able to locate away from competitors, or potentially rely more on supplier linkages. Related to this is novel research by Alcácer and Delgado (2016) who show that high tech firms rely less on inter-firm and more on intra-firm linkages and agglomeration.

Fourth, by correlating levels of concentration with sector characteristics, and also splitting sectors by technology groups we provide some additional stylised findings. While these remain largely speculative we underpin them with data or references to the literature wherever possible. What emerged was that there are four broad groups in terms of their geographical patterns, which we could qualify further. We found that various factors matter beyond the average level of technology. Among these some are static and some are dynamic and we want to underline that it is crucial to distinguish both also in the case of sectoral concentrations. While we advocate to look at both together as levels as well as changes play a role depending on the specific research questions. The former include the share of exports in total turnover, level of imported intermediate goods and human capital, and the latter encompassed employment and export growth (or decline), as well as whether a sector is further concentrating over time. For example, in the German context it has been found that increasing concentration can be associated with decreasing employment and outsourcing (Bade et al., 2015). Our findings somewhat support this. In the case of Canada, Behrens et al. (2015) corroborate that import competition leads to less concentration as firms rely less on local agglomerations. We do not have sufficient data to support this in the German case, though for example research by Mitze (2014) holds that import competition can have adverse effects on German regions. It would be interesting to look at these in relation to shifting technological paradigms and implications for localised knowledge spillovers, in addition to static measures of technology-intensity as we have done here. Related to this is a study by Wassmann et al. (2016) who investigate local and extra-local cooperation and partnerships of low tech firms in Bavaria. They find that cooperating with more distant partners is associated with more product innovation, while local cooperation matters for non-technological innovations.

*Limitations and implications for future research*

Our chapter also has limitations that should be addressed by future studies. Mainly because it remains a static analysis based on a snapshot of the spatial pattern of industry sectors. This is despite our efforts to compute the growth rate of employment and other variables and looking at the spatial pattern of entrants as compared to incumbents. We believe that the work on multinationals using geocoded data for their global locations is just at the beginning and will see increasing applications in the near future. We advocate for accounting for the spatial pattern and characteristics of sectors in their home country as well, as both are intrinsically connected. Another interesting application of our data is to compare the co-agglomeration of sectors based on the classification of primary and secondary activities of establishments, which is provided in our data.[42] This could tell us more about the linkages between sectors, as most firms are active across a number of sectors (also services). This brings us to the second point as due to different dynamics and spatial patterns (Koh and Riedel, 2014; Brakman et al., 2017) our study does not cover service sectors at all. Nakajima et al. (2012) show that service sectors have a higher level of concentration, though relatively fewer are concentrated in the first place. This is a relevant issue for regional development as for example Schiller et al. (2015) demonstrate that developing service sectors in a place is complex, as the transition from manufacturing to services is not straightforward but requires specific institutions and high skilled labour. Nevertheless, simpler service activities have been found to relocate (Meyer et al., 2012; Schiller et al., 2015).

The present study does not distinguish the ownership of establishments in Germany. It is likely that the dynamics look different for establishments that are owned by purely domestic firms as compared to those owned by German outward investors or foreign inward investors. While the implications for our comparison to the global geography are potentially minimal we think that this is a fruitful avenue to explore. Here also a more direct integration and analysis

[42] Appendix 4.A.2 explains this idea in more detail.

of exports and imports, e.g connected to the rise of China (Autor et al., 2013) would he interesting to explore further. For example Behrens et al. (2015) show that import competition is associated with decreasing concentration in Canada. In the German case Dauth et al. (2014) demonstrate that the rise of the 'East' leads to job losses in regions with sectors that face import competition. At the same time regions with export-oriented sectors experienced growth. Combining their findings with a spatial perspective as in the Canadian case has not been done so far but sounds like a promising project. Equally interesting would be to add a spatial perspective to their latest study on the impact of robots on labour markets in Germany (Dauth et al., 2017) as they find that employment does not benefit from a concentration of robots. Potentially, traditional agglomeration forces are changing in that sense that robots are not as susceptible to them as human workers.

Future research should further discuss the spatial evolution of sectors based on entrants using insights from evolutionary economic geography where especially start-ups, spinoffs (Helfat and Liebrman, 2002; Golman and Klepper, 2016) and 'related variety' between firms are central themes (Boschma and Wenting, 2007; Boschma and Iammarino, 2009). Especially our focus on the global spatial pattern could be of interest to researchers in this field as so far they mainly study single countries and sectors such as automotives (Klepper, 2001, 2007). Here the researcher could ideally also overcome another shortcoming of our study and weight establishments by employment as firm size is a key factor in these evolutionary dynamics.

# 4.A Appendix

## 4.A.1 Additional tables and figures

Figure 4.18: Share of manufacturing in intermediate consumption for selected countries, 1995-2015. (Source: calculation based on OECD data)

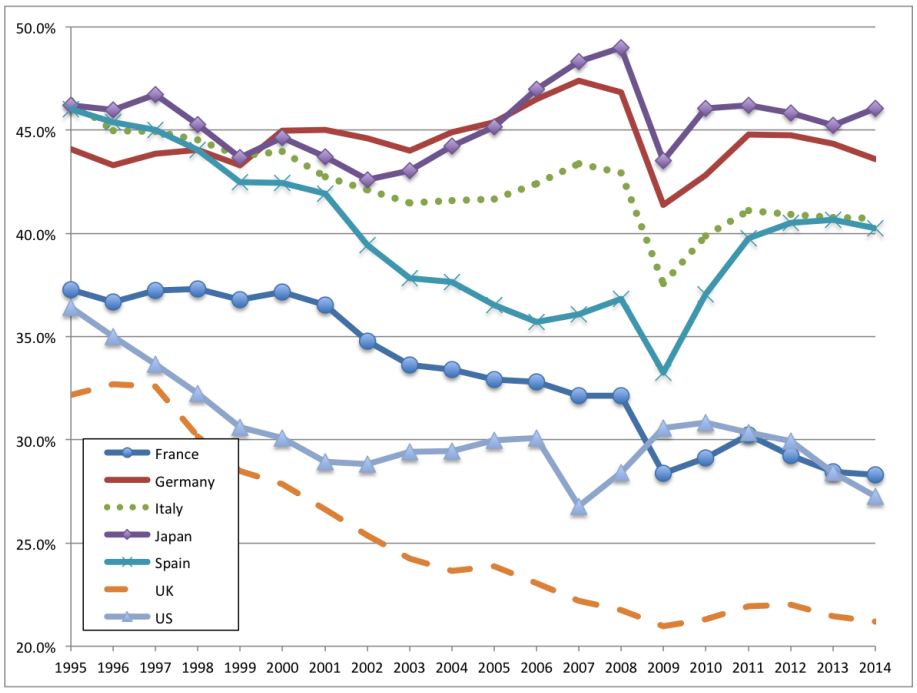
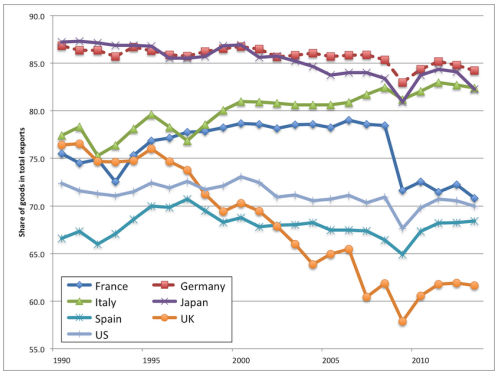
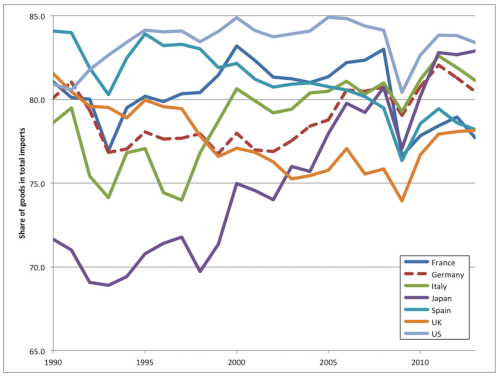


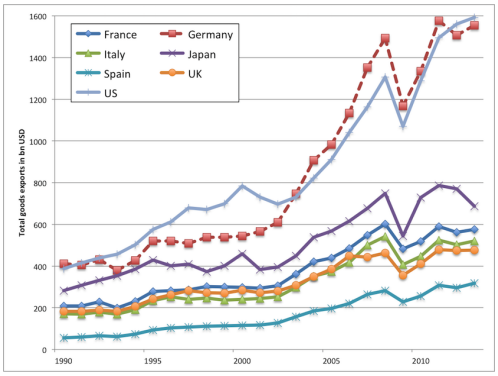
Figure 4.19: Comparison of relative and absolute manufacturing exports and imports for selected countries, 1990-2015 (Source: calculation based on UNCTAD data)



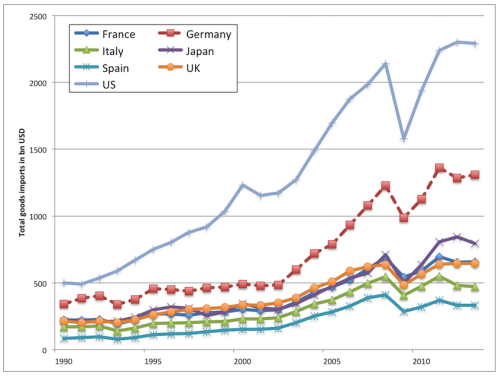

(a) Share in total exports




(b) Share in total imports

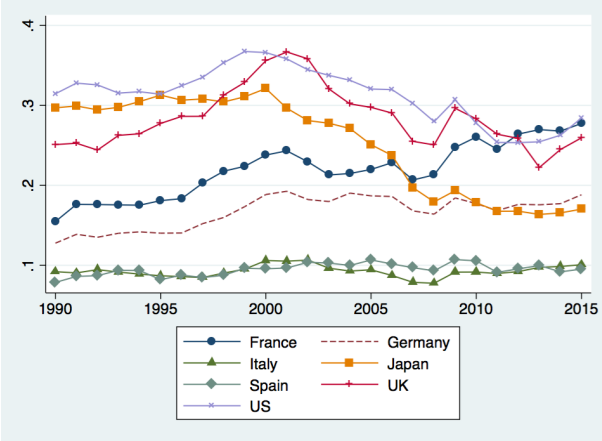



(c) Total goods exports (bn $)

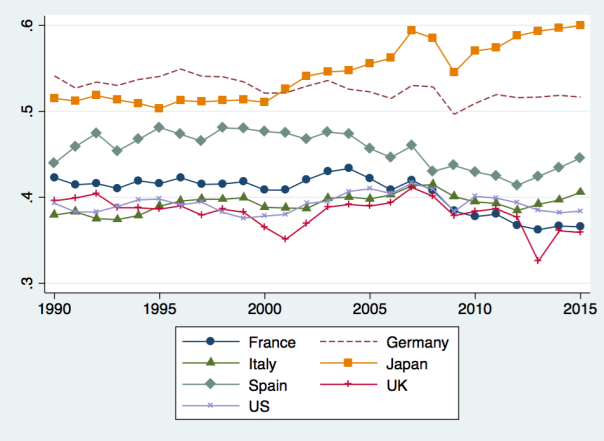



(d) Total goods imports (bn $)

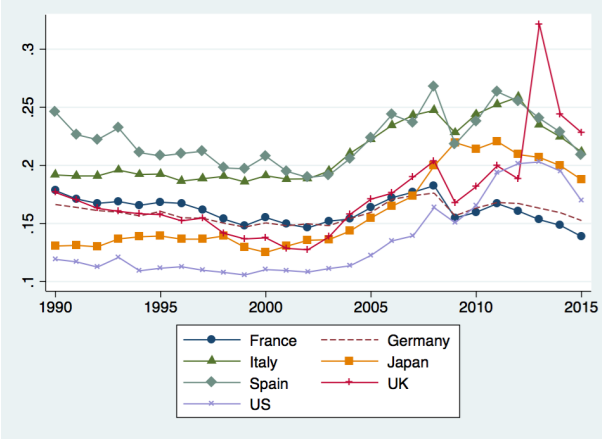
Figure 4.20: Comparison of goods export shares by technology intensity for selected countries, 1990-2015. (Source: calculation based on OECD data)



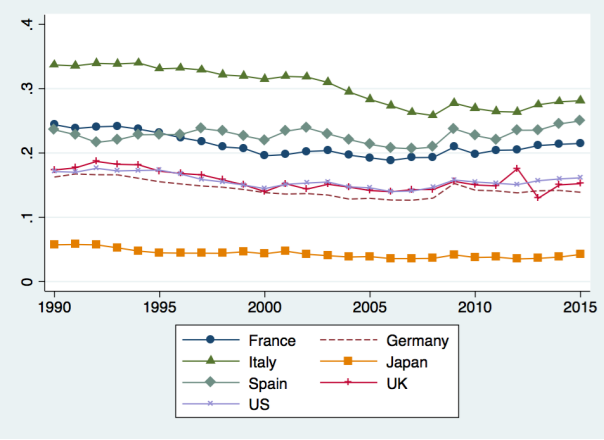

(a) High




(b) Medium-high

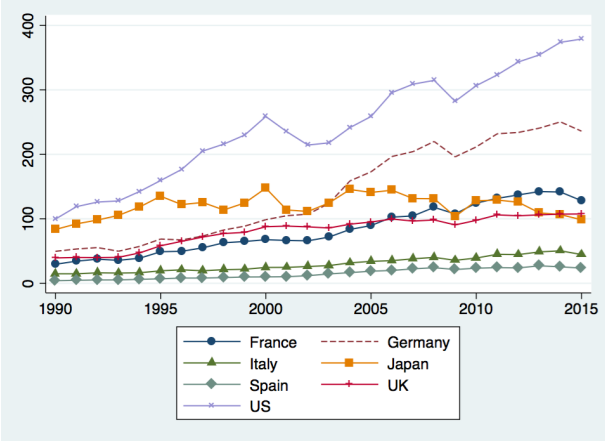



(c) Medium-low

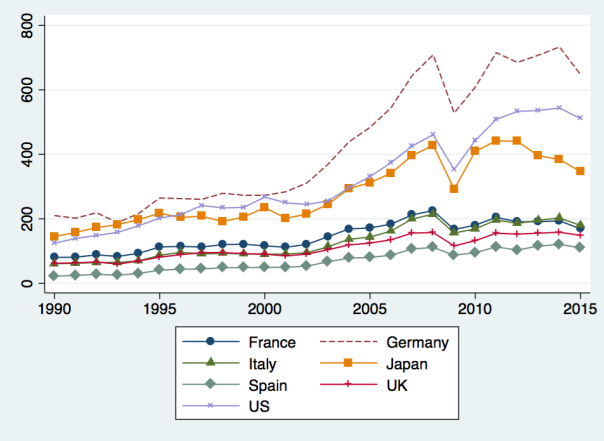



(d) Low

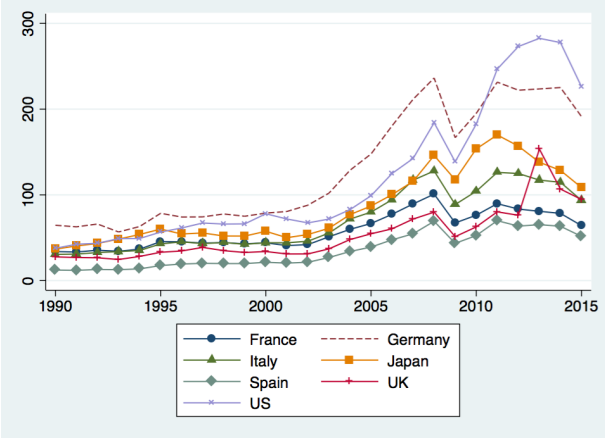
Figure 4.21: Comparison of goods exports value by technology intensity for selected countries, 1990-2015 (Source: calculation based on OECD data)



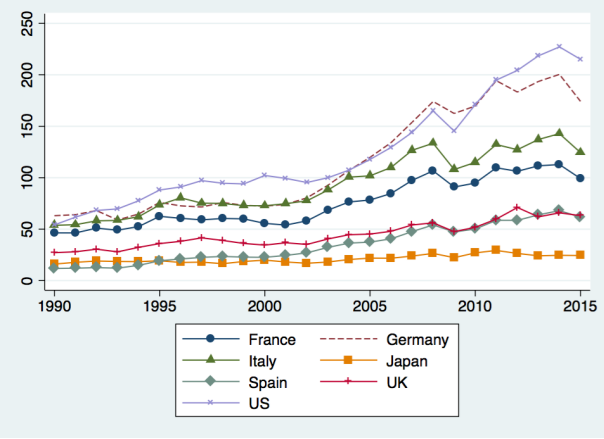

(a) High




(b) Medium-high




(c) Medium-low




(d) Low

Table 4.6: Characteristics of largest 4-digit sector per 2-digit sector class

| Code | Description | Emp. share | Emp. growth | Turn. share | Turn growth | Size index | Wage | Produc-tivity | Unit size | Unit growth | For. turn. share | For. turn. growth | Tech |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1071 | Manufacture of bread, fresh pastry goods, cakes | 2.84% | 9.4% | 0.91% | 21.9% | 1.87% | 20,227 | 94,282 | 72.5 | -1.4% | 5.3% | 46.9% | L |
| 1105 | Manufacture of beer | 0.44% | -9.4% | 0.44% | -4.4% | 0.44% | 43,930 | 290,246 | 106.2 | -14.5% | 11.2% | 41.3% | L |
| 1200 | Manufacture of tobacco products | 0.16% | 3.0% | 0.70% | 1.5% | 0.43% | 60,348 | 1,265,185 | 378.9 | -3.7% | 12.3% | -5.4% | L |
| 1396 | Manuf. of other technical and industrial textiles | 0.22% | 9.8% | 0.15% | 42.1% | 0.18% | 39,068 | 201,715 | 102.8 | 4.1% | 60.4% | 62.1% | L |
| 1413 | Manufacture of other outerwear | 0.24% | -24.1% | 0.26% | -11.5% | 0.25% | 38,386 | 320,767 | 147.6 | -41.7% | 43.0% | -15.2% | L |
| 1520 | Manufacture of footwear | 0.23% | 19.9% | 0.15% | 22.2% | 0.19% | 35,451 | 192,835 | 212.7 | -17.5% | 22.9% | -7.9% | L |
| 1623 | Manuf. of other builders' carpentry and joinery | 0.58% | 4.4% | 0.34% | 15.7% | 0.46% | 33,994 | 171,912 | 78.5 | -1.5% | 11.6% | -26.0% | L |
| 1721 | Manuf. of corrugated paper, paperboard etc. | 0.87% | -0.4% | 0.65% | 4.1% | 0.76% | 37,035 | 220,423 | 118.6 | -3.7% | 23.8% | -1.0% | L |
| 1812 | Other printing | 1.15% | -16.9% | 0.65% | -15.7% | 0.90% | 34,306 | 167,622 | 76.2 | -20.2% | 13.4% | -16.4% | L |
| 1920 | Manufacture of refined petroleum products | 0.29% | -10.7% | 3.75% | -27.6% | 2.02% | 71,904 | 3,840,731 | 276.7 | 0.0% | | | ML |
| 2014 | Manufacture of other organic basic chemicals | 1.41% | 103.2% | 2.70% | 79.7% | 2.05% | 68,821 | 562,035 | 566.7 | -3.2% | 69.6% | 99.6% | MH |
| 2120 | Manufacture of pharmaceutical preparations | 1.80% | -2.4% | 2.53% | 19.3% | 2.16% | 59,343 | 414,125 | 385.0 | 5.6% | 64.7% | 27.4% | HI |
| 2229 | Manufacture of other plastic products | 2.41% | 5.7% | 1.29% | 20.9% | 1.85% | 34,523 | 157,224 | 104.1 | 5.0% | 33.2% | 36.0% | ML |
| 2361 | Manuf. of concrete products for constr. purposes | 0.63% | 4.1% | 0.39% | 15.6% | 0.51% | 35,188 | 183,530 | 50.8 | -0.4% | 6.0% | -13.5% | ML |
| 2410 | Manuf. of basic iron and steel and of ferro-alloys | 1.22% | -4.4% | 1.72% | -27.2% | 1.47% | 51,470 | 416,263 | 803.1 | -1.1% | 33.5% | -25.5% | ML |
| 2550 | Forging, pressing, stamping, roll-forming of metal | 1.86% | 4.2% | 1.17% | 5.8% | 1.52% | 41,154 | 185,053 | 125.1 | 8.1% | 32.3% | 17.4% | ML |
| 2651 | Manuf. of instr. for measuring,testing, navigation | 2.19% | 19.6% | 1.50% | 28.5% | 1.85% | 51,340 | 201,397 | 136.9 | 13.0% | 57.3% | 39.7% | HI |
| 2712 | Manuf. of electricity distrib., control apparatus | 2.07% | 3.0% | 1.47% | 15.5% | 1.77% | 52,530 | 209,321 | 186.3 | 5.2% | 49.4% | 41.7% | MH |
| 2811 | Manuf. of engines,turbines, ex. aircraft eng. etc. | 1.94% | 10.8% | 1.95% | 28.7% | 1.95% | 61,239 | 295,368 | 741.4 | -12.6% | 65.3% | 26.4% | MH |
| 2910 | Manufacture of motor vehicles | 7.66% | 11.2% | 17.87% | 25.8% | 12.76% | 71,136 | 686,020 | 4553.9 | -3.8% | 71.9% | 34.7% | MH |
| 3030 | Manuf. of air and spacecraft and related machinery | 1.18% | 27.2% | 1.48% | 69.1% | 1.33% | 68,493 | 369,935 | 685.1 | 36.8% | 70.6% | 57.4% | HI |
| 3109 | Manufacture of other furniture | 0.86% | -17.4% | 0.51% | -6.0% | 0.68% | 34,617 | 174,400 | 97.0 | -10.5% | 31.0% | 16.8% | L |
| 3250 | Manuf. of medical and dental instruments, supplies | 1.83% | 21.4% | 1.10% | 37.9% | 1.47% | 40,445 | 177,199 | 94.4 | 8.2% | 56.4% | 49.8% | MH |
| 3299 | Other manufacturing n.e.c. | 0.23% | -16.5% | 0.14% | -3.2% | 0.19% | 36,919 | 183,487 | 95.8 | -5.2% | 48.6% | 3.6% | L |
| 3320 | Installation of industrial machinery and equipment | 1.39% | 1.9% | 0.83% | -1.9% | 1.11% | 48,308 | 175,207 | 88.1 | -2.0% | 22.7% | -5.3% | ML |

Notes: Calculations based on Destatis data for 2015. Growth figures refer to the period 2008-15. Technology groups: L = Low, ML = Medium-Low, MH = Medium-High, H = High.

Table 4.7: Number of German-owned business units globally by country and technology group

| Country | High-tech | Med.-high tech | Med.-low tech | Low-tech | All | Cumul. |
|---|---|---|---|---|---|---|
| United States | 654 (52.15%) | 1383 (33.44%) | 642 (24.04%) | 291 (16.67%) | 2970(30.29%) | 30.29% |
| Czech Republic | 39 (3.11%) | 298 (7.21%) | 346 (12.96%) | 169 (9.68%) | 852 (8.69%) | 38.98% |
| Poland | 32 (2.55%) | 210 (5.08%) | 313 (11.72%) | 228 (13.06%) | 783 (7.98%) | 46.96% |
| Romania | 33 (2.63%) | 182 (4.40%) | 176 (6.59%) | 274 (15.69%) | 665 (6.78%) | 53.74% |
| Switzerland | 69 (5.50%) | 176 (4.26%) | 80 (3.00%) | 53 (3.04%) | 378 (3.85%) | 57.60% |
| Austria | 44 (3.51%) | 125 (3.02%) | 123 (4.61%) | 78 (4.47%) | 370 (3.77%) | 61.37% |
| Italy | 34 (2.71%) | 197 (4.76%) | 83 (3.11%) | 36 (2.06%) | 350 (3.57%) | 64.94% |
| UK | 20 (1.59%) | 138 (3.34%) | 72 (2.70%) | 76 (4.35%) | 306 (3.12%) | 68.06% |
| France | 25 (1.99%) | 129 (3.12%) | 105 (3.93%) | 47 (2.69%) | 306 (3.12%) | 71.18% |
| Netherlands | 31 (2.47%) | 103 (2.49%) | 54 (2.02%) | 80 (4.58%) | 268 (2.73%) | 73.91% |
| Slovakia | 8 (0.64%) | 87 (2.10%) | 108 (4.04%) | 59 (3.38%) | 262 (2.67%) | 76.59% |
| Canada | 59 (4.70%) | 105 (2.54%) | 65 (2.43%) | 26 (1.49%) | 255 (2.60%) | 79.19% |
| Russia | 23 (1.83%) | 67 (1.62%) | 43 (1.61%) | 30 (1.72%) | 163 (1.66%) | 80.85% |
| Australia | 13 (1.04%) | 65 (1.57%) | 32 (1.20%) | 31 (1.78%) | 141 (1.44%) | 82.29% |
| Spain | 11 (0.88%) | 64 (1.55%) | 37 (1.39%) | 27 (1.55%) | 139 (1.42%) | 83.70% |
| Belgium | 12 (0.96%) | 54 (1.31%) | 36 (1.35%) | 17 (0.97%) | 119 (1.21%) | 84.92% |
| Denmark | 10 (0.80%) | 55 (1.33%) | 28 (1.05%) | 24 (1.37%) | 117 (1.19%) | 86.11% |
| Brazil | 9 (0.72%) | 92 (2.22%) | 13 (0.49%) | 3 (0.17%) | 117 (1.19%) | 87.30% |
| China | 12 (0.96%) | 89 (2.15%) | 10 (0.37%) | 3 (0.17%) | 114 (1.16%) | 88.47% |
| Turkey | 1 (0.08%) | 51 (1.23%) | 34 (1.27%) | 9 (0.52%) | 95 (0.97%) | 89.44% |
| India | 9 (0.72%) | 49 (1.18%) | 13 (0.49%) | 8 (0.46%) | 79 (0.81%) | 90.24% |
| Serbia | 6 (0.48%) | 23 (0.56%) | 26 (0.97%) | 13 (0.74%) | 68 (0.69%) | 90.93% |
| Luxmbourg | 5 (0.40%) | 23 (0.56%) | 21 (0.79%) | 18 (1.03%) | 67 (0.68%) | 91.62% |
| Mexico | 5 (0.40%) | 41 (0.99%) | 13 (0.49%) | 7 (0.40%) | 66 (0.67%) | 92.29% |
| Sweden | 8 (0.64%) | 33 (0.80%) | 17 (0.64%) | 4 (0.23%) | 62 (0.63%) | 92.92% |
| Hungary | 6 (0.48%) | 21 (0.51%) | 22 (0.82%) | 6 (0.34%) | 55 (0.56%) | 93.48% |
| Slovenia | 3 (0.24%) | 17 (0.41%) | 20 (0.75%) | 4 (0.23%) | 44 (0.45%) | 93.93% |
| Japan | 5 (0.40%) | 32 (0.77%) | 6 (0.22%) | 1 (0.06%) | 44 (0.45%) | 94.38% |
| South Africa | 5 (0.40%) | 22 (0.53%) | 5 (0.19%) | 8 (0.46%) | 40 (0.41%) | 94.79% |
| Portugal | 3 (0.24%) | 11 (0.27%) | 11 (0.41%) | 14 (0.80%) | 39 (0.40%) | 95.19% |
| (...) | | | | | | |
| North America | 713 (56.86%) | 1488 (35.98%) | 707 (26.48%) | 317 (18.16%) | 3225 (32.89%) | 32.89% |
| CE Eur. | 165 (13.16%) | 1005 (24.30%) | 1138(42.62%) | 857 (49.08%) | 3165 (32.28%) | 65.16% |
| Western Europe | 284 (22.65%) | 1148 (27.76%) | 697 (26.10%) | 487 (27.89%) | 2616 (26.68%) | 91.84% |
| Asia | 48 (3.83%) | 222 (5.37%) | 49 (1.84%) | 24 (1.37%) | 343 (3.50%) | 95.34% |
| Latin America | 21 (1.67%) | 166 (4.01%) | 32 (1.20%) | 16 (0.92%) | 235 (2.40%) | 97.74% |
| Ocania | 13 (1.04%) | 72 (1.74%) | 33 (1.24%) | 34 (1.95%) | 152 (1.55%) | 99.29% |
| Africa | 7 (0.56%) | 27 (0.65%) | 7 (0.26%) | 9 (0.52%) | 50 (0.51%) | 99.80% |
| Middle East | 3 (0.24%) | 8 (0.19%) | 7 (0.26%) | 2 (0.11%) | 20 (0.20%) | 100.00% |
| Total | 1,254 (100.00%) | 4,136 (100.00%) | 2,670 (100.00%) | 1,746 (100.00%) | 9,806 (100.00%) | 100.00% |

Notes: The total number is lower than in Table 4.2 as we drop sectors with less than 10 establishments.

Table 4.8: Summary of factors driving the concentration of sectors

| Indicator | Description | Aggregation | Year | Source |
|---|---|---|---|---|
| Total establishments | Count of establishments by sector | 4-digit | 2015 | Destatis: Annual report on local units in manuf. |
| Total employees | Count of employees by sector | 4-digit | 2015 | Destatis: Annual report on local units in manuf. |
| Employment growth | Growth rate 2008-15 | 4-digit | 2015 | Destatis: Annual report on local units in manuf. |
| Labour intensity | Share of wages in turnover | 4-digit | 2015 | Destatis: Annual report on local units in manuf. |
| Productivity | Turnover per employee in EUR | 4-digit | 2015 | Destatis: Annual report on local units in manuf. |
| Exports | Share of exports in turnover | 4-digit | 2015 | Destatis: Annual report on local units in manuf. |
| Size | Employees per establishment | 4-digit | 2015 | Destatis: Annual report on local units in manuf. |
| Human capital intensity | Wage per employee in EUR | 4-digit | 2015 | Destatis: Annual report on local units in manuf. |
| Technology-intensity | High - low (4 classes) | 3-digit | 2016 | OECD: Taxonomy of economic activities based on R&D intensity |
| Intermediates (own sector) | Share of inputs from own sector in turnover | 2-digit | 2012 | Destatis Input-Output table 2012 |
| Intermediates (domestic) | Share of domestic inputs in turnover | 2-digit | 2012 | Destatis Input-Output table 2012 |
| Intermediates (import) | Share of imported inputs in turnover | 2-digit | 2012 | Destatis Input-Output table 2012 |
| Intermediates (total) | Share of total inputs in turnover | 2-digit | 2012 | Destatis Input-Output table 2012 |
| Sector age | Years since incorporation (mean, median) | 4-digit | 2014 | Bureau van Dijk: ORBIS |

Table 4.9: Number of business units in Germany by selected 4-digit sectors

| Code | Name | Units |
|---|---|---|
| 1071 | Manufacture of bread, fresh pastry goods, cakes | 16493 |
| 3250 | Manuf. of medical and dental instruments, supplies | 9758 |
| 1812 | Other printing | 7094 |
| 1623 | Manuf. of other builders' carpentry and joinery | 5004 |
| 2651 | Manuf. of instr. for measuring,testing, navigation | 4771 |
| 2229 | Manufacture of other plastic products | 3363 |
| 3109 | Manufacture of other furniture | 2481 |
| 3320 | Installation of industrial machinery and equipment | 2383 |
| 3299 | Other manufacturing n.e.c. | 2352 |
| 2361 | Manuf. of concrete products for constr. purposes | 2026 |
| 2712 | Manuf. of electricity distrib., control apparatus | 1584 |
| 2550 | Forging, pressing, stamping, roll-forming of metal | 1464 |
| 2120 | Manufacture of pharmaceutical preparations | 1232 |
| 1105 | Manufacture of beer | 1157 |
| 1721 | Manuf. of corrugated paper, paperboard etc. | 952 |
| 1413 | Manufacture of other outerwear | 880 |
| 2811 | Manuf. of engines,turbines, ex. aircraft eng. etc. | 559 |
| 2910 | Manufacture of motor vehicles | 519 |
| 2014 | Manufacture of other organic basic chemicals | 482 |
| 2410 | Manuf. of basic iron and steel and of ferro-alloys | 416 |
| 1920 | Manufacture of refined petroleum products | 385 |
| (...) | | |
| Total | | 211,722 |

Table 4.10: Number of German-owned business units globally by selected 4-digit sectors

| Code | Name | Units |
|---|---|---|
| 2932 | Manuf. of other parts, access. for motor vehicles | 711 |
| 2611 | Manufacture of electronic components | 430 |
| 2120 | Manufacture of pharmaceutical preparations | 291 |
| 2910 | Manufacture of motor vehicles | 287 |
| 2030 | Manuf. of paints, varnishes, similar coatings etc. | 282 |
| 2899 | Manuf. of other special-purpose machinery n.e.c. | 278 |
| 2229 | Manufacture of other plastic products | 249 |
| 2452 | Casting of steel | 225 |
| 2651 | Manuf. of instr. for measuring,testing, navigation | 222 |
| 2599 | Manuf. of other fabricated metal products n.e.c. | 217 |
| 2829 | Manuf. of other general-purpose machinery n.e.c. | 200 |
| 3250 | Manuf. of medical and dental instruments, supplies | 200 |
| 2511 | Manuf. of metal structures and parts of structures | 177 |
| 2361 | Manuf. of concrete products for constr. purposes | 174 |
| 2562 | Machining | 173 |
| 2219 | Manufacture of other rubber products | 172 |
| 2059 | Manufacture of other chemical products n.e.c. | 162 |
| 2790 | Manufacture of other electrical equipment | 142 |
| 2561 | Treatment and coating of metals | 135 |
| 3299 | Other manufacturing n.e.c. | 131 |
| (...) | | |
| Total | | 9,806 |

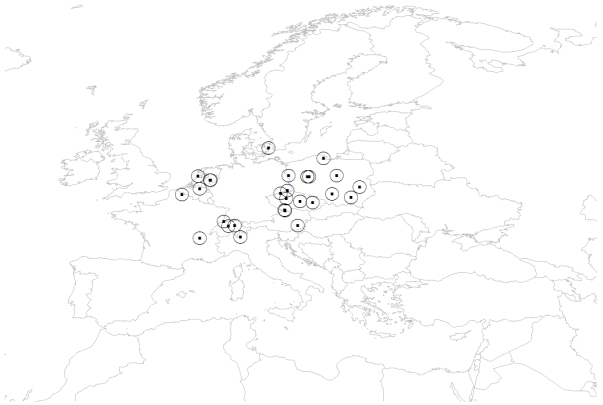
Table 4.11: Top 25 most concentrated sectors at home

| | Sector | Kd |
|---|---|---|
| 1 | Manufacture of cutlery | 0.744 |
| 2 | Cold rolling of narrow strip | 0.543 |
| 3 | Manufacture of watches and clocks | 0.321 |
| 4 | Cold drawing of wire | 0.301 |
| 5 | Building of pleasure and sporting boats | 0.267 |
| 6 | Manufacture of wine from grape | 0.237 |
| 7 | Manufacture of jewellery and related articles | 0.231 |
| 8 | Repair and maintenance of ships and boats | 0.223 |
| 9 | Processing,preserving of fish,crustaceans,molluscs | 0.220 |
| 10 | Cold forming or folding | 0.206 |
| 11 | Manuf. of imitation jewellery and related articles | 0.201 |
| 12 | Manufacture of other knitted and crocheted apparel | 0.192 |
| 13 | Manufacture of ice cream | 0.179 |
| 14 | Cold drawing of bars | 0.176 |
| 15 | Manufacture of prepared feeds for farm animals | 0.172 |
| 16 | Reproduction of recorded media | 0.160 |
| 17 | Manufacture of locks and hinges | 0.152 |
| 18 | Manufacture of magnetic and optical media | 0.151 |
| 19 | Operation of dairies and cheese making | 0.149 |
| 20 | Weaving of textiles | 0.147 |
| 21 | Building of ships and floating structures | 0.131 |
| 22 | Casting of steel | 0.126 |
| 23 | Manufacture of knitted and crocheted fabrics | 0.117 |
| 24 | Processing and preserving of poultry meat | 0.116 |
| 25 | Manufacture of refractory products | 0.108 |

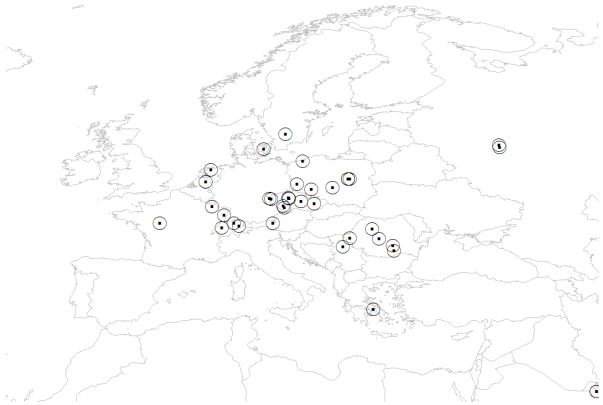
Table 4.12: Top 25 most concentrated sectors abroad

| | Sector | Kd |
|---|---|---|
| 1 | Manufacture of other knitted and crocheted apparel | 0.443 |
| 2 | Machining | 0.442 |
| 3 | Manufacture of builders' ware of plastic | 0.439 |
| 4 | Sawmilling and planing of wood | 0.438 |
| 5 | Manufacture of other food products n.e.c. | 0.433 |
| 6 | Manuf. of metal structures and parts of structures | 0.411 |
| 7 | Casting of steel | 0.407 |
| 8 | Manufacture of workwear | 0.398 |
| 9 | Manufacture of wiring devices | 0.387 |
| 10 | Manufacture of fluid power equipment | 0.386 |
| 11 | Manuf. of corrugated paper, paperboard etc. | 0.386 |
| 12 | Manufacture of plastics and rubber machinery | 0.383 |
| 13 | Manuf. of other builders' carpentry and joinery | 0.379 |
| 14 | Manufacture of other outerwear | 0.374 |
| 15 | Manufacture of footwear | 0.372 |
| 16 | Manufacture of locks and hinges | 0.370 |
| 17 | Manufacture of bread, fresh pastry goods, cakes | 0.368 |
| 18 | Manufacture of fruit and vegetable juice | 0.349 |
| 19 | Treatment and coating of metals | 0.337 |
| 20 | Manuf. of other products of wood, cork, straw etc. | 0.337 |
| 21 | Shaping and processing of flat glass | 0.323 |
| 22 | Manuf. of tubes, pipes, hollow profiles, of steel | 0.312 |
| 23 | Manuf. of made-up textile articles, except apparel | 0.311 |
| 24 | Weaving of textiles | 0.307 |
| 25 | Manufacture of ice cream | 0.302 |

Figure 4.22: Maps of most concentrated sectors by technology group in Europe.

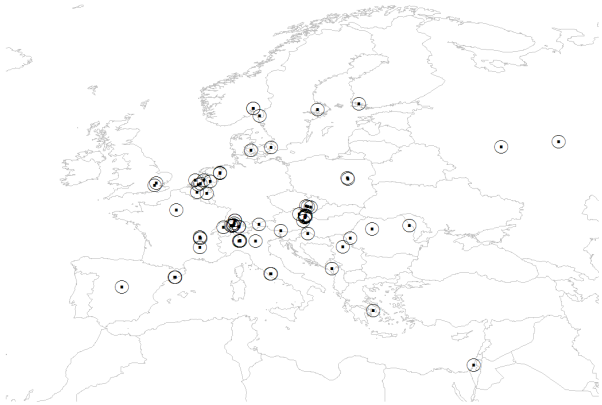


(a) Corrugated paper (N=28)



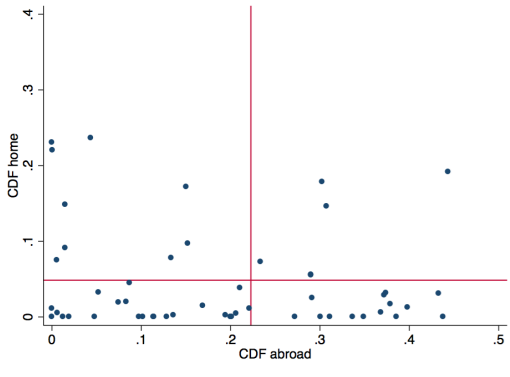
(b) Concrete (N=33)

(c) Automotive (N=38)

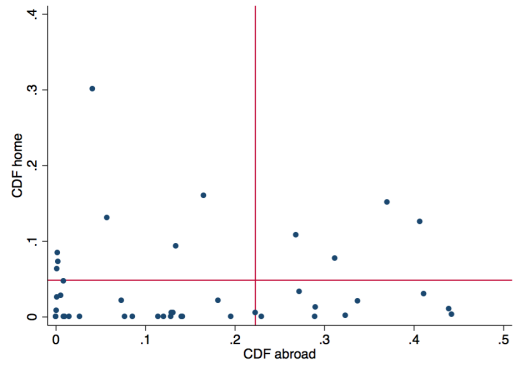


(d) Pharmaceuticals (N=70)

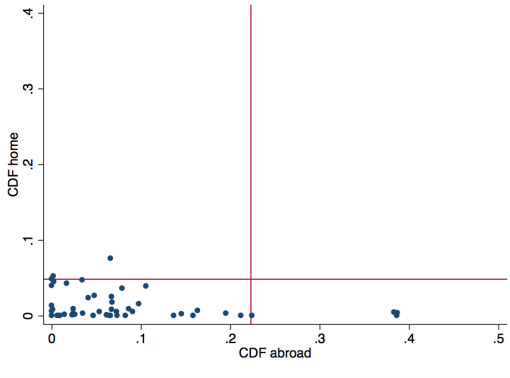
Figure 4.23: Scatter plot of concentration at home vs. abroad by technology group



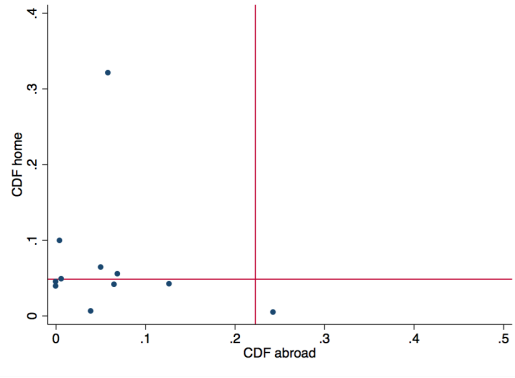

(a) Low




(b) Medium-low




(c) Medium-high




(d) High

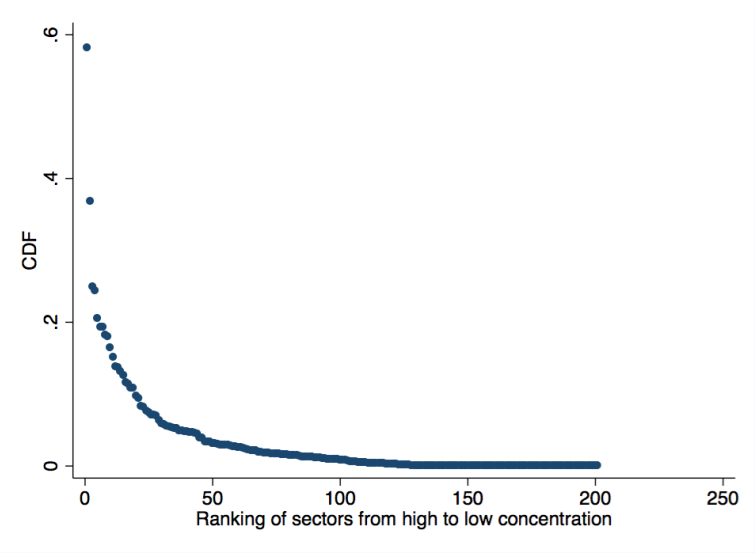
### 4.A.2 Discussion of K-densities for entrants vs. incumbents

The analysis to this point has been mainly static based on data for 2015. To get a feeling for dynamics we classify establishments as 'entrants' or 'incumbents' based on their date of incorporation. This is also done by Nakajima et al. (2012) who use 10 years since incorporation as the cutoff date. For consistence with our sector characteristics we choose 2008 as the cutoff year for the definition of entrants. We can then calculate the K-densities for each sector only for entrants and use the geography of incumbents as a benchmark to see whether a sector is concentrating over time or not. The same method is applied by Behrens and Bougna (2015) for the Canadian case and Brakman et al. (2017) for China. Also Duranton and Overman (2008) perform a similar analysis as they can observe when plants enter into their dataset.

We plot our findings based on a ranking of sectors from most to least concentrated in Figure 4.24. Unfortunately the number of entrants abroad is too low for a similar analysis. As in Brakman et al. (2017) the analysis is restricted to sectors with a minimum of 10 entrants. Our results indicate that entering establishments in around 140 sectors seem to be more concentrated than incumbents at some distance up to 200km. Nevertheless the actual CDF value can be quite small and only 94 sectors have value above 0.01. Going further up the rank to a value of 0.1, only in 19 sectors entrants are more concentrated than incumbents.

Future research could discuss the spatial evolution of sectors using insights from evolutionary economic geography where of start-ups, spinoffs (Helfat and Liebrman, 2002; Golman and Klepper, 2016) and 'related variety' between firms is a central theme (Boschma and Wenting, 2007; Boschma and Iammarino, 2009). Especially our focus on the global spatial pattern could be of interest to researchers in this field as so far they mainly study single countries and sectors such as automotives (Klepper, 2007, 2001).

Figure 4.24: Ranking of sectors by concentration of entrants vs. incumbents in the same 4-digit sector in Germany



### 4.A.3 Primary and secondary activities of firms and co-agglomeration patterns

We propose to look at the larger geography of a sector by looking not only at primary but also secondary activities of firms, which are provided by our dataset. Classifying the activity of firms is complex and many firms are active in a number of sectors simultaneously. For example, does Volkswagen only manufacture vehicles as classification 2910 suggests or also manufacture coachwork and other accessories as classifications 2920 and 2932 imply? This is not a trivial distinction as spatial patterns are typically measured at 4-digit classifications they might actually under- or overestimate the level of localisation in a sector depending on the pattern of the wider sector. One way to address this concern would be to aggregate to e.g. 2- or 3-digit classifications, however this would mean losing a lot of information on the sector. It would also not capture the fact that some firms perform similar or related tasks but do not operate in the same 2- or 3-digit sector. Duranton and Overman (2005) aggregate to 3-digit sectors and find that localisation patterns take place at a larger distance closer to a typical region when compared to 4-digit sectors. However they conclude that the 4-digit sector is more appropriate overall. Our data provide a different solution as ORBIS reports also the secondary sectors of activity of firms. Going back to our example of Volkswagen we can now see that it is also involved in sectors 2920 (Manufacture of coachwork for motor vehicles) and 2932 (Manufacture of other parts for motor vehicles) but also 7711 (Renting and leasing of cars). On a basic level this allows us to compare the 'narrow' and the 'wide' geography of a sector much more precisely than previously. If firms are evidently active in more than one sector this should affect the agglomeration patterns of that sector as well and we want to explore this. On the other hand this also provides an opportunity to look deeper into the questions of 'related variety' (Boschma and Iammarino, 2009) at the plant rather than regional level.

Here we also relate to studies that use geocoded data of establishments to estimate the coagglomeration between sectors for various countries (Duranton and Overman, 2008; Ellison et al., 2010; Faggio et al., 2017) including Germany (Falck et al., 2014). The most comprehensive studies explore the Canadian case (Behrens,

2016; Behrens and Guillain, 2017). Most of these studies test for the three Marshallian types of spillovers: input-output linkages are generally approximated by input shares from input-output tables, labour market pooling by occupation statistics on shared labour inputs, and knowledge spillovers by co-patenting or patent citations. Input-output relations are generally found to explain most of coagglomeration. Using information on secondary activities would allow for an interesting comparison of coagglomeration between establishments that operate in two sectors at the same time as compared to the input-output approach.

# Chapter 5

# Conclusion

This thesis has explored the regional and sectoral factors that are associated with the internationalisation of German firms. It represents a comprehensive analysis of these patterns as we explore the heterogeneity across firms, regions and sectors, as well as foreign destinations. In this concluding section we will briefly discuss the wider implications for policy and academic research, also growing out of our limitations.

Broadly speaking our empirical analyses shed new light on the geography of firm internationalisations - both in the home country of the firm and globally. The introductory chapter has outlined our conceptual framework and in doing so integrated studies from various literatures. We discussed how firms can rely on local proximity to MNEs to aide their foreign expansions. The analysis in Chapter 2 confirmed this empirically, and highlighted that different forms of proximity matter (spatial, technological, cultural). Our findings are original and could be seen as a contribution to the discourse on the source of heterogeneity in firm internationalisation (Castellani and Zanfei, 2007). Furthermore, we hypothesised that ties between regions and destinations can also influence the directionality of outward investments. The application of a choice model setting in Chapter 3 has provided supporting evidence for this and highlighted further that larger firms locate in more distant destinations. While this underlines the broader findings from Chapter 2 together they also hold some relevance for policy. We showed that international linkages in some regions (i.e. MNEs and migrants) can be leveraged

by expanding firms, which in turn reinforce these linkages. This means they can be seen as path-dependent 'pipelines' (Bathelt et al., 2004) with implications for endogenous regional growth and (slow) convergence as discussed by Martin and Sunley (1998) and more recently Crescenzi and Iammarino (2017).

Nevertheless these empirical chapters are not without limitations. One issue is that we obviously do not observe what is happening inside the firm itself. We presented some theoretical discussion of the channels we think can be at work and acknowledged that internationalisation decisions are complex and firm-specific. Nevertheless firms are embedded in an external environment and previous studies have shown that firms do react to external conditions and actions of competitors. Hence, while we do not claim a causal link here we show that there is a strong association that is robust across the use of different spatial and sectoral aggregations, specification of proxy variables and sample splits. We can think of two major directions for follow-up studies to explore this phenomenon further, though they do not come without caveats themselves. First, a detailed case study of a specific sector or few sectors based on a survey and interviews to question MNEs about the importance of home location factors. Second, a large panel of MNEs covering their foreign expansions for a good part of their sectors' product-life-cycle. However, as this controls for time-invariant (region-sector) factors it is questionable how much variation is left in the data as regional characteristics evolve generally at a slow pace.

In chapters 2 and 3 our findings revealed that especially the region-sector proximity to other German MNEs matters for extensive and intensive margins of outward investments. This is picked up in Chapter 4 where we compare the global location decisions of German firms within a sector to the general global spatial pattern of German manufacturing firms. We find that significant clustering of firms within a 4-digit sector also takes place at the global scale. The literature exploring the micro location patterns of MNE establishments is only beginning to emerge (Alfaro and Chen, 2014; Duranton and Kerr, 2015; Alcácer and Zhao, 2016). We see our study as an early contribution to these and highlight the importance of differentiating levels of technology in addition to a shared nationality and industry sector as key determinants of their spatial pattern.

In chapter 4 we show additionally that firms in low tech sectors appear to cluster much more globally than higher tech firms, and also more than they do domestically. This finding - though it needs to be explored further - adds to the general literature on firm internationalisation. A large number of studies demonstrates that productivity and ownership advantages are generally found to be key determinants of foreign expansions by firms (Hymer, 1960; Dunning, 1971; Bernard and Jensen, 1995; Helpman et al., 2004; Arnold and Hussinger, 2010), while firms tend to cluster by sector and nationality (Head et al., 1995; Crozet et al., 2004). Based on these we offer the tentative interpretation that lower tech firms find it more difficult to internationalise and hence exhibit a higher degree of spatial concentration. This can be supported by Alcácer and Delgado (2016) who show that high tech firms rely more on intra- rather than inter-firm agglomerations. However, we can also discuss this phenomenon on the background of the product-life-cycle (Vernon, 1971, 1979) as firms in lower tech sectors could be at an earlier stage of internationalisation and hence have not established themselves in many markets. Nevertheless also a combination of both is plausible and hence we need further research to look into these.

Chapter 4 also has a few shortcomings that we want to draw the readers' attention on. As common in this literature stream it precludes service sectors entirely from the analysis, as service firms follow different dynamics (Koh and Riedel, 2014). While some exhibit high levels of concentration (e.g. finance), many others are highly dispersed by definition (e.g. hairdressers, petrol stations). A similar imposition of spatial structure does not exist to such a degree in manufacturing. A detailed description of the manufacturing industry in Germany has furthermore confirmed the large importance it has for the international competitiveness of the country. As this can nevertheless impact our external validity we think future research should also explore the global locations of service firms in a similar vein. Another limitation is again the static nature of the data, as spatial patterns of sectors do change over time (Behrens and Bougna, 2015). This is important as some sectors started to offshore production much earlier than others and possibly this is associated with the level of concentration abroad. While we partially address this via the incorporation date we think more can be

done in that respect. Similarly as we outlined in the chapter itself we believe that future research should address the co-agglomeration across sectors. If this is based on establishment level data it would be truly novel for the agglomeration literature that uses these type of geocoded indices and it could shed new light on how firms interact across sectors.

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