**London School of Economics and Political Science**

# *Essays in International Trade and Investment*

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A thesis submitted to the Department of Economics of the London School of Economics and Political Science for the degree of Doctor of Philosophy

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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 other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).



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Chapter 2, **"The Role of Management Practices in Acquisitions and FDI"**, makes use of confidential data collected by the UK Office for National Statistics and securely provided by the UK Data Service. The following disclaimer applies: This work contains statistical data from the ONS, which is Crown Copyright. The use of ONS statistical data does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. This work uses research datasets which may not exactly reproduce National Statistics aggregates.

None of the information on individual German banks in Chapter 3, **"Evidence on the International Transmission of Crises Through Multinational Firms"**, was provided by the German Central Bank. The research proposal was approved by Commerzbank.

## Abstract

The first chapter of the thesis investigates the effect of trade on the size distribution of firms. I collected historical data between 1882 and 1907 from the German Empire to address this question. I can then match three data sets according to the same geographic boundaries: industry census data, railway trade data, and waterway trade data. The key findings are that trade integration impacts the firm size distribution heterogeneously across five size categories. I find evidence of a hierarchical and stark shift in employment and firm share from the smallest toward larger firm size categories. A "Bartik" instrument is proposed to argue that the correlations described are indeed causal. I provide evidence for a fall in transport costs and technology adoption as mechanisms to explain the stylized facts observed in the data.

The second chapter studies how management practices as intangible assets are associated with performance of multinational business groups. I show that management practices of parents and affiliates are positively correlated. I use acquisitions as an event-study and find that better managed parents improve productivity in their acquisition targets. In the cross-section, better parent management practices are positively correlated with affiliate size and productivity. The positive correlation between parent management practices and affiliate productivity is strengthened when the affiliate is in the first level of the corporate hierarchy or when the source country is more developed than the destination country in terms of income.

The third chapter examines whether multinational firms transmit the effects of a localized banking crisis to countries all over the world. An exogenous shock to the credit supply of multinational parent corporations located in Germany is identified. The shock to parents caused a reduction in the sales of their international affiliates for three years. Unique data on linkages between parents and affiliates are used to study the transmission mechanism from parents' credit supply to affiliates' sales. Both financial and real channels played a role: Parents withdrew equity from their affiliates, reduced intra-firm trade with affiliates, and required more long-term lending from the affiliates. The results improve our understanding of the internal operations of multinational firms and suggest that they contribute to global business cycle synchronization.

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# Chapter 1

# Trade and the Size Distribution of Firms: Evidence from the German Empire

## 1.1 Introduction

During the recent past firms have been in the focus of research in international trade. It has been shown in multiple studies that exporters perform better than non-exporters, who only serve the domestic market. Exporters are known to be more productive, larger in employment and sales, more skill- and capital intensive, and pay higher wages (Bernard et al. 2007).

In light of these findings, Melitz (2003) shows in a seminal theoretical work, how trade liberalization leads to a reallocation of labor from less productive to more productive firms when firms are heterogeneous in productivity. When countries open up to trade, only the most productive firms can overcome the fixed costs of exporting to enter foreign markets, and unproductive firms are driven out of the market by competition from foreign firms (selection channel). This gives rise to aggregate productivity and welfare gains through cross firm resource reallocation (Melitz and Redding 2015).

Subsequently, a large body of research in the literature on firm heterogeneity and trade has shown that firms can be induced to adopt a technology by export opportunities (Costantini and Melitz 2007; Bustos 2011). Firms, which export, can expand their market size. The fixed cost of adopting a technology can be amortized and the productivity cutoff for technology adoption decreases.

The increasing availability of firm-level data sets has transformed empirical evidence in international trade. The research field of international trade has - with few exceptions -

perhaps surprisingly made rarely use of historical firm-level data. In this paper, I exploit historical industry census data, which aggregate firm-level surveys to the regional level, to shed light on firm heterogeneity and trade in the context of the first wave of globalization in the German Empire between 1882 and 1907. The German Empire was a particularly relevant nation state in the period as it became the second largest economy in international trade by the end of the period. The degree of trade openness of the German Empire in 1913 was only reached again sixty years later. The historical context is particularly well-suited as international trade integration was driven by a fall in transport cost (Jacks, Meissner, and Novy 2010). In addition to falling international transport costs, I provide evidence for a fall in domestic transport costs.

In this paper, I address two research questions: What is the effect of trade integration on the size distribution of firms? Secondly, I investigate the underlying mechanism: Does closer trade integration lead to endogenous productivity upgrading through technology adoption?

To this end, I make use of three data sources: industry census data and trade data for transport modes railway and waterway that are all available at the administrative state level. I harmonize the data sets according to seventeen districts within the German Empire. Industry census data provide rich information on firms' employment and technology (motor usage) at the district level.

Firms in the industry census data are classified according to their size in five categories that range from small firms (less than 6 employees) to large firms (more than 200 employees). I document a heterogeneous treatment effect of trade integration across different size categories in the firm size distribution. My main finding is that trade induced a hierarchical and stark shift in firm and employment share along the five size categories from small toward large firms. To address reverse causality, I propose a "Bartik-Instrument" (the shift-share instrument) to argue that the correlations described are indeed causal.

Empirical studies have proven ample evidence in support of the reallocation effects of trade liberalization and found substantial productivity growth from reallocation. Pavcnik (2002) investigates the effect of trade liberalization in Chile on productivity growth. She finds that aggregate productivity grew by 25.4 and 31.9 percent in the export and import sectors respectively. The author shows that most of the productivity improvement can be explained by the reallocation of market shares and resources from fewer to more productive plants. Trefler (2004) studies the effect of the Canada-US free trade agreement on Canada and reports that labor productivity increased by 6 percent.

Axtell (2001) finds that the firm size distribution in the US is characterized by the Zipf distribution. Di Giovanni, Levchenko, and Rancière (2011) present a model which shows that international trade systematically affects power law estimates and claim that power law estimates which do not take into account international trade could be misleading. The authors find a higher power law coefficient for French exporters than for non-exporters for both measures of firm size. Atack, Haines, and Margo (2011) use historical manufacturing census data from 1850-1870 and find that access to the railroad had a positive causal effect on the share of firms with factory status (establishments with 16 or more workers) at the US county level. However, their data do not allow them to study the distributional consequences of market integration on the firm size distribution as I contribute in this study.

My first contribution to this literature is to provide causal evidence for the Melitz (2003) selection channel in the historical context of the first wave of globalization. Trade affects the allocation of resources across firms by shifting resources toward larger firms. In addition, I provide evidence for a productivity premium of larger firms.[1] A shift-share instrument that makes use of the regional industry variation of the data set is proposed for identification. The instrument assigns the aggregate trend in trade openness in all other districts to a district to predict changes of a district in trade openness in each industry. The estimation results are robust to different variations of the instrument.

As a second step, I suggest technology upgrading as an underlying mechanism how larger firms become more productive endogenously. Empirical evidence in several countries shows that there is a complementarity between entry into export markets and the adoption of technology (Verhoogen 2008; Lileeva and Trefler 2010; Bustos 2011). The period studied is not only known as first wave of globalization, but also as the second industrial revolution. Increased usage of motorized machinery as a substitute for handwork led to substantial productivity gains in industries in this period. I provide exemplifying evidence that this investment constituted a substantial fixed cost. I investigate the effects of market integration on technology adoption of existing technologies as well as a newly available technology in this period: the electric motor, which became a substitute for steam engine toward the end of the nineteenth century. My second contribution in line with the literature on trade and technology adoption is to describe a further channel through which trade triggered productivity gains: trade affected the endogenous adoption decision of existing technologies as well as contributed to the diffusion of a new technology.

The remainder of this paper is organized as follows: First I provide an overview of the historical setting. Then, I describe the data in more detail and present the estimation results. Finally, I discuss the underlying mechanisms for the empirical findings and conclude.

[1] In the canonical Melitz model firm size is perfectly correlated with productivity.

## 1.2 Historical Context

Before 1871 German-speaking countries were organized in a loose association of 39 states, the German Confederation. The German Empire was unified politically in 1871 following the Franco-Prussian war. The period I am considering falls into the first wave of globalization, a key period in the economic development of the German Empire.[2] Between 1882 and 1907, real GDP per capita grew at an annual rate of approximately 1.9 percent.[3] The German Empire became the second largest economy in terms of GDP in the world by 1908.

This impressive economic development coincided with a period of rapid trade integration. Most notably was the extension of transport infrastructure. The size of the railway network expanded by 71.3 percent from 32,797 km in 1882 to 56,191 km in 1907.[4] By this time the network was the largest in Europe. Between 1882 and 1907 transportation on railways steadily rose from 105,000 tons to 295,000 tons which implies an annualized growth rate of 4.6 percent.[5]

Investment in the waterway canal system was almost as high as for railways. According to Wehler (2007), more than 1,000 km of canals were newly constructed between 1880 and 1914. For example, the Dortmund-Ems Canal was completed in 1899 and could support ships with a capacity of more than 1,000 tons. Formerly built up canals were modernized to support ships with higher capacity, which was a necessity for waterways to remain competitive to railways. Kunz, Laake, and Nitsch (1999) document that the length of water canals, which could support more than 100 tons, increased from 6,600 km (1874) to approximately 10,000 km (1914). The average capacity of ships surged between 1877 and 1912 by 256 percent (from 80 tons per ship to 285 tons per ship).[6] The share of trade on waterways in relation to all trade rose from 21 percent in 1875 to 25 percent in 1910, i.e. the trade volume on waterways grew quicker than the volume on railways.[6] The rapid expansion of trade volume is even more remarkable in comparison to France which was the fourth largest economy in the world in 1882. As reported by Sympher (1913), the shipment measured in trillion tonne kilometers grew between 1880 and 1905 at an annualized growth rate of 5.9 percent on waterway in the German Empire whereas

[2]Chronological placements of the first wave of globalization vary in the literature. The end of the period is generally characterized by the year before the outbreak of World War I (1913). Jacks, Meissner, and Novy (2010) define the period as 1870-1913, i.e. their chronological placement includes 1882 to 1907. Hereafter, I follow their chronological definition.

[3]Calculated from Maddison Historical GDP Database on 10/12/2015: www.worldeconomics.com/Data/MadisonHistoricalGDP/MadisonHistoricalGDPData.efp.

[4]One mile is approximately equal to 1.61 kilometers.

[5]One metric ton is equal to 1,000 kilograms. I refer to metric ton as ton in the text.

[6]Information retrieved from Zentralblatt der Bauverwaltung. Issue 41. 1921, No.2. Prussian ministry for public work, Berlin.

in France the annual growth rate was approximately 3.7 percent. Likewise, the annualized growth rate on railway was significantly larger in the German Empire (4.9 percent) than in France (2.1 percent).

In allusion to Germany's "economic miracle" in the 1950s, the historian Wehler coined this period as Germany's "first economic miracle" (Wehler 2007, p. 596) and exports were its driving force. Torp (2014) presents data on international trade integration of the German Empire. Its export quota almost doubled from 8.5 percent (1874-78) to 15.8 percent (1909-13). Likewise, the import quota rose from 15.2 percent (1874-78) to 19.2 percent (1909-13).[7] Simultaneously, the share of exports originating from the German Empire of total world exports increased steadily from 1874-78 (9.5 percent) to 1909-1913 (12.2 percent). Figure 1.A.2 puts the level of trade openness in long run perspective: the level of trade openness of the German Empire attained by the end of the first wave of globalization in 1913 was only reached again sixty years later in 1973.[8]

O'Rourke (2000) estimates that tariffs in the German Empire on manufactured goods increased from 4-6 percent (1875) to 13 percent (1913). Calculations of tariffs in Table 1.A.1 show that for the industries considered in this analysis, tariffs neither declined nor increased substantially across the three census years. A comparison of 1882 to 1907 tariff levels reveals that in ten out of fourteen industries tariffs declined slightly which implies a marginal decline in the average tariff and a 1.8 percent decline in the median tariff across industries. Bismarck's tariff on iron and rye in 1879 was the beginning of an international tendency toward protection. However, the tariff level of the German Empire on manufactured goods was still lower than in France and Italy. Only the United Kingdom fully committed to free trade and maintained a zero tariff, whereas in the United States the tariffs displayed a much more pronounced level of protection than the German Empire. Estevadeordal, Frantz, and Taylor (2003) claim that international tariffs increased only modestly between 1870 and 1913 from 12 to 15 percent. While tariff protection may have restrained international competition and fostered cartel building in specific industries such as the steel industry (Webb 1980), my analysis will consider both domestic and international trade across a wide range of industries and rules out that the results are driven by protectionist tariffs in few industries.

At the same time, the German Empire underwent structural change as it transformed from an agrarian economy into an industrial economy. In the 1895 census, the population share employed in industry and craft (38.5 percent) passed the share employed in agriculture (35 percent), after coming second in the previous 1882 census. By 1907, the

[7]Torp (2014) calculates export and import quota as share of gross national product using constant 1913 prices.

[8]Trade openness as measured by the share of exports plus imports as of GDP.

industrial sector had supplemented its role as the leading sector with 42.2 percent of the population employed, whereas the share employed in agriculture declined even further to 28.4 percent.

In terms of value added, the industrial sector took the lead position in the German Empire in the 1880s. The share of value added in the industry and craft sector was the largest for the first time in 1889 and held this position until 1913. Its share of value added increased by approximately 15 percent between 1870 and 1913, from 26.4 to 41.1 percent.[9] The industrial index increased in all but for two years in the period between 1882 and 1907.[10] It surged by an astonishing 91.9 percent in this period corresponding to an annualized growth rate of 2.6 percent. Similarly, the index of production for producers' goods grew by 122.8 percent or an annualized growth rate of 3.3 percent.

Several of Germany's nowadays global players were founded and expanded significantly in this period. The chemistry sector is a good example in which closer trade integration coincided with concentration in employment. Employment at Germany's second largest chemistry producer almost eight-fold between 1888 (1,000 employees) and 1907 (7,811 employees). Similarly, employment at Germany's largest chemistry manufacturer more than tripled between 1885 (2,377 employees) and 1907 (8,877 employees). Both chemistry manufacturers were among the 100 largest in terms of employment in the German Empire in 1907.[11] By 1913 Germany had the largest share of world exports in chemistry (28 percent) with Great Britain (16 percent) coming second.

Wolf (2009) studies economic integration within the German Empire and across borders. His findings indicate that the German Empire before 1914 was poorly integrated in the sense that administrative borders and cultural heterogeneity across regions and states still mattered for trade flows across regions in the unified Empire.

## 1.3 Data

### 1.3.1 Industry Census Data

In this section, I describe the data deployed in the empirical analysis. I collected data on firm size and employment distributions. Data are available at the administrative level for 39 regions and states, which include among others Prussian provinces, Kingdoms such as Bavaria and Grand-Duchies such as Baden. The data stem from the industry census data in the German Empire for which consistent data are accessible in 1882, 1895, and

[9]Information retrieved from Federal Agency for Civic Education: www.bpb.de/system/files/dokument_pdf/BPB_Tabellen_WertschoepfungnachWirtschaftsbereichen.pdf (accessed on 31/03/2016).
[10]Published in special edition of quarterly economic research reports (Wagenführ 1933).
[11]Information retrieved from Fiedler (1999).

1907.[12] The data capture employment in the first half of June across all years, hence data comparisons across years are unaffected by annual seasonality. The time difference between the first and second censuses is thirteen years, while the time difference between the second and third is similar with twelve years.

Census data capture the complete picture of employment in industry in the German Empire. I focus on the industries to which I can assign goods from the classification in the trade data. In so doing, I match descriptions of traded goods and industry classification as narrowly as possible to the finest level of industry classification.[13] The industry classification contains three levels across all census years. In 1882, there were twenty industry groups, 96 industry classes, and 248 industries at the finest level of aggregation. By 1907 the detail of aggregation changed to 23 industry groups, 129 industry classes, and 396 industries.[14] I can compare the industry classifications consistently over the years by tables provided in the statistics.

Industry census data were collected in conjunction with occupation census data. Different establishments of one firm in different locations were counted as different units in the census, i.e. census data measure firm size at the establishment level. Each firm was assigned to an industry and in case its activity could fit into more than one category, the company was assigned to the industry which corresponded to its major business. In case a company was active in multiple industries, it was also possible to split it into subdivisions and count these as separate establishments. For the industries under consideration only 2.7 percent (1895) and 9.7 percent (1907) of the companies were active in multiple industries measured at the industry group level. Companies producing in the same industries with multiple locations accounted for only approximately 1 percent of all establishments. Hence, firms producing in multiple industries (either in the same location or in different locations) or producing in the same industry in multiple locations were not common and I continue hereafter to refer to firms for counts in the census data instead of establishments.

Companies were located according to industry, trade, tax, and other registers. In contrast to most modern data sets for firm size distributions, the historical data do not

[12]Industry census data are also available in 1875. However, the 1875 census data do not contain as much information relevant to my analysis as census data from 1882 onward. In contrast to later census data, 1875 census data were collected in December and counted firms with more than five employees only.

[13]See page 60 in the Appendix for a list of industries and goods included in the analysis.

[14]The detail in the classification of industry groups is similar to two-digit SIC industries, while the detail in the classification of industries is generally similar to three-digit or four-digit SIC industries. The difference between industry group, industry class, and industries can be illustrated by considering the industry group "Industry of stone and earth". The industry group comprises five industry classes: 1. Stones, 2. Gravel, sand, lime, cement, tuff, gypsum, and barite, 3. Clay extraction, kaolin extraction, and glaze and quartz mill, 4. Clay products, 5. Glass. For the main specifications, I can match all products within the industry group "Industry of stone and earth" to the narrowest industry classification, i.e. 1. Stone, 2. Earth, Gravel and Sand, 3. Lime and Cement, and 4. Glass. See page 60 for a list of industries considered, page 61 for a list of included industry classes, and page 62 for a list of included industry groups in the sample.

set any cutoff for counting, e.g. a minimum number of employees to be counted, i.e. all firms irrespective of size were counted. Thus, I have accessed industry census data, where participation was mandatory, and the population of firms was captured.[15]

Industry surveys were conducted at the municipality level. Municipalities were divided into counting districts and one assistant was responsible for each counting district. Assistants distributed and collected the surveys and checked their consistency. Assistants were asked to survey not more than 50 households and companies in a counting district such that distribution and collection of surveys was feasible within a time frame of one week.[16] Information about the counting was announced early and no public events should take place two days prior, on the day of the counting, and one day after the counting. Assistants filled out control lists passed to the head of the municipality. Thereafter, the head of the municipality had to confirm the consistency of the counting by signature before the results were transferred to the county and then to the regional statistical office. Not only summaries were transferred, but also the questionnaires themselves were shipped to the responsible statistical office of the state in which a county was located. Companies were forced by law to participate in the survey and the director of each company had to confirm the truthfulness of their information by signature. Misreporting was punished by 30 Mark in all census years which corresponds to a nominal value in 2015 of 213 Euro (1882) and 174 Euro (1907). Hence, measurement error stemming from untruthful reporting is unlikely to be an issue.[17] On the other hand, municipalities were offered an incentive to provide full coverage of industry and occupation census. For each inhabitant, they received one Pfennig before the counting, one Pfennig three and a half months after the counting day, and one Pfennig on January 1st in 1896 in the case of the 1895 census.[18]

To the best of my knowledge, the availability of data in the German Empire provides an unparalleled opportunity to combine trade and industry census data at the regional level in this historical context, particularly in contrast to the other two largest economies in terms of GDP in this period - the United Kingdom and the United States. In the United Kingdom, no industry census was conducted for the period under consideration. In the United States, information on companies was collected early on incidentally to

[15]Small firms with less than six employees were counted with the occupation census. All other firms, which employed more than five full time workers, were asked to answer a separate firm survey.

[16]Information on the counting procedure is exemplary presented for 1895 but it was similar in other census years.

[17]Information retrieved from https://www.bundesbank.de/Redaktion/DE/Downloads/Statistiken/Unternehmen_Und_Private_Haushalte/Preise/kaufkraftaequivalente_historischer_betrage_in_deutschen_waehrungen.pdf?_blob=publicationFile. (accessed on 31/03/2016), values are purchasing power equivalent of the average value of one Euro in 2015.

[18]100 Pfennig corresponded to one Mark, the currency of the German Empire. Payment before the counting was based on the recent population census data. For 1895 the reference year was the population census in 1890.

the collection of population data with a frequency of decennial census. However, only companies with a value of production of more than 500 dollars were counted. According to Hesse (1914), a significant fraction of factories and small companies had not been counted arbitrarily. In addition, Hesse cites Francis Walker, who in 1869 was chief of the statistical office in Washington and census superintendent for the 1870 and 1880 censuses. According to Walker, respondents had little incentives to report truthfully due to fear of the use of census data by tax authorities or simply to escape counting. A comparison across years and regions before 1900 is hardly reasonable. Only from 1900 did the quality of data improve and did industry censuses comprise full coverage of all firms.[19]

By 1882 the twenty industries under consideration in my empirical analysis comprised 1.41 M. employees and 173,770 firms and by 1907 2.94 M. employees and 203,589 firms were counted. I focus on count of full-time employment as opposed to secondary employment. All firms with at least one person working full-time are taken into consideration.[20]

Comparing the average firm size in 1882 (8.12 employees) across all industries to the average firm size in 1907 (14.42 employees), the data reveal a striking concentration process - an increase in average firm size of approximately 77.5 percent within a 25-year period.

All in all, there are five bins of size for the number of firms in the data (1-5, 6-10, 11-50, 51-200, and more than 200 employees). Information on the number of employees is available for three size categories: employees in small firms with less than 6 employees, between 6 and 50 employees in medium firms, and in large firms with more than 50 employees.[21] Thus, I can calculate firm shares and employment shares across size categories.[22] Although these categories look quite small at first sight, a recent survey by Hsieh and Olken (2014) on the firm size distribution in developing countries uses similar categories.[23]

Figure 1.1 shows the evolution of the firm share in five size categories in the three census years. The share of small firms with less than six employees has fallen from 88.9 percent in 1882 to 77.6 percent in 1907, whereas the share of all other size categories

[19]Walkers' concerns are also discussed in Atack and Bateman (1999). The quality of the US census data at the aggregate level is doubtful. Atack, Haines, and Margo (2011) use digitized original firm surveys. However, for the same industries as considered in this paper their sample contains 2,567 establishments in 1880 compared to 173,770 establishments in the 1882 census data deployed here.

[20]I exclude self-employment as data were not fully collected in 1882.

[21]Employment data are available for small, medium, and large firms in 1882 and 1895 at the industry class aggregation for nine out of seventeen of districts. At the finest industry aggregation in 1882 and 1895 for all districts, but only for small firms and the data do not distinguish between medium and large firms. At the industry group aggregation, employment data are available for all districts in 1895 and 1907, and for nine out of seventeen districts in 1882.

[22]I calculate firm size distributions according to the finest level of industry classification. For the illustration in Figure 1.2, I calculate the employment distributions at the level of the industry group in order to have three census year observations and picture the evolution of employment across all three census years. For example, for the industries cotton and wool the corresponding industry group is textile.

[23]All category boundaries are the same as for the employment shares in this paper except the smallest size category has an upper bound of 10 employees.

has increased within the 25-year period.[24] On the other hand, the share of large firms with 51-200 employees increased steadily from 1.7 percent (1882) to 3.5 percent (1907). Likewise, the share of firms with more than 200 employees rose from 0.6 to 1.1 percent.

Data for employment are not readily available at the finest industry aggregation. Based on the information available, I can calculate that the employment share of small firms declined from 27.6 to 19.6 percent between 1882 and 1895 for the finest level of industry aggregation.

Instead of presenting the incomplete picture of employment shares based on a finer level of industry aggregation, I show the employment shares at the industry group level in Figure 1.2.[25] The share of employment in small firms (1-5 employees) decreases markedly from well above 44.5 percent in 1882 to approximately 19.5 percent in 1907. While there is only a modest increase in the share of employment in firms with 6 to 50 employees, there is a significant surge in the employment share of firms with more than 50 employees from approximately 36.6 to 57.4 percent between 1882 and 1907.

One reason for the more pronounced shifts in the employment share is the discontinuity of the number of firms in each bin. For example, a firm shifts size categories from 10-49 employees to the next size category if it grows above 50 employees, while a firm with 49 employees is still counted in category 10-50 employees. However, such a firm may have grown in employment by a factor of more than four in case its employment was ten in the previous census.

### 1.3.2 Trade Data

I collected data for twenty goods which are among the most significant in terms of trade volume and that I can assign to an industry in the census data.[26] Two examples of industries are iron ore and chemistry products.[27] Data were collected for two transport modes onto which goods were predominantly traded in the period under consideration: railways and waterways.[28] The data comprise all inland railway and waterway transportation and

[24]In absolute terms, there was a slight increase in the number of small firms from 154,420 to 157,721 between 1882 and 1907 (Table 1.A.2), as industrial employment expanded, and population was growing.

[25]The industries in my analysis at the finest level of aggregation have a significantly smaller employment share of small firms. Their share of employment as of total employment in the industry group grew from 47.3 to 56.9 percent between 1882 and 1907. Therefore, the shift in employment share from small firms toward large firms is likely to be more pronounced than the shift presented in Figure 1.2 at the industry group level.

[26]The share of total railway trade volume of the 20 goods considered marginally increased from 50.8 percent (1883) to 53.5 percent (1907).

[27]See page 60 in the Appendix for a full list of goods included.

[28]Statistics for land transportation were not collected, because land transportation (e.g. horse-drawn vehicles) was only locally important. The automobile industry was still in its infancy between 1882 and 1907. For example, the van with engine was invented only in 1896.

international trade on railroad.[29] Despite the fact that the railway network expanded by more than 70 percent between 1882 and 1907, I observe an upswing in trade volume per mile of the network of 146 percent for the goods under consideration.

For seaports, the data also capture trade of goods transferred to the most important seaports via railway. Hence, only trade by seaports not transferred by railway is possibly not fully captured in the data. As a robustness exercise in my analysis, I drop the districts which are seaport locations, i.e. I consider only landlocked districts in the estimation. For this set of districts, the data capture all trade flows apart from local land transportation, which was too costly for longer distances compared to railways and waterway transportation. Gutberlet (2012) reports estimates that suggest road transportation was nearly 40 times as expensive as waterway and more than 10 times as expensive as railway.

Data for trade on railway are available from 1883, so I take these data as best proxy for railway trade in 1882 for which data were not yet collected. For the other census years in 1895 and 1907 railway data are readily available, likewise waterway data are available for all three census years I am considering. All trade data are measured as quantities in tons. The list of goods collected for railway trade statistics was guided by the list of goods collected for waterway trade statistics, hence I collected the same good categories for both trade modes apart from two industries for which no trade on waterway was documented in the statistics.[30]

Trade data on railroads are divided according to 36 trade districts. These districts follow closely the administrative states and regions according to which the industry census data are classified. I merge districts, states, and regions in the industry census and railway data to construct seventeen districts for both types of data which contain the same geographic boundaries, which is a unique characteristic of the data. Hence, I can construct region-specific firm size distributions and trade flows which would not be feasible with modern data and is a benefit of using the historical data.[31] I can match the location of each port, and hence waterway trade to the same seventeen districts. For example, there were 117 waterway ports in 1907.

Both type of trade data were collected for transport to the final destination, i.e. there is no double counting when goods passed through other districts to their final destination.

[29]Conservative estimates suggest a maximum of 1.1 percent in railway network length not covered in the statistics for 1907 and a smaller proportion for 1883 and 1895. The lines not covered were mostly short distance and relevant for local traffic. Waterway transport was measured at custom borders, important port stations, and water gates.

[30]The industries are chemistry and paper.

[31]Figure 1.A.1 shows a map of the seventeen districts and the following pages contain a definition of the constructed districts. Construction of districts is dictated by the spatial units of industry census data and trade statistics. What is more, I construct districts such that most industries are represented in all districts. Table 1.A.4 contains the aggregate employment in the twenty industries for each district by year and Table 1.A.5 shows the total population for each district by year.

Waterway data were recorded annually, whereas railway data were collected quarterly until 1895 and thereafter annually. Railway data were published as a separate statistical series titled "Statistik der Güterbewegung auf Deutschen Eisenbahnen". On the other hand, waterway data were published as part of the series "Statistik des Deutschen Reichs" which contains all sort of statistics. The detail of data collection differed across trade modes: railway data were collected bilaterally for final shipments between regions whereas waterway data were collected as aggregate final shipments.

Finally, I will consider international shipments in a robustness exercise. Just like the waterway data these were also published as part of the series "Statistik des Deutschen Reichs". The international shipments data were only compiled at the national level which reduces the number of observations. More importantly, the data do not allow to construct an instrumental variable that I use for estimation with regional railway and waterway trade data. The international shipping data were reported annually at a finer aggregation than for railway and waterway data. Nonetheless, I can draw a narrow correspondence between both classifications.

## 1.4 Estimation and Discussion

I combine industry census data with the trade data using the constructed seventeen districts in the regression analysis. Let c denote the firm size category under consideration. Furthermore, i is the sub-index for industry, j for district and t for time. Finally, the trade data come in seven modes indexed by m:

- exports of district with the rest of the German Empire (railroad)
- imports of district with the rest of the German Empire (railroad)
- international exports of district with 17 countries and regions outside of the German Empire (railroad)[32]
- international imports of district with 17 countries and regions outside of the German Empire (railroad)[32]
- internal trade within district itself (railroad)
- exports of district within the German Empire (waterway)
- imports of district within the German Empire (waterway)

Overall data for seven distinct trade modes are in the list. Table 1.A.3 shows summary statistics across trade modes by year. The trade mode internal trade is correlated with

[32]Page 67 in the Appendix enumerates the seventeen countries and regions outside of the German Empire.

consumption within a district, however it captures transport of goods via railway for final consumption and not goods produced for final consumption within a district that are not transported by railway.[33] Figure 1.A.3 illustrates the composition of trade across five trade modes on railway. The shares of each trade mode remain stable across all three years. Exports and imports within the German Empire constituted about one third of trade on railway, while the share of internal trade was 25 percent in 1907. International exports accounted for 6.4 percent and international imports for 3.7 percent of railway trade in 1907.

Bernard, Jensen, and Schott (2009) document stylized facts about importing firms in US data (1993-2000). According to their analysis, more than 50 percent of firms that import also export and these firms account for the clear majority of trade. While the early literature on firm heterogeneity has focused on exporters, I want to consider both effects of exports (selection) and imports (import competition) on the size distribution of firms.

I collapse all trade flows via seven trade modes into a single measure of trade openness by taking the sum across trade modes as index for local trade exposure of an industry. Formally, I define $\text{trade}_{mijt}$ as trade on trade mode m, in industry i, district j, at time t. By taking the sum over all trade modes m, I obtain an aggregate measure of trade openness:

$$\text{trade openness}_{ijt} = \sum_{m=1}^{7} trade_{mijt}. \tag{1.1}$$

The advantage of this measure over considering trade flows across different modes separately is fewer zero trade flows and hence fewer missing data points through the log transformation. The main outcome is the share of firms in size category c which is formally defined as:

$$\text{firmshare}^{c}_{ijt} = \frac{\text{Number of firms}^{c}_{ijt}}{\text{Number of firms}_{ijt}}. \tag{1.2}$$

The share of employment in category c is defined correspondingly. Thereafter, I run the following fixed-effects regressions for each of the five (three) size categories c to quantify how trade is correlated with the firm shares (employment shares) across size categories respectively.

$$\text{firmshare}^{c}_{ijt} = \beta^{c} \times \ln(\text{trade openness}_{ijt}) + \lambda_{ij} + \epsilon^{c}_{ijt}. \tag{1.3}$$

[33] I adjust domestic exports, domestic imports, and internal trade, because I aggregate districts in railway statistics. For example, I merge the railway districts "Kingdom of Bavaria" and "Bavarian Palatine" into one district. Hence, I subtract the trade flow between those two trade districts from domestic exports and imports and add it to internal trade. I adjust trade flows for 1895 and 1907 precisely, for 1883 I accessed trade flows for the third and fourth quarter and I multiply them times two as an approximation, because statistics for the first half of 1883 were published monthly and the digitization requirement would have been too extensive. Results without this adjustment do not differ substantially from the results presented with the adjustment.

$$\text{employmentshare}_{ijt}^{c} = \beta^{c} \times \ln(\text{trade openness}_{ijt}) + \lambda_{ij} + \epsilon_{ijt}^{c}. \tag{1.4}$$

The left-hand side in this regression $\text{firmshare}_{ijt}^{c}$($\text{employmentshare}_{ijt}^{c}$) is the share of firms (employees) in size category c, in industry i, in district j, at time t. Figure 1.A.4 exemplifies, how I constructed the dependent variable firm share for one district-industry pair from the 1907 census data. I define a district-industry pair as unit of observation. By including district-industry fixed-effects, the coefficient $\beta^c$ identifies the effects of changes in trade openness on the change of the firm size distribution. Alternatively, I consider equations (1.3) and (1.4) in first differences:

$$\Delta\,\text{firmshare}_{ijt}^{c} = \beta^{c} \times \Delta\ln(\text{trade openness}_{ijt}) + u_{ijt}^{c}. \tag{1.5}$$

$$\Delta\,\text{employmentshare}_{ijt}^{c} = \beta^{c} \times \Delta\ln(\text{trade openness}_{ijt}) + u_{ijt}^{c}. \tag{1.6}$$

Since the specifications use the natural logarithm of the trade volume as regressor, it allows me to interpret the estimates as semi-elasticities. The interpretation of $\beta^c$ in equations (1.3) and (1.4) is as follows: a 1 percent deviation from period t trade flow relative to the average trade flow in industry i in district j leads to $\frac{\beta^c}{100}$ deviation from the average share in category c in firm- and employment share respectively.

Similarly, I interpret the coefficient $\beta^c$ in equations (1.5) and (1.6): a 1 percent increase in the ratio of period t relative to period t-1 trade flows implies a $\frac{\beta^c}{100}$ change in the firm- and employment share respectively.

As primary specification, I report the regressions that match industry classifications and traded goods as narrow as possible. For the firm share variable it was possible to collect data for all districts at the finest level of industry aggregation. At the finest level of industry aggregation employment data are available for all districts in 1882 and 1895, but the data only allow me to calculate the share of employment in firms with less than six employees and its residual. As a second step, I estimate equations (1.4) and (1.6) for all districts at the industry group aggregation. Finally, I can investigate how the average firm size responds to trade integration at the finest level of industry aggregation.

I do not impose any restriction on the minimum number of firms within a district. In other words, I include observations with degenerate distributions, i.e. only one firm in a district-industry pair. While such observations may lead to extreme shifts in the distribution, restrictions on the minimum number of firms within a district corroborate the estimates.[34] Standard errors are clustered at the district level.[35] Serial correlation within districts might be less of a problem, since the census years are twelve and thirteen years apart. Estimated clustered standard errors turn out to be larger than robust standard errors. I note, however, that the number of clusters is with seventeen quite small.

First of all, I estimate this reduced form regression and will later propose an instrumental variable approach to establish causality of the reduced form results.

[Table 1.1-1.2 here]

I conclude that the share of small firms (1-5 employees) decreases as trade increases. In contrast, the share of large firms (size categories 50-200 employees and more than 200 employees) is positively correlated with trade volume. All of these three estimates are statistically highly significant. Estimates for all categories are similar across both estimation methods fixed effects and first differences. The only size category where fixed effects and first differences lead to deviating conclusions is for firms with 6-10 employees. Point estimates are positive and statistically significant in the fixed effects results, whereas the point estimate for the change in trade openness is insignificant when estimating equation (1.5). There is a hierarchy across estimates moving from negative significant effects for the smallest firm size category to insignificant and positive effects for medium size firms and positive and highly significant for shares of the largest firms in the sample. This hierarchy is represented in Figure 1.A.5 that plots coefficients with confidence bands for first differences estimates of equation (1.5).

[Table 1.3-1.4 here]

For the employment shares, I observe larger point estimates in absolute magnitude compared to firm shares. One reason for the more pronounced shifts in the employment share variable is the previously mentioned discontinuity of the size categories.[36] I distinguish between small (less than six employees), medium (6-50 employees), and large firms (more than fifty employees) as the data at the industry group level are only available for those coarser size categories. I find negative and significant estimates for employment shares of small firms (Table 1.3-1.4). Note that this result holds for both the finest (column 1) and the coarsest industry aggregation (column 2) and point estimates turn out to be similar. Again, the conclusion for medium size diverges when comparing the first difference and

[34] Results are available on request. Alternatively, I weight observations in equation (1.3) by the firm share at the district level in each year and correspondingly for equation (1.4) by the employment share at the district level.

[35] Results are similar when standard errors are two-way clustered at the level of the district and the industry.

[36] A firm changes the size category only if it exceeds the upper threshold of its category. On the other hand, firm employment may grow within the boundaries of its firm size category.

fixed effects specification. It is small and positive in both estimations, but only significant in the latter estimation. On the other hand, changes in the share of employment in large firms are positively and significantly correlated with changes in aggregate trade flows as can be seen in column 4 of both tables.

### 1.4.1 Instrumental Variable Approach

Naturally, there are concerns of reverse causality - the firm size distribution affecting trade and not the other way around as implicitly assumed in the presentation of my reduced form regression analysis. For example, district-specific demand shocks can influence the shape of the firm size distribution which in turn can increase firm productivity and subsequently trade flows of a district. Alternatively, simultaneity may be a concern, i.e. trade flows and the size distribution are jointly influenced by a third unobserved factor such as productivity.

To alleviate such concerns, I propose an instrumental variable (IV) approach, the shift-share approach, which was popularized by David Card in the context of migration (Card 2001).[37] The idea behind the instrument is to decompose the growth in trade according to its aggregate growth and to district specific components. The instrument absorbs all district-specific shocks by holding the district share constant at a base year and assigning the aggregate growth component within an industry to it. The *identifying assumption* is that the initial distribution of trade volumes in the base year is uncorrelated with any district specific shocks that affect the firm size distribution in 1895 and 1907 respectively.

I use trade flows in 1882 as base year for 1895 and 1907 to guarantee that the predicted trade flow is independent from any district specific shock until 1895 and 1907 respectively. To further clarify the construction of the instrument, I explain its calculation for the year 1895.[38] The following predicted trade flow absorbs all district-specific shocks:

$$\text{trade } \widehat{\text{openness}}_{ij,1895} = \sum_{m=1}^{7} (1 + g_{mi-j,1882-1895}) \times \text{trade}_{mij,1882}. \tag{1.7}$$

In equation (1.7), trade $\widehat{\text{openness}}_{ij,1895}$ denotes the predicted variable for observed trade flows in 1895 and $g_{mi-j,1882-1895}$ denotes the aggregate growth rate in industry i between the base year 1882 and 1895 *excluding* district j for trade via mode m.[39]

I then calculate the variable which I use as an instrument for observations in 1895: $\ln(\text{trade } \widehat{\text{openness}}_{ij,1895})$. Note that this value is independent from any district-specific shock provided the identifying assumption holds. Hence, I run the following first stage

[37] In the literature this approach is also known as "Bartik" instrument following Bartik (1991).

[38] The construction for 1907 follows the same method.

[39] For railway trade I have chosen - dictated by data availability - 1883 as base year.

regression:

$$\ln(\text{trade openness}_{ijt}) = \beta^{IV} \times \ln(\widehat{\text{trade openness}}_{ijt}) + \lambda_{ij} + u_{ijt}. \tag{1.8}$$

The scatter plot in Figure 1.3 illustrates the constructed instrument plotted against observed trade flows. There is a strong positive correlation of 0.92 between the logarithm of observed and predicted trade flows.

To instrument for the change in the logarithm of trade openness, I lean on the approach of Autor, Dorn, and Hanson (2013). They instrument for the import exposure of US commuting zones to import competition from China with the change in trade exposure in other advanced economies. The authors attribute US trade by their lagged shares of industry employment to commuting zones. I will adopt their approach to my setting by instrumenting for $\Delta \ln(\text{trade openness}_{ijt})$. Firstly, I rewrite this expression as:

$$\ln(\frac{\text{trade openness}_{ijt}}{\text{trade openness}_{ijt-1}}) = \ln(\frac{\Delta\,\text{trade openness}_{ijt}}{\text{trade openness}_{ijt-1}} + 1). \tag{1.9}$$

To instrument for the numerator on the right-hand side, I define $\sigma_{mij,1882}$ as the intensity of trade via trade mode m in sector i for district j in 1882, i.e. the share of trade via that trade mode for a given district-industry pair relative to aggregate trade via that trade mode in industry i:

$$\sigma_{mij,1882} \equiv \frac{\text{trade}_{mij,1882}}{\sum_{j=1}^{17} \text{trade}_{mij,1882}}. \tag{1.10}$$

Like Autor, Dorn, and Hanson (2013) I instrument for the change in trade flows as follows:

$$\Delta\,\widehat{\text{trade openness}}_{ijt} = \sum_{m=1}^{7} \sigma_{mij,1882} \times \Delta\, trade_{mi-jt}. \tag{1.11}$$

The instrument uses the initial intensity $\sigma_{mij,1882}$ of trade via trade mode m to attribute aggregate changes in trade via mode m to each district-industry pair thereby excluding a district itself. The final step is to plug this expression into equation (1.9) and divide by two period lagged trade flow instead of lagged trade flow as it is exogenous to contemporaneous and lagged shocks. Then the logarithm of the predicted change that I use to instrument changes between 1895 and 1907 is defined by the right-hand side of the following equation:

$$\ln(\widehat{\text{trade openness}}_{ijt}) - \ln(\widehat{\text{trade openness}}_{ijt-1}) \approx \ln(\frac{\Delta\,\widehat{\text{trade openness}}_{ijt}}{\text{trade openness}_{ijt-2}} + 1). \tag{1.12}$$

[Table 1.5-1.6 here]

Instrumental variable estimation results indicate that significance prevails for almost all significant coefficients in the reduced form regressions. Significance maintains for all coefficients across the size categories for the first difference IV estimation (Table 1.6). The conclusion for fixed effects instrumental variable estimation is the same as for first difference IV estimation in terms of sign and significance of the estimates (Table 1.5). In contrast to reduced form estimates, the coefficient for firms employing six to ten employees turns insignificant.[40]

[Table 1.7-1.8 here]

Instrumental variable estimates for employment shares are similar to reduced form estimates, except that estimates for the employment share of firms with six to fifty employees change from insignificant (first differences) and positive significant (fixed effects) to negative significant (Table 1.7-1.8). Note that instrumental variable estimates are not directly comparable to Table 1.3-1.4 as I can only instrument for observations in 1895 and 1907. If I restrict the reduced form estimates to this sample, the estimate for medium sized firms are negative and significant in the first place.

Finally, I consider the average firm size as third alternative to highlight the reallocation effects of trade across the firm size distribution:

$$\ln(\text{average firm size}_{ijt}) = \beta \times \ln(\text{trade openness}_{ijt}) + \lambda_{ij} + \epsilon_{ijt}. \quad (1.13)$$

[Table 1.9 here]

I obtain strongly significant estimates both for the reduced form and instrumental variable specifications. In this regression, I can interpret estimates for $\beta$ as elasticity. The estimates are striking in magnitude: A one percent increase in trade integration implies ceteris paribus approximately an increase by 0.22-0.24 percent in average firm size across specifications. This is in line with the reallocation effects described for both firm- and employment shares across size categories.

### 1.4.2 Robustness Specification

In this section, I present variations of the baseline regression by adding time fixed effects, time-varying district fixed effects, and time-varying industry fixed effects. Demand shocks or industry specific shocks may be correlated over time. By adding time varying fixed effects, I address the concern that shocks may be correlated over the sample period. I

[40] Note that instrumental variable estimates are not directly comparable to Table 1.1 as I can only instrument for observations in 1895 and 1907. If I restrict the reduced form estimates to this sample, the estimate for firms with 6-10 employees is insignificant as well. When restricting the reduced form estimates to 1895-1907 there is no clear-cut tendency as to whether the magnitude of IV estimates is smaller or larger compared to the reduced form regression.

consider the natural logarithm of average firm size as outcome.[41] The saturated regression specification is given by:

$$\Delta\ln(\text{average firm size}_{ijt}) = \beta \times \Delta\ln(\text{trade openness}_{ijt}) + \gamma_{dt} + \delta_{it} + \lambda_{ij} + \epsilon_{ijt}. \quad (1.14)$$

[Table 1.A.7 here]

Table 1.A.7 reports estimates similar to column 2 in Table 1.9. Controlling for time fixed effects reduces the point estimate by approximately by 9 percent. The elasticity of the average firm size with respect to trade openness falls from 0.24 to 0.15 (1.A.7 columns 1 and 2). The coefficient is slightly larger when adding time-varying district fixed effects and marginally smaller when controlling for time-varying industry fixed effects. The final column shows the estimation of equation (1.14) and controls for both time-varying district and industry fixed effects. The point estimate is marginally significant at the 10 percent level and implies an elasticity of 0.14.

### 1.4.3 Robustness Measured Trade Content

I present robustness checks for the fixed effects specification using the firm share as left-hand side, i.e. equation (1.3). Although I do not report the results, this also holds for regressions with the employment share as dependent variable and estimating in first differences instead of fixed effects.[42]

International sea trade is captured in the data by the railway data through trade of goods transferred to the most important seaports via railway. Districts with direct sea port access might transfer their goods through local land transportation that is not measured in the data. Therefore, I show two robustness checks. First, I exclude all districts with direct seaport access.[43] The idea underlying this robustness exercise is that all goods traded internationally need to be transported to seaports somehow. For districts without direct seaport access, the distance to those seaports is so far that local land transportation to the seaport is too costly and goods are most likely transported via railway or waterway to the seaport. Then, all trade of those districts is captured in the trade data.

[Table 1.A.8-1.A.9 here]

By comparing Table 1.A.8 and 1.A.9 to Table 1.1 and 1.5, I conclude that there is almost

[41] Results for the largest firm share and employment share categories are also robust in terms of significance to the inclusion of time-varying fixed effects. They are qualitatively similar for the small size category. I report the results for the average firm size to show robustness for the outcome that captures the distributional consequences.

[42] Results available upon request.

[43] In other words, I drop districts 1,3,7,8, and 16 as defined on page 64.

no difference between the unrestricted sample and restricting the sample to landlocked districts.

As a second robustness check, I use international shipments as measure for trade openness. The data were only compiled at the national level, so the number of observations reduces to 57 (nineteen industries and three years).[44] There are no regional trade data available for international sea shipment and the data do not allow to instrument the way I introduced before. Therefore, I report reduced form results only.

[Table 1.A.10 here]

The results presented in Table 1.A.10 are similar to Table 1.1 both in terms of magnitude and significance. There is literally no difference and the estimation results indicate that the results are not driven by considering railway and waterway data at the regional level in the analysis.

### 1.4.4 Robustness Instrument

While the instrument presented previously accounts for district-specific shocks, one might argue that industry-specific shocks matter. To address this concern, I present a version of the instrumentation which aggregates at a higher level than at the industry and is therefore robust to this issue. This version of the Bartik style instrument was first used by Altonji and Card (1991) in the context of immigration. The instrument uses a national growth rate to predict migration from different source countries.

In this context, I take the sum of trade flows across all industries and districts but this time I exclude district j and industry i simultaneously. Analogous to equation (1.7), the predicted trade flow is given by:

$$\text{trade } \widehat{\text{openness}}_{ij,1895} = \sum_{m=1}^{7} (1 + g_{m-i-j,1882-1895}) \times \text{trade}_{mij,1882}, \tag{1.15}$$

where the growth rate is defined as

$$g_{m-i-j,1882-1895} \equiv \frac{\sum_{l \neq i}^{20} \sum_{k \neq j}^{17} \text{trade openness}_{mlk,1895}}{\sum_{l \neq i}^{20} \sum_{k \neq j}^{17} \text{trade openness}_{mlk,1882}}. \tag{1.16}$$

Note that by summing across all industries and excluding industry i this is independent of shocks to a specific industry i driving the change in trade openness and the instrument reflects the national openness shock. The aggregation here is based on weights, so products

[44] I aggregate "Iron and steel" and "Iron and steel products" into one industry, therefore the number of industries reduces from twenty to nineteen.

like coal that are cheap and traded in large quantities influence the growth rate more significantly than valuable products but lightweight goods such as leather products.

[Table 1.A.11 here]

By comparing Table 1.5 to Table 1.A.11, I conclude that the results are robust to this version of the instrument in terms of sign and significance. The only notable difference is that magnitudes of IV estimates are larger compared to Table 1.5 and the estimate for large firms with 50-200 employees is only marginally significant at 10 percent.

## 1.5 Mechanisms

### 1.5.1 Productivity

In this section, I provide evidence for the productivity premium of larger firms. Ultimately, this is the channel through which trade affects welfare, in my analysis, by reallocating resources toward more productive firms and raising productivity as outlined in Melitz (2003).

Resource allocation across firms can have profound effects for total factor productivity (TFP): Hsieh and Klenow (2009) study to what extent misallocation of capital and labor can lower aggregate TFP. They find stunning TFP gains if China or India would move to the resource allocation of the United States.

Production data are not readily available for all industries. For mines, metallurgy plants, and saline production data exist, and I therefore focus on these industries in this section. More precisely, out of the twenty industries I consider five: brown coal, hard coal, iron as part of iron and steel, iron ore, and table salt as part of the salt industry. Data on production, the number of firms and employees at the administrative regional level enable me to consider the same seventeen districts as in the previous analysis. As a comparison, I merge the corresponding industry census data to the output data. The correlation between production data and census data is high (number of employees: 0.95; number of firms: 0.64).

Remarkably, all industries trade a significant share as of total production on railway (trade openness) and that share increased over time. For example, trade openness for hard coal increased from 72.2 percent (1883) to 80.7 percent (1907), for brown coal from 36.2 percent (1883) to 47.7 percent (1907), and for iron ore from 43.7 percent (1883) to 68.9 percent (1907).

As a reasonable approximation for productivity I consider output per worker (labor productivity). Note that output is measured as weight and therefore the productivity measure is real labor productivity. I then specify the following regression to quantify the impact of trade openness on labor productivity:

$$\ln(\text{labor productivity}_{ijt}) = \beta \times \ln(\text{trade openness}_{ijt}) + \lambda_{ij} + \epsilon_{ijt}. \qquad (1.17)$$

[Table 1.10 here]

Due to limited availability for production data the number of observations for this regression is 132. The limited number of observations makes estimates more sensitive to outliers. For example, there are seven district-industry pairs with only one firm. Therefore, I weight observations by the firm share of each district by industry in 1882 to address this issue and to estimate economically meaningful averages.[45] Estimates are statistically significant, and the elasticity estimate implies that a 1 percent increase in trade openness induces roughly a 0.22 percent increase in average labor productivity. Instrumental variable estimates turn out to be larger, because the sample is restricted to 1895 and 1907 and the relationship is stronger in those two years.

Hence, I have identified the productivity channel through which trade matters for welfare in line with Melitz (2003). Trade integration leads to a shift in resources from smaller to larger firms (Table 1.1-1.8) implying an increase in average firm size (Table 1.9). This resource reallocation across size categories maps into a gain in labor productivity (Table 1.10).

### 1.5.2 Technology

The question arises of why larger firms are more productive than smaller firms. Aside from the productivity channel through endogenous selection of firms and increasing returns to scale, I now examine firms' technology. The period between 1870 and 1913 is not only known as first wave of globalization but also as the second industrial revolution and was characterized by an increasing use of motorized machinery in the production process. Inventors from the German Empire were at the forefront of developing new types of motors, such as Otto (in 1877) and Diesel (in 1893).

The purchase of motorized machinery was expensive. For example, the cost of a small steam engine in Berlin in 1891 ranged from 1,550 Mark (one horsepower) to 3,530 Mark (six horsepower).[46] The operation costs for 300 ten hour working days amounted from 901.25 Mark (one horsepower) to 2,689.10 Mark (six horsepower). By comparison, the

[45] Results for weighting by employment share are quantitatively very similar. Formally, the time-constant weight is given by $weight_{ij,1882} = \frac{\text{Number firms}_{ij,1882}}{\sum_{j=1}^{17}\text{Number firms}_{ij,1882}}$.

[46] Information retrieved from Matschoss (1908). The unit horsepower was adopted by James Watt in the late 18th century and is still used nowadays to measure the physical power of machinery. One horsepower corresponds to the power necessary to lift 75 kilograms pond meter per second.

wage of a male laborer in Berlin amounted to 2.70 Mark per day.[47] Hence, the expense for purchasing the machinery with one horsepower corresponded to the annual wage of approximately two male laborers and the purchasing cost for the steam engine with six horsepower corresponded to the annual wage of approximately four male laborers.

A cost-benefit analysis revealed the relative efficiency of lifting weight of one workman, one horse, and one physical horsepower in steam engines: the cost for one ton-kilometer was 33.67 Pfennig for the steam engine, 185.76 Pfennig for the horse, and 662.60 Pfennig for the workman. Thus, one physical horsepower was as profitable as approximately five and a half horses or hiring almost twenty workmen.[48]

The adoption of steam technology transformed production in sectors such as the textile industry. According to Matschoss (1908), the adoption of steam technology in weaving mills, as part of the supply chain in the textile industry, increased productivity by a factor of 90 compared to manual work.

[Table 1.11-1.12 here]

I accessed data on the motor use by different firm size categories from industry censuses. Table 1.11 illustrates that the probability of adopting a motorized machinery increases as one moves upwards toward larger firm size categories, i.e. technology adopting firms are larger than the average firm. The probability of adoption of all firms increases from 14 percent in 1882 to 21.7 percent in 1907.[49] While almost all firms with more than 200 employees had already adopted the technology in 1882, the increase in adoption was driven by firm size categories with 11-50 and 51-200 employees.

This finding is related to Bustos (2011) who finds that tariff cuts induced technology upgrading in the third quartile of the firm size distribution. The probability of adoption is significantly smaller for firms between one and five and six and ten employees respectively. These findings suggest that the fixed cost of adopting motorized machinery are more likely to be overcome by larger firms.

It is also evident in the data that larger firms have both a higher horsepower per firm and per employee, which is conditional on firms adopting motorized machinery. As can be seen in Table 1.12, the horsepower per company increases dramatically as firm size increases in 1907. More importantly, the horsepower per employee is monotonically increasing across firm size categories. The horsepower per employee in firms with more

[47] Information retrieved from Becker et al. (2014).

[48] The cost-benefit analysis was published in Zeitschrift des Königlich Preussischen Statistischen Bureaus by Ernst Engel (1880, page 123 and following). The analysis was based on contemporaneous information and compared a twelve horsepower steam engine running eleven hours a day, a workman of 60 kilograms (average power of working with hand gear, crank and treadwheel), and one horse moving 45 kilograms at 0.9 meter per second for eight hours.

[49] The questionnaire in 1907 asked firms to report more types of motors than in 1882. For example, due to technological progress in case of the electric motor.

than 1,000 employees is almost ten times as large as the horsepower per employee in firms with up to five employees. The data do not allow me to examine to what extent the differences in horsepower per employee are driven by the intensive margin (higher horsepower per machine) or extensive margin (more machinery) for the German Empire as a whole. However, Matschoss (1908) presents data for stationary steam engines in Prussia. From 1885 to 1904 their number more than doubled and their average horsepower increased from 31.5 to 55.7, i.e. by 76.8 percent.

Data on technology adoption by firm size are not available at a spatial level. Yet, I collected spatially disaggregated data on the probability of adopting the technology across all firms to quantify the impact of trade integration on this outcome. To this end, I run the following regressions:

$$\Delta \, \text{motorshare}_{ijt} = \beta \times \Delta \ln(\text{trade openness}_{ijt}) + \epsilon_{ijt}. \tag{1.18}$$

$$\Delta \, \text{electricmotorshare}_{ijt} = \beta \times \Delta \ln(\text{trade openness}_{ijt}) + \epsilon_{ijt}. \tag{1.19}$$

The structure in equations (1.18) and (1.19) is like equations (1.5) and (1.6). I present only results in first differences as fixed-effects estimation yields similar estimates. The left-hand side is the change in the share of adopting a technology as of all firms within a district.[50] The questionnaire changes over time. More types of motors are included in the 1895 and 1907 survey and the questionnaire is similar as opposed to the one in 1882. Therefore, I estimate equation (1.18) using only data from 1895 and 1907 as robustness check. Alternatively, I consider the adoption of electric motors in equation (1.19). A technology that became available for industrial use through the spread of electrification and a substitute to steam engine. Electrification and its wide-spread use were one of the main characteristics of the second industrial revolution.[51] In the sample, the number of firms across all industries using electric motors increased by a factor of 35 from 2,259 (1895) to 79,304 (1907).

[Table 1.13-1.14 here]

I find robust statistically significant effects of market integration on technology adoption across all specifications (Table 1.13). Closer trade integration through a fall in trade costs can decrease the productivity cutoff for surviving firms to adopt the technology and

[50] As data on technology adoption are not distinguishable by firm size, self-employment is included in the count. Therefore, the left-hand side represents a slightly different population of firms in comparison to the previous analysis. As self-employment is statistically not represented in 1882 data, I take this into consideration by considering only 1895 and 1907 data in a robustness check.

[51] Important inventions of electric motors fall between 1882 and 1895. For example, the three-phase induction motor was developed in 1889 by an inventor of the company AEG (English translation: General electricity company, founded in 1883).

increases the probability of adoption over time.

Table 1.14 reports statistically highly significant estimates for all coefficients on the probability of adopting electric motors. Not only did changes in market integration increase the probability of adopting existing technologies, but also contributed to the diffusion of newly available technologies.

### 1.5.3 Trade Costs

Trade costs comprise among other things tariffs, transport costs, and further components such as exchange rate volatility. There is an extended literature examining the role of trade costs reduction as a cause for the first wave of globalization. Jacks, Meissner, and Novy (2010) report that trade costs fell by 10-16 percent between 1870 and 1913 explaining approximately 44 percent of the rise in international trade in this period. Estevadeordal, Frantz, and Taylor (2003) claim that a fall in transport costs is the dominant explanation for the trade boom seen between 1870-1913. According to Pascali (2017) technological advance in shipping, namely the use of steam power, was the major reason for the reduction in trade costs and the first wave of globalization. Due to steam power international maritime shipment became more reliable, as opposed to wind dependent sail ships, and shipping times were considerably reduced.

I accessed official railway freight rate data in 1881 and 1904. During this time, the railway network was gradually nationalized such that the freight rate was the same across all regions within the German Empire. The nominal freight rate tariff remained roughly constant between 1881 and 1904 for most distances. Thus, the real freight cost declined for producers by the inflation rate of the producer price index. The corresponding inflation rate for the consumer price index was roughly 12 percent. Other freight rates such as unit load experienced a real decline of up to 43 percent (1,000 km distance). According to Lenschau (1907) nominal revenues per ton kilometer on railway declined by approximately 13 percent between 1882 and 1903 implying a real decline of 25 percent in freight cost per ton kilometer.

While railway freight rates were independent of any route characteristics apart from distance, waterway freight rates were determined in bargaining by demand and supply. Therefore, they were subject to more volatility over time compared to railway freight rates. Even so, I can provide evidence of a fall in transport costs for specific routes and goods[52]:

[52]Data for the listed freight rates taken from Teubert (1912). The inflation rate is calculated based on purchasing power equivalent. Information retrieved from https://www.bundesbank.de/Redaktion/DE/Downloads/Statistiken/Unternehmen_Und_Private_Haushalte/Preise/kaufkraftaequivalente_historischer_betrage_in_deutschen_waehrungen.pdf?_blob=publicationFile. (accessed on 31/03/2016).

- Ruhrort-Mannheim (coal, 1885-87 to 1908-1912) real decline of approximately 55 percent
- Ruhrort-Rotterdam (coal, 1878 to 1908-1912) real decline of approximately 55 percent
- Hamburg-Dresden (cotton, fertilizer, iron, and petroleum, 1876-1880 to 1905-1909) real decline of approximately 57, 51, 50, and 61 percent respectively

Thus, in addition to the decline in international trade costs as described in the literature, there is a downward trajectory in domestic trade costs at least through the margin of a fall in real transport costs. In this section, I provided evidence from official freight rates on railway and examples for route specific freight rates on waterway.

### 1.5.4 Agglomeration

Combes et al. (2012) study the relative importance of agglomeration and selection toward higher productivity in a larger city. Their structural approach allows them to empirically distinguish between the two mechanisms. While selection left truncates the productivity distribution of firms, agglomeration right shifts and dilates the productivity distribution. In the case of agglomeration, all firms enjoy the benefits of locating in a large city. The authors use French firm-level data to test predictions of their model. They report significant effects of agglomeration economies in contrast to mostly insignificant results for selection in areas with employment- and population density above the median. Combes et al. (2012) find only some evidence of selection for the smallest firms. On the other hand, they estimate consistent significant agglomeration forces and dilation effects, which also increase in magnitude as firm size increases.

In this section, I explore heterogeneity across districts to investigate whether I can find effects similar to Combes et al. (2012). To define a measure of agglomeration I follow the literature and calculate two measures: the population density defined as inhabitants per square kilometer and the employment density defined as employees per square kilometer, where I take total employment count at the finest level of industry aggregation. I calculate these measures for all districts and rank them according to the densities with the highest density across all districts assigned a value of one and the lowest density across all districts assigned a value of seventeen. Then, I take the sum of ranks across all three years 1882, 1895, and 1907, calculate the rank of the sum and classify districts with rank one to the median as agglomerated districts.[53] Classifications of districts into agglomerated and

[53] The nine districts classified as agglomerated districts are number 5, 6, 9, 10, 12, 13, 14, 15, and 17 as defined on page 64.

non-agglomerated districts are the same for both measures of agglomeration.

$$\begin{aligned} \text{firmshare}^c_{ijt} = &\beta^c \times \ln(\text{trade openness}_{ijt}) \\ &+ \gamma^c_{agglom} \times \ln(\text{trade openness}_{ijt}) \times \mathbb{1}(\text{agglomeration district}_j) \\ &+ \lambda_{ij} + \epsilon^c_{ijt}. \end{aligned} \quad (1.20)$$

In equation (1.20), these districts are defined as "agglomeration district", whereas all other districts are defined as "non-agglomeration district". I investigate heterogeneity across agglomerated and non-agglomerated districts by estimating the coefficient $\gamma^c_{agglom}$ on the interaction between trade openness and a dummy equal to one for agglomeration districts. I focus on the analysis of firm shares as these are available at the finest level of industry aggregation. Table 1.15 and 1.16 show the results for equation (1.20) similar to Table 1.1 and 1.5.

[Table 1.15-1.16 here]

Results for first difference and fixed effects estimation are very similar and I only show the tables for fixed effects estimation. The sign of estimates is negative for small firms in the fixed effects estimation and the interaction term is negative but insignificant. This suggests that selection forces are more distinct in densely populated districts.

The effects on medium sized firms with 11 to 50 employees appear to be different: negative effects of trade on the share of medium-sized firms are driven by non-agglomeration districts (Table 1.16) whereas the total effect for agglomerated districts in this size category is insignificant as in Table 1.5. The interaction coefficients for the two largest firm size categories are small and insignificant which suggests that agglomeration forces play no role for the right tale of the firm size distribution.

### 1.5.5 Descriptive Evidence

In this section, I provide descriptive evidence to corroborate my first key finding that changes in trade integration are explanatory for changes in the size distribution. For this purpose, I refer to address books of German exporting firms. These were published from 1883 onward and I have accessed the first four volumes in 1883-85 and a follow-up volume from 1897. The publication dates are close in time to the first and second census year in 1882 and 1895 respectively. The Prussian department of commerce suggested the idea of such books and the German Central Association of Industry and the German Chambers of Commerce implemented them. One motivation underlying the publication of these books was "to show the most distant places in the world market that the German industry is fully competitive to the foreign."[54]

The books were distributed in foreign countries through the consulates. The idea of export promotion through foreign consulates is also pointed out by Huberman, Meissner, and Oosterlinck (2017). Their findings highlight the expansion of Belgium's international diplomatic network as explanatory factor for entry into foreign markets (extensive margin) that contributed to Belgium's trade boom between 1870-1914. Meissner and Tang (2017) report for Japan that the product and country extensive margin accounted for 30 percent of the growth in exports between 1880 and 1910.

In Table 1.A.6, I analyze for two industries, chemistry and wool, how many new bilateral trade relationships between districts on railway were formed between 1882 and 1907.[55] Wool is the industry in the sample with the lowest growth rate and chemistry with the highest proportionate increase in railway trade between 1882 and 1907. The average district added 2.5 and 1.8 new export destinations abroad out of seventeen recorded in railway statistics in the chemistry and wool industry respectively. While overall growth in trade was driven by the intensive margin, these numbers highlight a role for the extensive margin.

Selection of advertisements in the export promotion books was delegated to industries and industrial unions. It is stressed that the companies were represented as national ones. However, local government bodies could intervene if they felt their region was underrepresented to avoid any signs of partisanship. Most advertisements were translated into three further languages: English, French, and Spanish. To ensure appropriate translation of technical language the patent office was consulted. Companies advertisements include information about their specialties and their location. Along their core competencies, some firms published information on their size, output and machinery (e.g. efficiency measured as total horsepower).

I accessed volumes from 1883-85 that contain overall 3,200 advertisements. I consider advertisement which can be assigned to any of the twenty industries taken from the industry census data. The industry classification is like the one used in industry census data. Overall, I assign 1,161 firms to the twenty industries, i.e. 36.3 percent of all advertisements, thus a substantial fraction of the advertising manufacturing industry is represented in my analysis.

I have calculated the total number of firms advertising across all industries for each

[54] Quote taken from preface of Adress-Buch Deutscher Export-Firmen (1883, Volume 1).
[55] As pointed out before, railway data available from 1883.

district.[56] Likewise, I have computed the number of establishments across all industries counted in each district and the share of small and large firms in 1882 census data. The share of firms advertising as of all firms counted in census data ranges from 0.13 percent in district "Provinces of East- and West Prussia" up to 1.23 percent in district "Province of Westphalia, Principalities of Lippe and Waldeck". The correlation between the share of advertisements and small firms with less than six employees is strongly negative with -0.88 and highly significant at the one percent level, whereas the correlation between the share of advertisements and large firms with more than 200 employees is positive with 0.59 and significant at the five percent level. If one takes out Alsace-Loraine, which seems to be an outlier, the correlations magnify to -0.97 and 0.91 respectively.[57]

To capture these correlations in a more formal regression, I assign each advertisement to a district-industry pair and specify the following cross-sectional regression specification:

$$\text{firmshare}^c_{ij,1882} = \gamma \times \text{share of firms advertising}_{ij,1882} + \delta_i + \nu_j + \epsilon^c_{ij,1882}. \tag{1.21}$$

I weight the observations by the share of firms in each industry across districts to mitigate the impact of outliers in districts with few observations. I only include industries with more than ten advertisements.[58] Equation (1.21) conditions on industry fixed effects $\delta_i$ to consider within industry variation and district fixed effects $\nu_j$ to control for district specific differences such as market access.

[Table 1.A.12 here]

The results in Table 1.A.12 confirm the pattern of the raw correlations. The first column of Table 1.A.12 shows a negative and significant correlation of the share of small firms with less than six employees and the share of firms advertising in 1882. On the other hand, the advertisement intensity of exporting firms is positively and significantly correlated with the share of firms with 11 to 50 and 51 to 200 employees. The correlation is also positive for the largest firms with more than 200 employees though imprecisely estimated and insignificant.

I use information on firm size included by some companies to provide additional descriptive evidence. To take into account the fact that firms may have multiple establishments, I divide employment by the number of establishments if multiple locations were

[56]Note that advertisements refer to the firm level as opposed to establishments. Some firms are assigned to more than one location if they advertise with many locations, but most advertisements show only one location of the firm.

[57]The under-representation of Alsace-Loraine might be related to the fact that it was annexed only in 1871.

[58]The industries considered are iron and steel; earth, gravel, and sand; glass; iron and steel products; chemistry products; wool; cotton; paper; leather; and timber. Results are robust to not restricting the sample.

advertised. Out of 140 companies that list their employment in the advertisements 135, i.e. 96.4 percent, employ more than 49 employees and belong to the large firm size category in the census data. Only five companies belong to medium-sized firms with ten to 49 employees. Their employment is close to the upper boundary of medium sized firms.[59] Though there may be selection into reporting of employment, this is additional compelling evidence that the majority of exporters are large firms. As falling trade barriers enable more firms to start exporting the productivity cutoff falls and because of this there is a rise in the portion of large firms over time.

I find similar evidence when I examine a new series of advertisements that was published in 1897. The preface was written in 1895 and thus it appears reasonable to repeat this exercise for this new series of advertisements and the 1895 industry census data. This volume contains a total of 1,299 advertisements. Again, I identify the advertisements relating to industries considered in the quantitative analysis. I can match 453 firms, i.e. 34.9 percent, to those industries. The correlation between the share of advertisements and small firms with less than six employees is negative with -0.68 and significant at the one percent level, whereas the correlation between the share of advertisements and very large firms with more than 200 employees is positive with 0.46 and significant at the ten percent level. If one takes out Alsace-Loraine, which again seems to be an outlier, the correlations magnify to -0.83 and 0.69 respectively.[57] All firms that reveal information about their firm size have more than fifty employees.[60] Reassuringly, the descriptive evidence for 1882 is confirmed in the data for 1895.

Finally, I provide evidence on the location of exporters and relate this to agglomeration. The advertisements also reveal the exact location of the headquarters of each firm. I examine all locations with more than ten advertisements, which is approximately one percent of all advertisements considered.[61] Overall, eighteen locations satisfy this requirement. Berlin, Leipzig, and Dresden are the locations with most advertisements. Eight out of eighteen locations have more than 100,000 citizens (defined as large cities in population census) and a further nine out of eighteen locations belong to the medium-sized cities with 20,000-100,000 citizens. This suggests that densely populated areas were more likely to be a location of exporting firms.

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[59] The sizes of those firms are 25;36;40;40; and 40-50 employees.

[60] Taken as a whole, 37 firms published information on their employment in the respective industries in this address book.

[61] In this exercise, I exclude single advertisements of many firms within the same industry and location.

## 1.6 Conclusion

To the best of my knowledge this is the first study that uses region-industry specific data to illustrate the importance of trade integration to explain observed changes in firm and employment distributions across different size categories. For this purpose, I used census data in the historical context of the first wave of globalization, a unique setting characterized by closer trade integration through the expansion of the transport infrastructure and falling transport costs as important component of trade costs. This paper emphasizes the role economic integration has played in shaping the industrial employment structure during the industrialization in the German Empire.

My first contribution is to show that the firm size distribution shifts to larger firms in response to increased trade integration using domestic and international trade data across regions. Secondly, I propose a shift-share instrumental variable estimation that relies on regional trade by product to identify the causal effect.

Finally, I confirm some of the predictions of the Melitz model for firms in this early period of trade integration. I provide evidence for productivity gains in response to increased trade integration in line with the conclusions of the Melitz model. Furthermore, I investigate technology adoption as mechanism through which firms upgrade their productivity in response to closer market integration.

Firm heterogeneity has been the center of attention in the literature in international trade over the past two decades. This paper is arguably the first to assess key implications of this literature in historical data. My analysis confirms, in an unparalleled historical setting, that the effects theoretically described by Melitz (2003) have also been present during the first wave of globalization - a century before the emergence of this pioneering literature.

Figure 1.1: Firm shares across size categories

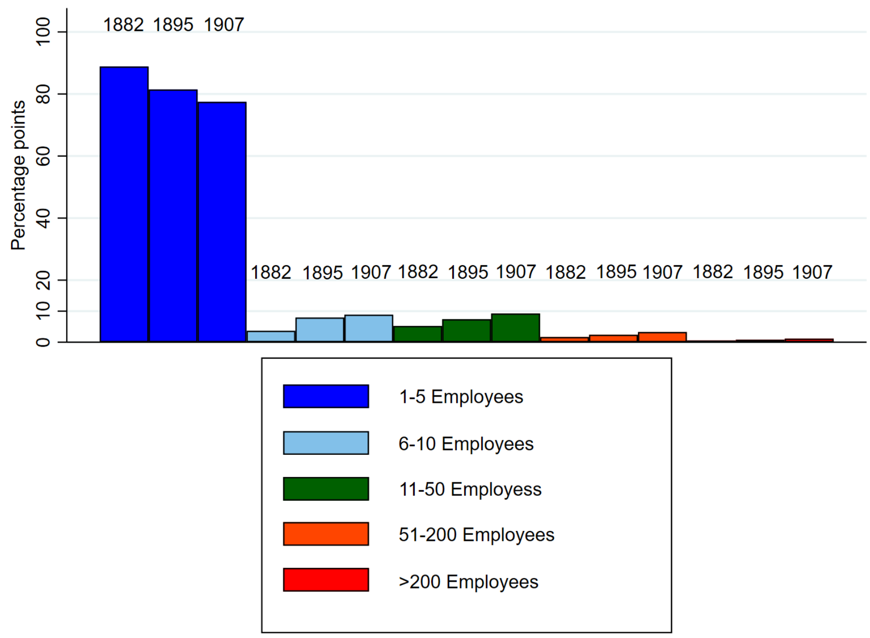



Figure 1.2: Employment shares across size categories

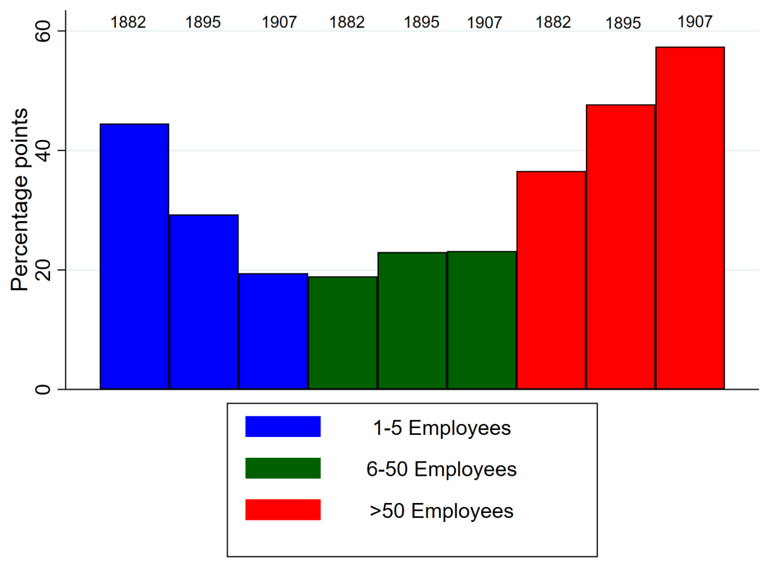


Figure 1.3: Correlation between observed and predicted trade flows

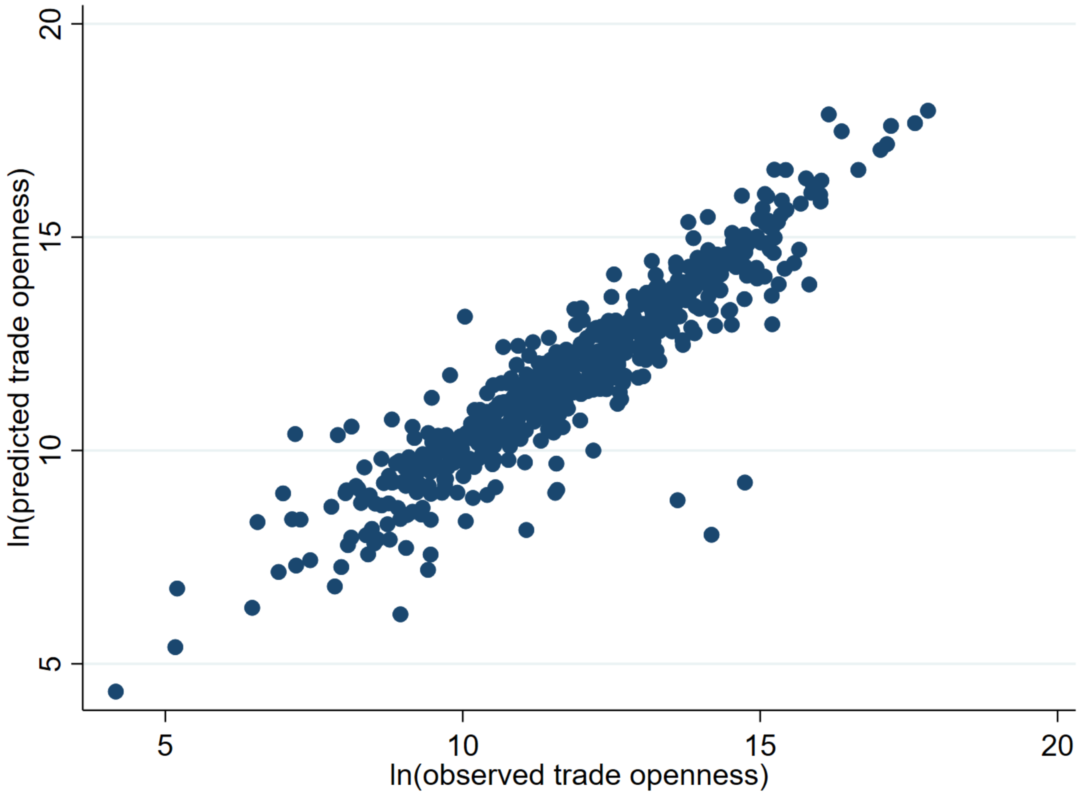


Table 1.1: Firm share - fixed effects

| | $\text{firmshare}^c_{ijt}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | $> 200$ |
| $\ln(\text{Trade openness}_{ijt})$ | $-0.0518^{***}$ | $0.0136^{***}$ | 0.0070 | $0.0167^{***}$ | $0.0144^{***}$ |
| | (0.0067) | (0.0041) | (0.0068) | (0.0042) | (0.0023) |
| Estimation method | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. |
| $R^2$ | 0.149 | 0.018 | 0.003 | 0.025 | 0.045 |
| Observations | 939 | 939 | 939 | 939 | 939 |

Notes: Estimates of equation (1.3). The unit of observation is a district-industry pair at time t. The dependent variable is the firmshare in size category c (number of employees), industry i, district j at time t. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair. All specifications include district-industry fixed-effects. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.2: Firm share - first differences

| | $\Delta$firmshare$^{c}_{ijt}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | > 200 |
| $\Delta$ln(Trade openness$_{ijt}$) | $-0.0505^{***}$ | 0.0064 | 0.0126 | $0.0163^{***}$ | $0.0153^{***}$ |
| | (0.0069) | (0.0090) | (0.0084) | (0.0038) | (0.0026) |
| Estimation method | First diff. | First diff. | First diff. | First diff. | First diff. |
| Observations | 611 | 611 | 611 | 611 | 611 |

Notes: Estimates of equation (1.5). The unit of observation is a district-industry pair at time t. The dependent variable is the first difference of the firmshare in size category c (number of employees), industry i, district j at time t. The independent variable is the change in the logarithm of the sum of railway and waterway trade for the respective district-industry pair. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.3: Employment share - fixed effects

| | $\text{employmentshare}^{c}_{ijt}$ | | | |
|---|---|---|---|---|
| Number of employees | 1-5 | 1-5 | 6-50 | $> 50$ |
| ln(Trade openness$_{ijt}$) | $-0.0752^{***}$ | $-0.1096^{***}$ | $0.0095^{**}$ | $0.1000^{***}$ |
| | (0.0105) | (0.0070) | (0.0044) | (0.0064) |
| Estimation method | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. |
| $R^2$ | 0.199 | 0.499 | 0.010 | 0.462 |
| Observations | 622 | 430 | 430 | 430 |

Notes: Estimates of equation (1.4). The unit of observation is a district-industry pair at time t. The dependent variable is the employmentshare in size category c (number of employees), industry i, district j at time t. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The sample in column 1 is based on all districts where employment shares are calculated at the finest industry aggregation in 1882 and 1895. Employment shares in columns 2-4 are calculated at the industry group classification. Observations in columns 2-4 in 1882 are available for districts 1,2,6,7,8,9,11 (without Principalities of Lippe and Waldeck), 12 (without Principality of Birkenfeld), and district 15. Grand Duchy of Oldenburg (Duchy of Oldenburg, Principalities of Birkenfeld and Lübeck) is assigned to district 5. All specifications include district-industry fixed-effects. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.4: Employment share - first differences

| | $\Delta$employmentshare$^{c}_{ijt}$ | | | |
|---|---|---|---|---|
| Number of employees | 1-5 | 1-5 | 6-50 | $> 50$ |
| $\Delta$ln(Trade openness$_{ijt}$) | $-0.0752^{***}$ | $-0.1024^{***}$ | 0.0052 | $0.0972^{***}$ |
| | (0.0105) | (0.0062) | (0.0055) | (0.0077) |
| Estimation method | First diff. | First diff. | First diff. | First diff. |
| Observations | 303 | 260 | 260 | 260 |

Notes: Estimates of equation (1.6). The unit of observation is a district-industry pair at time t. The dependent variable is the first difference of the employmentshare in size category c (number of employees), industry i, district j at time t. The independent variable is the change in the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The sample in column 1 is based on all districts where employment shares are calculated at the finest industry aggregation in 1882 and 1895. Changes in employment shares in columns 2-4 are calculated at the industry group classification. Observations in columns 2-4 for the first difference between 1882-1895 are available for districts 1,2,6,7,8,9,11 (without Principalities of Lippe and Waldeck), 12 (without Principality of Birkenfeld), and district 15. Grand Duchy of Oldenburg (Duchy of Oldenburg, Principalities of Birkenfeld and Lübeck) is assigned to district 5. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.5: Firm share IV - fixed effects

| | $\text{firmshare}^{c}_{ijt}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | > 200 |
| ln(Trade openness$_{ijt}$) | $-0.0351^{***}$ | $-0.0048$ | $-0.0004$ | $0.0224^{***}$ | $0.0179^{***}$ |
| | (0.0100) | (0.0103) | (0.0107) | (0.0080) | (0.0050) |
| Estimation method | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV | Fixed Eff. IV |
| Observations | 616 | 616 | 616 | 616 | 616 |
| First-stage F-stat | 783.45 | 783.45 | 783.45 | 783.45 | 783.45 |

Notes: Instrumental variable estimates of equation (1.3). Equivalent fixed effects estimation presented as in Table 1.1. The unit of observation is a district-industry pair at time t. The dependent variable is the firmshare in size category c (number of employees), industry i, district j at time t. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The first stage of the IV estimation is given in equation (1.8). All specifications include district-industry fixed-effects. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.6: Firm share IV - first differences

| | $\Delta\text{firmshare}^c_{ijt}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | $> 200$ |
| $\Delta\ln(\text{Trade openness}_{ijt})$ | $-0.0342^{***}$ | $-0.0025$ | $-0.0006$ | $0.0213^{***}$ | $0.0159^{***}$ |
| | (0.0100) | (0.0110) | (0.0100) | (0.0076) | (0.0046) |
| Estimation method | First diff. IV | First diff. IV | First diff. IV | First diff. IV | First diff. IV |
| Observations | 308 | 308 | 308 | 308 | 308 |
| First-stage F-stat | 869.59 | 869.59 | 869.59 | 869.59 | 869.59 |

Notes: Instrumental variable estimates of equation (1.5). Equivalent first difference estimation presented as in Table 1.2. The unit of observation is a district-industry pair at time t. The dependent variable is the firmshare in size category c (number of employees), industry i, district j at time t. The independent variable trade openness is the change in the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The instrument of the IV estimation is defined in equation (1.12). Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.7: Employment share IV - fixed effects

| | $\text{employmentshare}_{ijt}^{c}$ | | |
|---|---|---|---|
| Number of employees | 1-5 | 6-50 | $> 50$ |
| $\ln(\text{Trade openness}_{ijt})$ | $-0.1047^{***}$ | $-0.0188^{***}$ | $0.1235^{***}$ |
| | (0.0077) | (0.0065) | (0.0103) |
| Estimation method | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV |
| Observations | 340 | 340 | 340 |
| First-stage F-stat | 923.02 | 923.02 | 923.02 |

Notes: Instrumental variable estimates of equation (1.4). Equivalent fixed effects estimation of results presented as in columns 2-4 in Table 1.3. The unit of observation is a district-industry pair at time t. The dependent variable is the employmentshare in size category c (number of employees), industry i, district j at time t. Employment shares are calculated at the industry group classification. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The first stage of the IV estimation is given in equation (1.8). All specifications include district-industry fixed-effects. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.8: Employment share IV - first differences

| | $\Delta$employmentshare$^{c}_{ijt}$ | | |
|---|---|---|---|
| Number of employees | 1-5 | 6-50 | $> 50$ |
| $\Delta\ln$(Trade openness$_{ijt}$) | $-0.1048^{***}$ | $-0.0185^{***}$ | $0.1233^{***}$ |
| | (0.0078) | (0.0065) | (0.0104) |
| Estimation method | First diff. IV | First diff. IV | First diff. IV |
| Observations | 170 | 170 | 170 |
| First-stage F-stat | 921.25 | 921.25 | 921.25 |

Notes: Instrumental variable estimates of equation (1.6). Equivalent first differences estimation of results presented as in columns 2-4 in Table 1.4. The unit of observation is a district-industry pair at time t. The dependent variable is the first difference of the employmentshare in size category c (number of employees), industry i, district j at time t. Employment shares are calculated at the industry group classification. The independent variable trade openness is the change in the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The instrument of the IV estimation is defined in equation (1.12). Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.9: Average firm size - reduced form and IV

| | ln(av. f. size$_{ijt}$) | $\Delta$ln(av. f. size$_{ijt}$) | ln(av. f. size$_{ijt}$) | $\Delta$ln(av. f. s.$_{ijt}$) |
|---|---|---|---|---|
| ln(Trade openness$_{ijt}$) | 0.2426$^{***}$ | | 0.2436$^{***}$ | |
| | (0.0186) | | (0.0307) | |
| $\Delta$ln(Trade openness$_{ijt}$) | | 0.2406$^{***}$ | | 0.2365$^{***}$ |
| | | (0.0234) | | (0.0309) |
| Estimation method | Fixed eff. | First diff. | Fixed eff. IV | First diff. IV |
| $R^2$ | 0.245 | | | |
| Observations | 939 | 611 | 616 | 308 |
| First-stage F-stat | | | 783.45 | 869.59 |

Notes: Estimation of equation (1.13) in levels and in first differences. Columns 1 and 2 present the reduced form estimation and columns 3 and 4 the instrumental variable estimation. The unit of observation is a district-industry pair at time t. The dependent variable is the logarithm of the average firm size in industry i, district j at time t (columns 1 and 3) and the first difference of this variable (columns 2 and 4) respectively. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair (columns 1 and 3) and the first difference of this variable (columns 2 and 4) respectively. The first stage of the IV estimation in column 3 is given in equation (1.8). The instrument of the IV estimation in column 4 is defined in equation (1.12). Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.10: Labor productivity - reduced form and IV

| | $\ln(\text{lab. prod.}_{ijt})$ | $\Delta\ln(\text{lab. prod.}_{ijt})$ | $\ln(\text{lab. prod.}_{ijt})$ | $\Delta\ln(\text{lab. prod.}_{ijt})$ |
|---|---|---|---|---|
| $\ln(\text{Trade openness}_{ijt})$ | $0.2210^{***}$ | | $0.3711^{***}$ | |
| | (0.0434) | | (0.0793) | |
| $\Delta\ln(\text{Trade openness}_{ijt})$ | | $0.1524^{**}$ | | $0.3768^{***}$ |
| | | (0.0589) | | (0.1253) |
| Estimation method | Fixed eff. | First diff. | Fixed eff. IV | First diff. IV |
| $R^2$ | 0.149 | | | |
| Observations | 129 | 76 | 72 | 36 |
| First-stage F-stat | | | 328.93 | 143.32 |

Notes: Estimation of equation (1.17) in levels and in first differences. Columns 1 and 2 present the reduced form estimation and columns 3 and 4 the instrumental variable estimation. The unit of observation is a district-industry pair at time t. The dependent variable is the logarithm of the labor productivity in industry i, district j at time t (columns 1 and 3) and the first difference of this variable (columns 2 and 4) respectively. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair (columns 1 and 3) and the first difference of this variable (columns 2 and 4) respectively. The first stage of the IV estimation in column 3 is given in equation (1.8). The instrument of the IV estimation in column 4 is defined in equation (1.12). Observations are weighted across districts by the respective share of firms in the specific district in each industry in 1882. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.11: Technology adoption by firm size category

| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | 200-1,000 | >1,000 |
|---|---|---|---|---|---|---|
| Probability of adoption in 1907 (%) | 11.32 | 38.62 | 71.15 | 91.08 | 95.84 | 97.74 |
| Probability of adoption in 1882 (%) | 8.41 | 36.59 | 63.27 | 87.67 | 97.45 | 100 |
| Difference 1907-1882 (%) | 2.91 | 2.03 | 7.88 | 3.41 | -1.61 | -2.26 |

Notes: Author's calculation based on several volumes of Statistik des deutschen Reichs. Table 1.11 presents average adoption rates across twenty industries for the German Empire.

Table 1.12: Horse power per firm and per employee by firm size category

| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | 200-1,000 | >1,000 |
|---|---|---|---|---|---|---|
| Horsepower per firm in 1907 | 0.65 | 4.43 | 21.77 | 119.39 | 634.88 | 5,861.46 |
| Horsepower per employee in 1907 | 0.26 | 0.60 | 0.95 | 1.19 | 1.47 | 2.41 |

Notes: Author's calculation based on several volumes of Statistik des deutschen Reichs. Table 1.12 presents average horse power per firm and per employee by firm size category across twenty industries for the German Empire in 1907.

Table 1.13: Technology adoption motor - reduced form and IV

| | $\Delta$motorshare$_{ijt}$ | | |
|---|---|---|---|
| Sample period | 1882-1907 | 1895-1907 | 1895-1907 |
| $\Delta$ln(Trade openness$_{ijt}$) | 0.0226*** | 0.0706*** | 0.0787*** |
| | (0.0074) | (0.0153) | (0.0079) |
| Estimation method | First diff. | First diff. | First diff. IV |
| Observations | 604 | 304 | 304 |
| First-stage F-stat | | | 837.90 |

Notes: Estimates of equation (1.18). The unit of observation is a district-industry pair at time t. The dependent variable is the first difference of the variable motorshare in industry i, district j at time t. The independent variable trade openness is the change in the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The sample in column 1 includes observations from 1882, 1895, and 1907. The sample in columns 2 and 3 contains observations from 1895 and 1907. The instrument of the IV estimation in column 3 is defined in equation (1.12). Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.14: Technology adoption electric motor - reduced form and IV

| | $\Delta$electricmotorshare$_{ijt}$ | |
|---|---|---|
| Sample period | 1895-1907 | 1895-1907 |
| $\Delta$ln(Trade openness$_{ijt}$) | 0.1183$^{***}$ | 0.1300$^{***}$ |
| | (0.0127) | (0.0088) |
| Estimation method | First diff. | First diff. IV |
| Observations | 308 | 308 |
| First-stage F-stat | | 869.59 |

Notes: Estimates of equation (1.19). The unit of observation is a district-industry pair at time t. The dependent variable is the first difference of the variable electromotorshare in industry i, district j at time t. The independent variable trade openness is the change in the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The sample includes observations from 1895 and 1907. The instrument of the IV estimation in column 2 is defined in equation (1.12). Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.15: Firm share agglomeration - fixed effects

| | $\text{firmshare}_{ijt}^{c}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | $> 200$ |
| ln(Trade openness$_{ijt}$) | $-0.0449^{***}$ | 0.0107 | 0.0024 | $0.0165^{**}$ | $0.0153^{***}$ |
| | (0.0075) | (0.0067) | (0.0109) | (0.0065) | (0.0040) |
| ln(Trade openness$_{ijt}$) | $-0.0129$ | 0.0055 | 0.0087 | 0.0003 | $-0.0015$ |
| $\times\mathbb{1}$(agglomeration district) | (0.0124) | (0.0085) | (0.0132) | (0.0085) | (0.0047) |
| Estimation method | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. |
| $R^2$ | 0.151 | 0.019 | 0.004 | 0.025 | 0.046 |
| Observations | 939 | 939 | 939 | 939 | 939 |

Notes: Estimates of equation (1.20). The unit of observation is a district-industry pair at time t. The dependent variable is the firmshare in size category c (number of employees), industry i, district j at time t. The independent variables are trade openness which is the logarithm of the sum of railway and waterway trade for the respective district-industry pair and its interaction with a dummy for agglomerated districts. All specifications include district-industry fixed-effects. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.16: Firm share agglomeration IV - fixed effects

| | $\text{firmshare}^{c}_{ijt}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | $> 200$ |
| $\ln(\text{Trade openness}_{ijt})$ | $-0.0247^{*}$ | 0.0031 | $-0.0254^{**}$ | 0.0257 | $0.0213^{**}$ |
| | (0.0145) | (0.0208) | (0.0128) | (0.0173) | (0.0084) |
| $\ln(\text{Trade openness}_{ijt})$ | $-0.0179$ | $-0.0138$ | $0.0433^{**}$ | $-0.0057$ | $-0.0058$ |
| $\times\mathbb{1}$(agglomeration district) | (0.0195) | (0.0226) | (0.0182) | (0.0181) | (0.0103) |
| Estimation method | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV |
| Observations | 616 | 616 | 616 | 616 | 616 |
| First-stage F-stat | 161.24 | 161.24 | 161.24 | 161.24 | 161.24 |

Notes: Instrumental variable estimates of equation (1.20). Equivalent fixed effects estimation of results presented as in Table 1.15. The unit of observation is a district-industry pair at time t. The dependent variable is the firmshare in size category c (number of employees), industry i, district j at time t. The independent variables are the trade openness which is the logarithm of the sum of railway and waterway trade for the respective district-industry pair and its interaction with a dummy for agglomerated districts. The first stage of the IV estimation is an adjusted version of equation (1.8). All specifications include district-industry fixed-effects. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

## 1.7 Appendix

**List of industries considered**

- Fishery
- Iron ore
- Iron and steel
- Salt
- Hard coal
- Brown coal
- Stone
- Earth, gravel, and sand
- Lime and cement
- Glass
- Iron and steel products
- Chemistry products
- Fertilizer
- Fat and oil
- Petroleum and other mineral oil
- Wool
- Cotton
- Paper
- Leather
- Timber

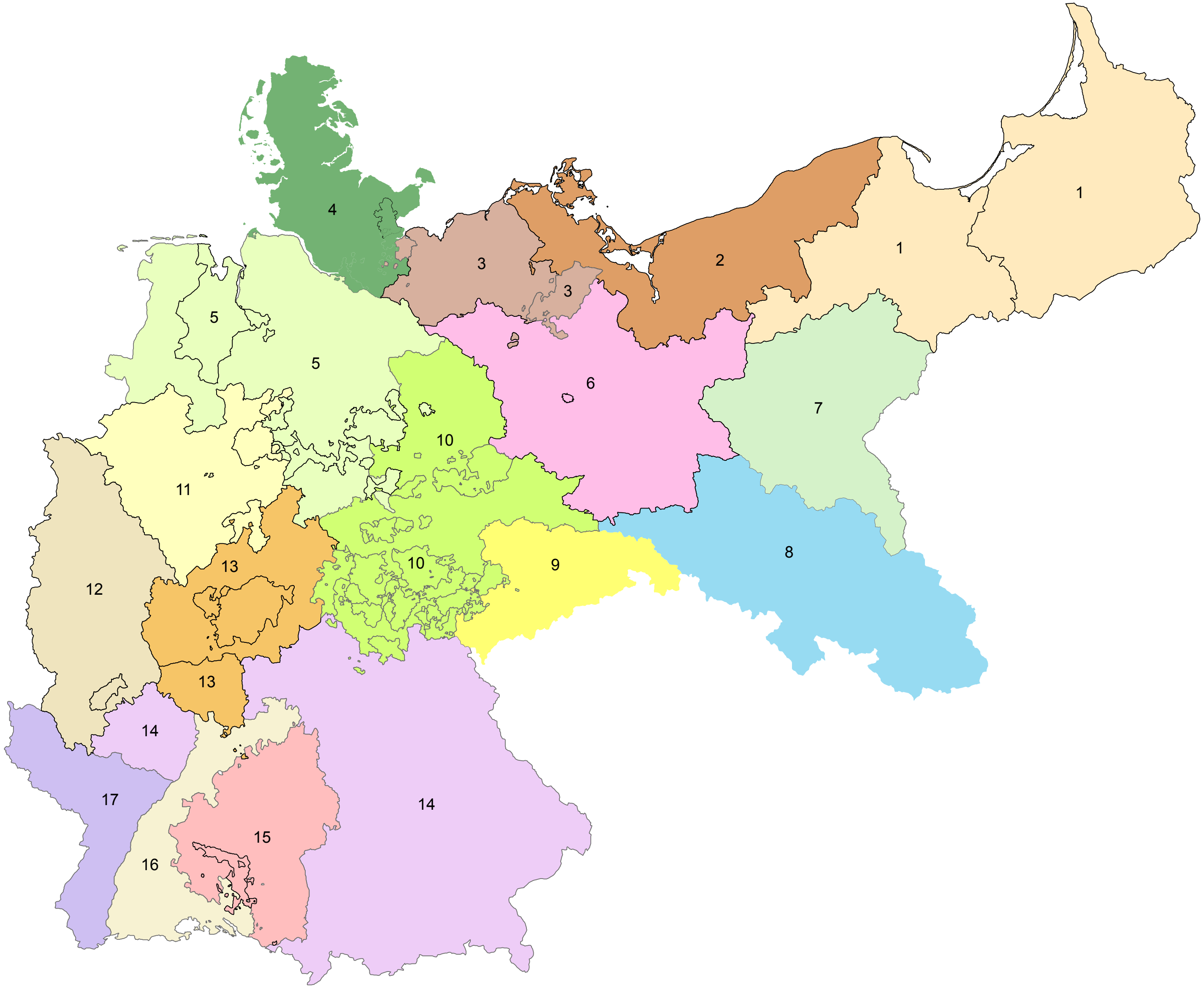
**List of industry classes (goods)**

- Fishery
- Ore winning and processing of ore (iron ore)
- Steel mill operation (iron and steel)
- Salt
- Mining of hard coal and brown coal, coke, graphite, asphalt, petroleum, amber, briquette fabrication (hard coal; brown coal)
- Stone
- Gravel and sand, lime, cement, tuff, gypsum, barite (earth, gravel and sand; lime and cement)
- Glass
- Iron and steel products
- Chemistry products
- Waste products and synthetic fertilizer (fertilizer)
- Light and soap fabrication, oil mills, coal tar, fabrication of ethereal and mineral oil, fats and varnish (fat and oil; petroleum and other mineral oil)
- Textile (wool; cotton)
- Paper and cardboard (paper)
- Leather
- Timber conservation and finishing (timber)

**List of industry groups (goods) considered in Tables 1.3-1.4 and Tables 1.7-1.8**

- Animal husbandry and fishery (fish)
- Coal mining, metallurgy, and saline (brown coal; iron ore; iron and steel; hard coal; salt)
- Stone and earth (lime and cement; stone; glass; earth, gravel, and sand)
- Iron processing (iron and steel products)
- Chemistry (chemistry products; fertilizer)
- Forestry byproducts, soaping, fat, oil, varnish (fat and oil; petroleum and other mineral oil)
- Textile (cotton; wool)
- Paper (paper)
- Leather (leather dermis)
- Timber (timber)

Figure 1.A.1: Map of districts



**List of districts**

- 1: Provinces of East and West Prussia and sea ports Memel, Pillau, Königsberg, Elbing, and Neufahrwasser
- 2: Province of Pomerania and sea ports Stolpmünde, Rügenwalde, Colberg, Stettin, Swinemünde, Wolgast, and Stralsund
- 3: Grand Duchies of Mecklenburg-Strelitz and Mecklenburg-Schwerin and sea ports Rostock, Warnemünde, and Wismar[62]
- 4: Province of Schleswig-Holstein, City of Lübeck, City of Hamburg, Principality of Lübeck and sea ports Flensburg, Kiel, Lübeck, Hamburg, Altona, and Glückstadt[62][63]
- 5: City of Bremen, Province of Hanover, Duchy of Oldenburg, Duchy of Braunschweig, Principality of Schamburg-Lippe, counties Pyrmont and Rinteln, and sea ports Harburg, Stade, Cuxhafen, Bremen, Vegesack, Geestemünde, Bremerhafen, Nordenham, Brake, Elsfleth, Emden, Leer, and Papenburg[62][63]
- 6: Urban district of Berlin and Province of Brandenburg
- 7: Province of Posen
- 8: Province of Schlesien
- 9: Kingdom Saxony
- 10: Province of Saxony, Grand Duchy Sachsen-Weimar, Duchies of Sachsen-Meiningen, Sachsen-Altenburg, Sachsen-Coburg-Gotha, Anhalt and Principalities of Schwarzburg-Sonderhausen, Schwarzburg-Rudolfstadt, Reuss-Greiz, and Reuss-Gera, and county Schmalkalden
- 11: Province of Westphalia, Principality of Lippe, Principality of Walbeck without county Pyrmont
- 12: Province of Rhineland and Principality of Birkenfeld without county Wetzlar[63]

[62] Two trade districts defined in the railway statistics include sea ports from two of the seventeen districts: railway district "Sea ports Rostock, Wismar, Flensburg, Kiel and Lübeck" contains sea ports from districts three and four. Railway district "Sea ports Hamburg, Altona, Glückstadt, Harburg, Stade and Cuxhafen" contains sea ports from districts four and five. As allocation rule to proxy trade in each district, I assign the share of the trade flow to each district according to their share of the number of ships trading goods in each of these ports.

[63] The Grand Duchy Oldenburg consisted of separate territories Duchy of Oldenburg, Principality of Birkenfeld, and Principality of Lübeck, which by construction belong to three different districts. For 1882 it is feasible to correctly allocate the number of firms to each spatial unit. For years 1895 and 1907 I make use of industry census data that contain information about the number of firms of each spatial unit. I allocate firms according to the corresponding industry shares taking into account the differences in total employment within each industry.

- 13: Province of Hessia-Nassau and Grand Duchy of Hessia with county Wetzlar but without counties Rinteln and Schmalkalden
- 14: Kingdom of Bavaria and Bavarian Palatine[64]
- 15: Kingdom of Württemberg and Province of Hohenzollern
- 16: Grand Duchy of Baden[64]
- 17: Alsace Lorraine

Districts in railway statistics assign the following counties different from census data which follow administrative boundaries:

- County Pyrmont in Waldeck located in district eleven is assigned to district five
- County Rinteln located in district thirteen is assigned to district five
- County Schmalkalden located in district thirteen is assigned to district ten
- County Wetzlar located in district twelve is assigned to district thirteen

The administrative structure divided the German Empire into 1,049 counties in 1900. I cannot correct for this assignment, because firm size distribution data are not available at the county level. However, this departure from administrative boundaries does not induce any systematic measurement error given the size of these counties.

[64]Mannheim belonged to Grand Duchy Baden and Ludwigshafen to Kingdom of Bavaria. Hence, the railway district "Mannheim and Ludwigshafen" contains parts of two districts. I apportion trade flows of the railway district according to the share of employment of Mannheim (Grand Duchy Baden) and Ludwigshafen (Kingdom of Bavaria) as of total employment of Mannheim and Ludwigshafen in the corresponding industry group.

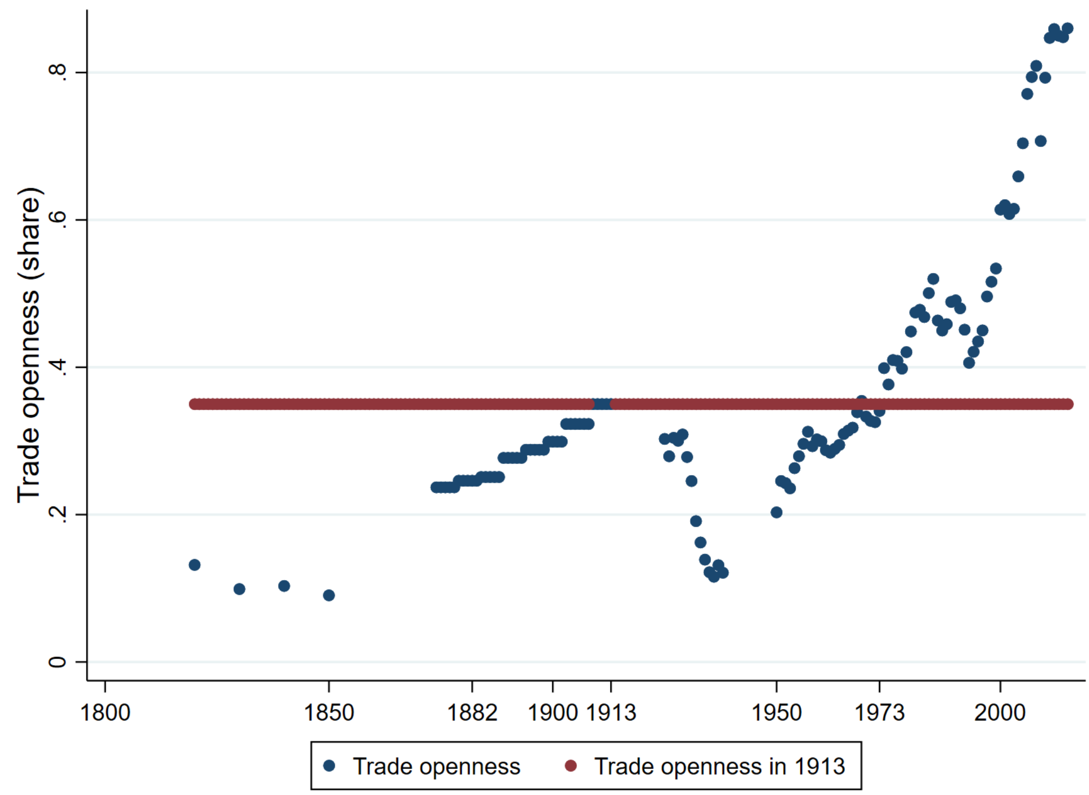
I use industry census data from Prussia in 1882 in equations (1.4) and (1.6). The following differences arise:

- In 1882 district eleven is represented without Principality of Lippe and Principality of Walbeck without county Pyrmont, i.e. as Province of Westphalia
- In 1882 district twelve is represented without Principality of Birkenfeld and without county Wetzlar, i.e. as Province of Rhineland[63]

**List of 17 countries and regions outside of German Empire included as trading partners in international exports and imports on railway**

- Russia
- Poland
- Galicia and Bukovina
- Romania
- Hungary, Slavonia, Croatia, Transylvania, Bosnia and Herzegovina
- Serbia, Bulgaria, Turkey, and Greece
- Bohemia
- Austria (without Bohemia and Galicia)
- Switzerland
- Italy
- France
- Luxembourg
- Belgium
- Netherlands
- Great Britain
- Sweden and Norway
- Denmark

Figure 1.A.2: Trade openness in Germany from 1820 to 2015




Notes: The variable trade openness is defined as share of exports plus imports as of total GDP. The red line illustrates the level of openness reached in 1913 and the graph shows that this level was passed sustainable only sixty years later. The data steam from different sources with possibly different price indices. GDP data for 1820, 1830, 1840, and 1850 interpolated from Fremdling (1995) and nominal trade data from Bondi (1958). The data for 1874-1913 are five-year averages taken from Torp (2014). Torp (2014) measures trade openness normalized by GNP. The data for 1925-1938 taken from Ritschl (2002). Observations from 1950-2015 calculated from statistics published by Federal Statistical Office of Germany (2016).

Federal Statistical Office of Germany (2016) online sources retrieved on 20/09/2016:
https://www.destatis.de/DE/ZahlenFakten/Indikatoren/Globalisierungsindikatoren/Tabellen/01_02_03_AH.html
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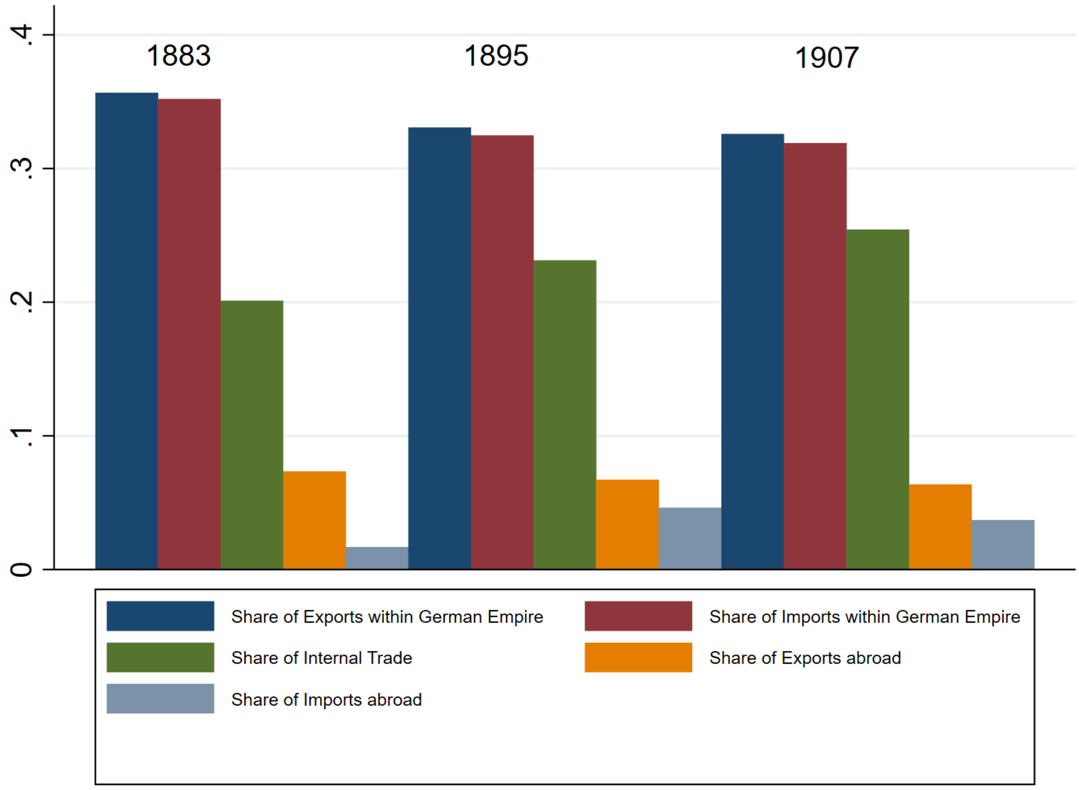
https://www.destatis.de/DE/ZahlenFakten/Indikatoren/LangeReihen/Aussenhandel/lrahl01.html

Figure 1.A.3: Shares of trade across modes on railway




Notes: Author's calculation based on various volumes of Statistik der Güterbewegung auf deutschen Eisenbahnen.

Figure 1.A.4: Sample calculation of the firm share from industry census data

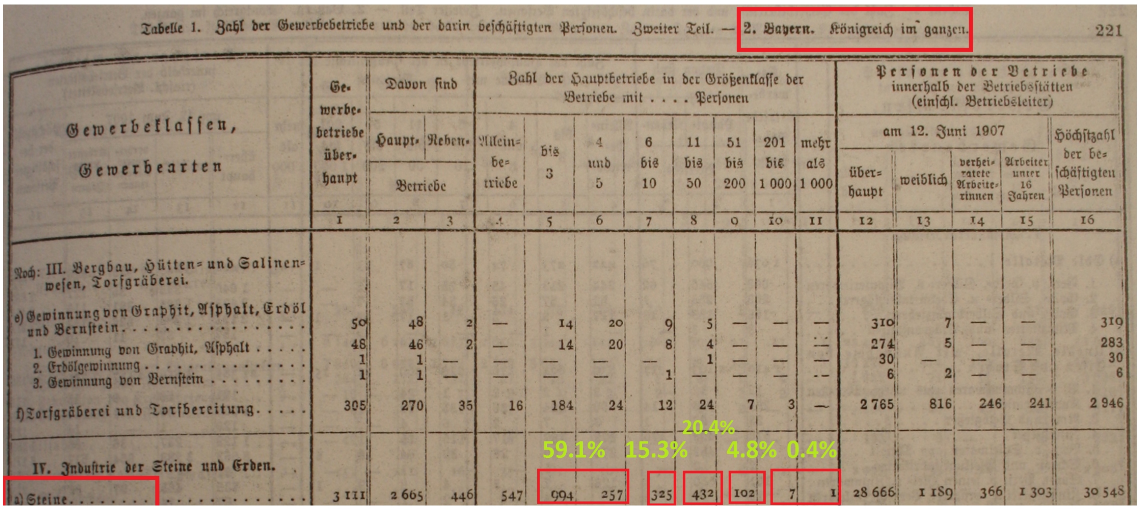


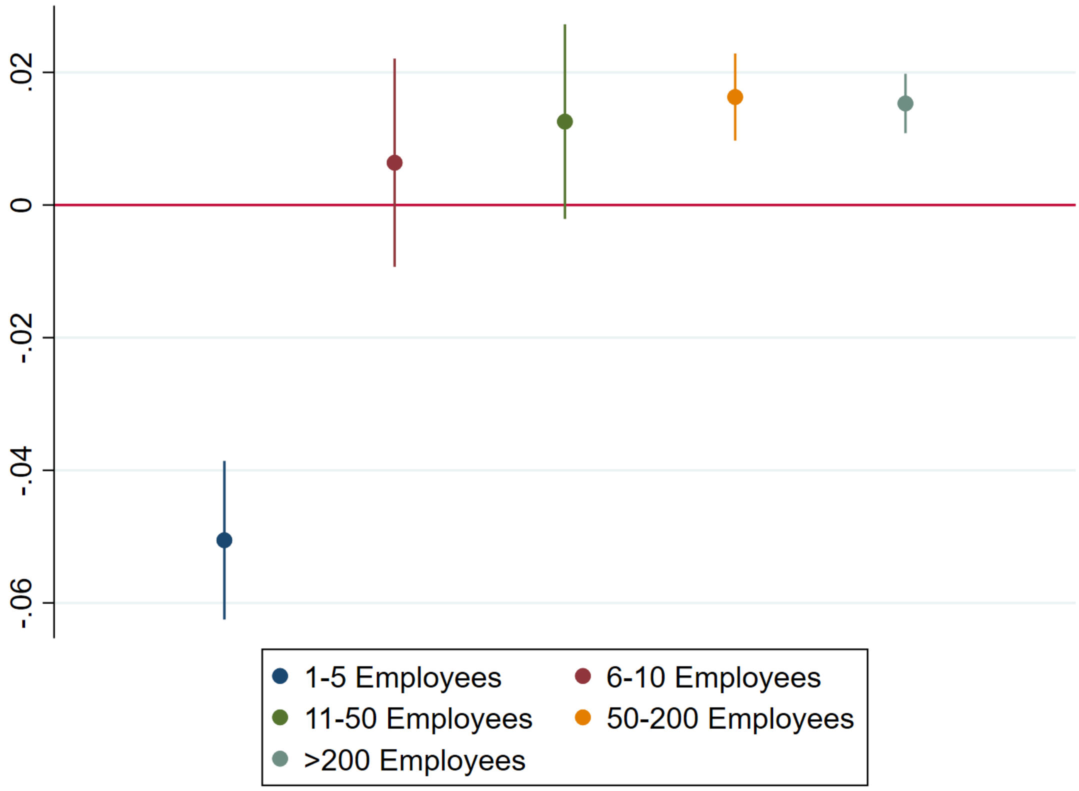
Tabelle 1. Zahl der Gewerbebetriebe und der darin beschäftigten Personen. Zweiter Teil. — 2. Bayern. Königreich im ganzen. 221

| Gewerbeklassen, Gewerbearten | Gewerbebetriebe überhaupt | Davon sind Hauptbetriebe | Davon sind Nebenbetriebe | Alleinbetriebe | Zahl der Hauptbetriebe in der Größenklasse der Betriebe mit .... Personen: bis 3 | 4 und 5 | 6 bis 10 | 11 bis 50 | 51 bis 200 | 201 bis 1 000 | mehr als 1 000 | Personen der Betriebe innerhalb der Betriebsstätten (einschl. Betriebsleiter) am 12. Juni 1907: überhaupt | weiblich | verheiratete Arbeiterinnen | Arbeiter unter 16 Jahren | Höchstzahl der beschäftigten Personen |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| Noch: III. Bergbau, Hütten- und Salinenwesen, Torfgräberei. | | | | | | | | | | | | | | | | |
| e) Gewinnung von Graphit, Asphalt, Erdöl und Bernstein | 50 | 48 | 2 | — | 14 | 20 | 9 | 5 | — | — | — | 310 | 7 | — | — | 319 |
| 1. Gewinnung von Graphit, Asphalt | 48 | 46 | 2 | — | 14 | 20 | 8 | 4 | — | — | — | 274 | 5 | — | — | 283 |
| 2. Erdölgewinnung | 1 | 1 | — | — | — | — | — | 1 | — | — | — | 30 | — | — | — | 30 |
| 3. Gewinnung von Bernstein | 1 | 1 | — | — | — | — | 1 | — | — | — | — | 6 | 2 | — | — | 6 |
| f) Torfgräberei und Torfbereitung | 305 | 270 | 35 | 16 | 184 | 24 | 12 | 24 | 7 | 3 | — | 2 765 | 816 | 246 | 241 | 2 946 |
| IV. Industrie der Steine und Erden. | | | | | | | | | | | | | | | | |
| a) Steine | 3 111 | 2 665 | 446 | 547 | 994 | 257 | 325 | 432 | 102 | 7 | 1 | 28 666 | 1 189 | 366 | 1 303 | 30 548 |



Notes: The figure shows how I constructed the variable firm share. The data point is the stone industry in district 15 (Kingdom of Bavaria and Bavarian Palatine) in the census year 1907. Overall, there are 2,118 firms in this district-industry pair. The firm share of firms with less than six employees is then given by $\frac{994+257}{2,118} \approx 59.1\%$. The firm shares for the other size categories are calculated correspondingly.

Figure 1.A.5: Coefficient plot for five size categories





Notes: The figure shows, point estimates for all five size categories with 90% confidence intervals for equation (1.5). The corresponding estimation results are presented in Table 1.2.

Table 1.A.1: Tariffs by industry

| Industry | 1882 | 1895 | 1907 |
|---|---|---|---|
| Fishery | 6.76 | 9.61 | 6.76 |
| Iron ore | 0 | 0 | 0 |
| Iron and steel | 16.12 | 19.73 | 11.30 |
| Salt | 30.12 | 33.10 | 20.74 |
| Hard coal | 0 | 0 | 0 |
| Brown coal | 0 | 0 | 0 |
| Stone | 7.31 | 1.26 | 2.70 |
| Earth, gravel, and sand | 0 | 0 | 0 |
| Lime and cement | 0 | 0 | 0 |
| Glass | 10.66 | 14.12 | 10.91 |
| Iron and steel products | 11.95 | 14.18 | 9.07 |
| Chemistry products | 6.44 | 0.38 | 1.28 |
| Fertilizer | 0 | 0 | 0 |
| Fat and oil | 6.27 | 9.01 | 9.73 |
| Petroleum and other mineral oil | 33.16 | 76.79 | 56.47 |
| Wool | 3.61 | 1.08 | 2.04 |
| Cotton | 8.75 | 2.58 | 5.92 |
| Paper | 6.38 | 7.07 | 6.79 |
| Leather | 4.61 | 3.63 | 3.07 |
| Timber | 2.73 | 6.12 | 6.65 |
| Average tariff | 7.74 | 9.93 | 7.67 |
| Median tariff | 6.32 | 3.11 | 4.49 |

Notes: Tariffs (%) are calculated from foreign trade statistics published as part of the Statistik des deutschen Reichs. Tariff revenues per 100 kg are divided by the price of 100 kg declarable goods.

Table 1.A.2: Firm number across size categories

| Number of employees | 1882 | 1895 | 1907 |
|---|---|---|---|
| 1-5 | 154,420 | 153,338 | 157,721 |
| 5-10 | 6,383 | 14,980 | 18,053 |
| 11-50 | 9,111 | 13,932 | 18,830 |
| 51-200 | 2,903 | 4,501 | 6,676 |
| > 200 | 955 | 1,483 | 2,309 |
| Total | 173,770 | 188,234 | 203,589 |

Notes: The table shows the distribution of firms by size category aggregated across districts and industries.

Table 1.A.3: Trade flows across trade modes

| Trade mode | 1882 | 1895 | 1907 |
|---|---|---|---|
| Domestic exports | 118,793 | 210,036 | 429,761 |
| | (786,492) | (1,181,668) | (2,071,704) |
| Domestic imports | 118,777 | 210,028 | 429,762 |
| | (553,357) | (826,381) | (1,548,399) |
| Internal trade | 64,960 | 131,571 | 286,638 |
| | (301,064) | (471,002) | (846,833) |
| Foreign exports | 23,646 | 40,161 | 81,399 |
| | (198,288) | (354,418) | (661,505) |
| Foreign imports | 6,131 | 28,141 | 47,470 |
| | (27,473) | (182,889) | (263,972) |
| Waterway exports | 14,534 | 27,901 | 43,942 |
| | (151,293) | (290,624) | (486,831) |
| Waterway imports | 16,365 | 32,343 | 75,158 |
| | (61,189) | (125,595) | (344,025) |
| Trade openness | 320,099 | 611,333 | 127,343,5 |
| | (1,505,580) | (2,388,757) | (4,383,565) |

Notes: Mean of trade flows based on 340 district-industry pairs in each year. Railway data in column 1882 refer to railway statistics for the year 1883. The variable trade openness is defined as sum of trade across all trade modes within a district by industries. Standard deviation in parentheses.

Table 1.A.4: Employment across districts

| District number | 1882 | 1895 | 1907 |
|---|---|---|---|
| 1 | 26,723 | 34,033 | 53,543 |
| 2 | 99,783 | 138,675 | 204,334 |
| 3 | 22,482 | 25,745 | 35,561 |
| 4 | 10,642 | 14,975 | 20,862 |
| 5 | 138,682 | 198,043 | 285,086 |
| 6 | 118,759 | 157,110 | 224,213 |
| 7 | 29,916 | 40,862 | 67,442 |
| 8 | 62,433 | 85,096 | 133,158 |
| 9 | 147,924 | 224,763 | 372,262 |
| 10 | 254,968 | 343,814 | 547,264 |
| 11 | 108,318 | 182,451 | 239,881 |
| 12 | 148,434 | 211,691 | 300,345 |
| 13 | 43,788 | 66,038 | 86,432 |
| 14 | 35,277 | 52,055 | 81,077 |
| 15 | 58,002 | 92,064 | 123,162 |
| 16 | 8,139 | 10,565 | 13,776 |
| 17 | 90,803 | 99,774 | 147,339 |
| Total | 1,405,073 | 1,977,754 | 2,935,737 |

Notes: Total employment across twenty industries by district. Author's calculations based on various volumes of Statistik des deutschen Reichs.

Table 1.A.5: Population across districts

| District number | 1882 | 1895 | 1907 |
|---|---|---|---|
| 1 | 3,302,528 | 3,450,746 | 3,633,579 |
| 2 | 3,434,972 | 4,409,244 | 5,706,576 |
| 3 | 1,517,712 | 1,575,052 | 1,702,286 |
| 4 | 1,665,617 | 1,774,046 | 1,964,806 |
| 5 | 3,998,782 | 4,355,477 | 4,993,098 |
| 6 | 3,754,116 | 4,328,073 | 4,889,295 |
| 7 | 1,689,621 | 2,080,890 | 2,599,051 |
| 8 | 2,922,288 | 3,364,889 | 3,986,105 |
| 9 | 2,234,514 | 2,850,951 | 3,980,652 |
| 10 | 4,147,917 | 5,090,825 | 6,697,844 |
| 11 | 5,268,761 | 5,779,176 | 6,598,168 |
| 12 | 3,014,822 | 3,753,262 | 4,585,500 |
| 13 | 2,023,843 | 2,136,572 | 2,406,659 |
| 14 | 1,558,598 | 1,719,238 | 2,057,561 |
| 15 | 2,474,327 | 2,768,928 | 3,351,508 |
| 16 | 674,160 | 709,836 | 747,592 |
| 17 | 1,539,580 | 1,623,079 | 1,820,249 |
| Total | 45,222,158 | 51,770,284 | 61,720,529 |

Notes: Population across districts and time. Author's calculation based on Statistik des deutschen Reichs Volume 111 and Statistik des deutschen Reichs Volume 213.

Table 1.A.6: Extensive margin for domestic and international trade on railway

| | 1882 | 1895 | 1907 | Difference 1907-1882 |
|---|---|---|---|---|
| Industry | | | Chemistry | |
| Domestic | 13.24 | 14.59 | 16.18 | 2.94 |
| Foreign destination | 8 | 8.29 | 10.47 | 2.47 |
| Foreign source | 5.35 | 5.29 | 8.06 | 2.71 |
| Industry | | | Wool | |
| Domestic | 13.71 | 14.29 | 16.06 | 2.35 |
| Foreign destination | 7.76 | 8.47 | 9.53 | 1.77 |
| Foreign source | 6.76 | 7.41 | 9 | 2.24 |

Notes: Mean number of destinations for seventeen districts defined on page 64 for the industries chemistry and wool. Data in column 1882 refer to railway statistics for the year 1883. The number of domestic and foreign regions is seventeen respectively. Domestic is the number of domestic trade relationships with positive trade flow out of seventeen. Foreign destination is the number of foreign regions that import from a domestic district. Foreign source is the number of foreign regions that export to a domestic district. Author's calculation based on bilateral trade flows digitized from various volumes of Statistik der Güterbewegung auf deutschen Eisenbahnen.

Table 1.A.7: Average firm size robustness - reduced form specification

| | $\Delta$ln(av. firm size$_{ijt}$) | | | | |
|---|---|---|---|---|---|
| $\Delta$ln(Trade openness$_{ijt}$) | 0.2406$^{***}$ | 0.1502$^{***}$ | 0.1626$^{***}$ | 0.1394$^{**}$ | 0.1479$^{*}$ |
| | (0.0234) | (0.0432) | (0.0529) | (0.0541) | (0.0706) |
| Estimation method | First diff. | First diff. | First diff. | First diff. | First diff. |
| Time FE | No | Yes | No | No | No |
| District-time FE | No | No | Yes | No | Yes |
| Industry-time FE | No | No | No | Yes | Yes |
| $R^2$ | | 0.026 | 0.061 | 0.171 | 0.208 |
| Observations | 611 | 611 | 611 | 611 | 611 |

Notes: The table shows versions of the baseline specification in equation (1.13) by adding different sets of fixed effects. The final column shows the estimation results of equation (1.14). The unit of observation is a district-industry pair at time t. The dependent variable is the change in the logarithm of the average firm size in industry i, district j at time t. The independent variable trade openness is the change in the logarithm of the sum of railway and waterway trade. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.A.8: Firm share robustness landlocked districts - fixed effects

| | firmshare$^c_{ijt}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | > 200 |
| ln(Trade openness$_{ijt}$) | $-0.0514^{***}$ | $0.0140^{**}$ | 0.0094 | $0.0157^{***}$ | $0.0124^{***}$ |
| | (0.0079) | (0.0046) | (0.0074) | (0.0047) | (0.0020) |
| Estimation method | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. |
| $R^2$ | 0.176 | 0.028 | 0.007 | 0.037 | 0.045 |
| Observations | 679 | 679 | 679 | 679 | 679 |

Notes: Estimates of equation (1.3). The unit of observation is a district-industry pair at time t. The dependent variable is the firmshare in size category c (number of employees), industry i, district j at time t. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair. All specifications include district-industry fixed-effects. The sample includes observations from landlocked districts only. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.A.9: Firm share IV robustness landlocked districts - fixed effects

| | $\text{firmshare}^c_{ijt}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | > 200 |
| ln(Trade openness$_{ijt}$) | $-0.0345^{***}$ | $-0.0141^{**}$ | 0.0105 | $0.0237^{***}$ | $0.0143^{***}$ |
| | (0.0116) | (0.0071) | (0.0122) | (0.0056) | (0.0048) |
| Estimation method | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV |
| Observations | 446 | 446 | 446 | 446 | 446 |
| First-stage F-stat | 601.73 | 601.73 | 601.73 | 601.73 | 601.73 |

Notes: Instrumental variable estimates of equation (1.3). Equivalent reduced form estimation as presented in Table 1.A.8. The unit of observation is a district-industry pair at time t. The dependent variable is the firmshare in size category c (number of employees), industry i, district j at time t. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The sample includes observations from landlocked districts only. The first stage of the IV estimation is given in equation (1.8). All specifications include district-industry fixed-effects. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.A.10: Firm share robustness international shipments - fixed effects

| | $\text{firmshare}^c_{it}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | > 200 |
| $\ln(\text{Trade openness}_{it})$ | $-0.0470^{***}$ | $0.0213^{***}$ | $-0.0100$ | $0.0132^{**}$ | $0.0224^{**}$ |
| | (0.0103) | (0.0064) | (0.0150) | (0.0056) | (0.0105) |
| Estimation method | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. | Fixed eff. |
| $R^2$ | 0.283 | 0.253 | 0.023 | 0.117 | 0.221 |
| Observations | 57 | 57 | 57 | 57 | 57 |

Notes: Estimates of equation (1.3) at the national level. The unit of observation is an industry i at time t. The dependent variable is the firmshare in size category c (number of employees), industry i at time t. The independent variable trade openness is the logarithm of international shipments measured at the national level. All specifications include industry fixed-effects. Robust standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 1.A.11: Firm share robustness IV aggregation - fixed effects

| | $\text{firmshare}^{c}_{ijt}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | $> 200$ |
| ln(Trade openness$_{ijt}$) | $-0.0459^{***}$ | 0.0007 | 0.0027 | $0.0235^{*}$ | $0.0191^{***}$ |
| | (0.0125) | (0.0142) | (0.0139) | (0.0126) | (0.0066) |
| Estimation method | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV | Fixed eff. IV |
| Observations | 616 | 616 | 616 | 616 | 616 |
| First-stage F-stat | 579.45 | 579.45 | 579.45 | 579.45 | 579.45 |

Notes: Instrumental variable estimates of equation (1.3). Equivalent fixed effects estimation as presented in Table 1.5. The unit of observation is a district-industry pair at time t. The dependent variable is the firmshare in size category c (number of employees), industry i, district j at time t. The independent variable trade openness is the logarithm of the sum of railway and waterway trade for the respective district-industry pair. The first stage of the IV estimation is given in equation (1.8). The constructed predicted trade flow is based on the growth rate of aggregated trade flows across industries by weights as defined in equations (1.15) and (1.16). All specifications include district-industry fixed-effects. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.A.12: Firm share - advertisements

| | $\text{firmshare}^c_{ij,1882}$ | | | | |
|---|---|---|---|---|---|
| Number of employees | 1-5 | 6-10 | 11-50 | 51-200 | > 200 |
| Share of firms advertising$_{ij,1882}$ | $-0.7242^{**}$ | $-0.0415$ | $0.4926^{**}$ | $0.1553^{**}$ | 0.1177 |
| | (0.2850) | (0.0703) | (0.1858) | (0.0692) | (0.1025) |
| Estimation method | OLS | OLS | OLS | OLS | OLS |
| $R^2$ | 0.769 | 0.475 | 0.654 | 0.659 | 0.665 |
| Observations | 167 | 167 | 167 | 167 | 167 |

Notes: Estimates of equation (1.21). The unit of observation is a district-industry pair in 1882. The dependent variable is the firmshare in size category c (number of employees), industry i, district j in 1882. The independent variable measures the share of firms advertising in the Adress-Buch Deutscher Export-Firmen published from 1883 to 1885. Observations are weighted across districts by the share of firms in the respective district within an industry. Robust standard errors in parentheses, clustered at the district level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

**Statistical Appendix**

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# Chapter 2

# The Role of Management Practices in Acquisitions and FDI

## 2.1 Introduction

Multinational corporations are the most productive firms in the global economy. The question of why multinationals operate efficiently across many countries is still open and puzzling.

One potential explanation for their productivity advantage across borders is the sharing of intangible assets within the boundaries of multinational firms. Examples of such intangible assets include spillovers from R&D investment (Bilir and Morales 2016) or the transplantation of the organizational structure (Marin, Rousova, and Verdier 2013). Implicitly, the assumption that more productive firms can transplant their productivity advantage to their affiliates abroad has already been featured in models of foreign direct investment (Helpman, Melitz, and Yeaple 2004; Burstein and Monge-Naranjo 2009).

The idea of sharing knowledge within multinationals firms has been examined in the management literature (e.g. Gupta and Govindarajan 2000). Case studies lend further support to the notion of sharing managerial knowledge within the firm that leads to a transfer of management practices across plants. Khanna and Palepu (1997) report that an Indian business group uses professional management training to facilitate talent and information flows within the group.

This paper introduces the idea of portability of management practices as intangible assets that can be shared within the boundaries of multinational firms. Management practices have for a long time been considered a productivity driver. They have been measured systematically for the first time through the World Management Survey (Bloom and Van Reenen 2007). One finding that is robust across firms surveyed in the World Management Survey (WMS) in all countries is that multinational affiliates are better managed than non-multinationals. Therefore, the expected gains from transferring management practices across borders are potentially significant.

I use the World Management Survey data to study the role of parent management practices in their investment decisions and in size and the productivity of their affiliates. Finally, I investigate which determinants possibly strengthen or weaken the transplant of management practices across borders. For this purpose, I merge WMS data to the Microdatabase Direct Investment (MiDi) at the German Central Bank, to the Business Structure Database (BSD) at the Office for National Statistics (ONS), and to Orbis data.

I find a positive association of management practices with all aspects of international investment. Better managed firms are more likely to engage in FDI and have more international corporate relationships. Importantly, parent management practices are positively correlated with the size and productivity of affiliates. A one standard deviation increase in parent management practices is associated with a 12.3 percent increase in employment and a 7.6 percent increase in labor productivity. Economic factors that tend to strengthen the correlation between parent management practices and affiliate outcomes are positive income differences between the source and the destination country and whether the affiliate is in the first level of the corporate hierarchy. On the other hand, the correlation between affiliate outcomes and parent management practices decreases with distance.

The positive correlation of parent management practices and affiliate productivity also holds for the productivity dynamics of acquisition targets post-acquisition. Better-managed parents decrease employment post-acquisition and thereby improve productivity in their acquisition targets. My findings highlight and quantify a new channel of productivity gains in foreign direct investment: the transplant of best parent management practices to their affiliates abroad intra-firm.

One body of the literature seeks to understand whether there are overall productivity gains from foreign direct investment. Generally, this strand of the literature focuses on the comparison between acquired and domestic firms after acquisitions through foreign multinationals. Most studies, such as Arnold and Javorcik (2009) in the case of Indonesian firms and Guadalupe, Kuzmina, and Thomas (2012) for Spanish firms establish positive gains from acquisitions. On the other hand, Wang and Wang (2015) do not find any productivity advantage from foreign acquisitions in China. Fons-Rosen et al. (2013) find modest effects of foreign investment on country-level productivity growth. Criscuolo and Martin (2009) point out source-country heterogeneity in productivity of foreign affiliates in the United Kingdom, namely that affiliates of American multinationals are more productive than affiliates of non-American multinationals.

An open question in this literature is how multinationals improve productivity in their foreign affiliates. The literature has highlighted various channels through which multinationals increase productivity such as an increase in access to foreign markets (Arnold and Javorcik 2009) or the interplay between the adoption of organizational innovations and market access (Guadalupe, Kuzmina, and Thomas 2012) as potential mechanisms. This paper contributes to this strand of the literature by suggesting that foreign affiliates do not only benefit through a scale effect but that management practices are important for understanding the readjustment within firm boundaries post-acquisition.

Recent work has started to intertwine both research on management practices and international economics. In the context of international trade, Bloom et al. (2018b) provide evidence that better managed firms are likely to export more products to more destinations. Alfaro et al. (2018) analyze the role of delegation for company boundaries. They point out that the positive relationship between delegation and integration is mediated through management practices.

I highlight four papers that deal with the intersection of organizational economics and multinational companies. Bloom, Sadun, and Van Reenen (2012a) find that the productivity advantage from IT investment of foreign affiliates in Europe managed by US multinationals over affiliates managed by non-US multinationals can be explained by the complementarity between IT investment and tougher people management practices. Marin, Rousova, and Verdier (2013) investigate when multinationals transplant the mode of their organization to foreign affiliates. Their conclusion is that competition in the host market as well as corporate culture matter for the likelihood of transplanting the organizational mode. Bloom, Sadun, and Van Reenen (2012b) show causally that trust in the region of multinational headquarters facilitates decentralization and multinationals from high trust regions have larger affiliates.

The work perhaps most closely related to this paper is by Heyman, Norbäck, and Hammarberg (2019). They use WMS data to calculate management source-country fixed effects and examine the impact of source-country management practices on productivity changes in foreign affiliates in Sweden as an FDI destination market. They find that heterogeneity in the average management score of source countries is important to productivity in Swedish affiliates: multinationals from the US, the country with the highest source-country fixed effect, improve productivity most in their Swedish affiliates compared to all other FDI source countries.

One disadvantage of source-country management fixed effects is that they mask heterogeneity in firms' management practices across sectors and within countries. In fact, within the set of multinational headquarters, I find that country fixed effects can only explain up to 14 percent of the variation in management practices. This paper differentiates from the work by Heyman, Norbäck, and Hammarberg (2019) and contributes to the literature in two important aspects. Firstly, the analysis accesses management practices measured at the headquarter level and assumes that management practices are transferred from parents to the affiliates and thereby improve affiliate productivity. Secondly, I move beyond source-country management fixed effects and control for source-destination fixed effects by leveraging management practices measured at the *firm-level* to make use of the significant variation of management practices across firms within countries, instead of the variation of management practices across countries.

The remainder of this paper is organized as follows: First I describe the World Management Survey design. The following section deals with the data and how I organize them for the analysis. Then, I outline the estimation strategy and discuss the results before the final section concludes.

## 2.2 Measuring Management Practices - the World Management Survey

In this section, I succinctly delineate the design of the World Management Survey.[1] The World Management Survey collected firm-level management survey data across many industries and countries. Firms in the survey were scored from 1 to 5 on a grid, which was developed by a leading international consulting firm to evaluate management practices. Best management practices are viewed to potentially apply to all firms and are not idiosyncratic to an individual firm as strategic management decisions are likely to be. The survey questions can be grouped into four broader categories: monitoring (five questions), operations (two questions), people (six questions), and targets (five questions). The management z-score is then the unweighted average across eighteen survey questions.

Companies were surveyed by graduate and MBA students, who received training on leading telephone interviews that typically took about 45 minutes. Interviews of the same company by two different interviewers revealed a strong and significant correlation of management scores suggesting validity of the way management practices were measured across different interviewers.[2]

The interview design prevents psychological bias from the interviewers or interviewees as documented in the surveying literature, due to the use of the "double blind" procedure.[3]

[1] Since the design of the survey has been described in the literature on management practices, I refer to Bloom and Van Reenen (2007) for a more detailed overview.

[2] In addition, it is possible to reduce measurement error in the survey through noise controls (interviewer fixed effects).

[3] Details on psychological biases in survey data can be found in Bertrand and Mullainathan (2001).

The survey was introduced to interviewees as an interview about lean manufacturing, i.e. they were not aware that their answers were scored. On the other hand, interviewers were not given any information about the companies, apart from their contact details. Therefore, interviewers did not know anything about the performance of the companies they were surveying, and at the same time the firms surveyed were not generally well known. More importantly, interviewers did not have access to any financial information on the companies they were interviewing. They were only provided with their names and contact details. In addition, they were paid by the number of interviews, so they had no incentive to search for further information about companies during their working time. For the purpose of this study, it is noteworthy that interviewers asked about multinational status but did not further interrogate about any information on affiliates abroad of global ultimate owners in the survey and the structure of multinational business groups. Therefore, the measure of parent management practices is unbiased for the following analysis that relates parent management practices to affiliate outcomes.

Unlike in the influential work by Bertrand and Schoar (2003) that highlights the effects of CEOs and CFOs for firm performance, typically, the interview partner in the WMS is a plant manager, who is familiar with the production process and can answer questions pertaining to day-to-day routines.[4] Interview requests were supported by endorsements of official government institutions such as the Bundesbank in Germany or the Treasury in the United Kingdom. The response rate was high and not correlated with any financial fundamentals of firms included in the random sample.

Recently, official government statistics have started to adopt the methodology of the WMS to measure management practices on a larger scale. The US census bureau conducted the "Management and Organizational Practice Survey" (MOPS) as part of the 2015 census data collection. The survey was mandatory for all manufacturing companies to participate in and the survey questionnaire was based on the original WMS questions. Besides the US census bureau, the Office for National Statistics (ONS) in the UK has run the Management Practice Survey (MPS) to measure management practices through a questionnaire.

Firms in the WMS were randomly sampled medium and large firms (50-10,000 employees, median 300 employees) from population databases. In this paper, I make use of data from twenty-three countries that were collected in survey waves between 2001 and 2014.[5] Overall, I access interview scores for approximately 8,700 firms. Typically, the WMS is a cross section, i.e. there is a single interview score for each firm. For approximately 27

[4]Dessein and Prat (2019) distinguish between the leader-centric empirical approach (e.g., CEOs) and the organization-centric approach (e.g., management practices).

[5]See Appendix for a list of countries.

percent of the companies surveyed, the data is a panel of more than one interview per firm from at least two different survey years.

## 2.3 Data

I combine the management practice data with three data sources. In this section, I briefly describe each of the data sources used in this paper. In the analysis, I consider the affiliates of global ultimate owners. The global ultimate owner is not controlled by another firm and holds the majority, i.e. more than 50 percent, of voting rights at each node along the corporate tree to an affiliate that belongs to its corporate group. Figure 2.1 illustrates the ownership concept with a fictitious example. The concept of global ultimate ownership follows the international standard definitions for multinational corporations (OECD 2008).

### 2.3.1 Orbis Ownership and Financial Data

I can match approximately three-quarters of the firms (6,618 companies) to a corresponding Bureau van Dijk ID. Within this set of firms, I identify 839 global ultimate owners. I construct the ownership tree for global ultimate owners with ownership data from Orbis. The Historical Ownership Database is available from Bureau van Dijk (2016a). It collects information on business groups and contains the direct and ultimate owner for each company in the data between 2007 and 2015. The database is updated annually. I complement the tree of the corporate group with unconsolidated financial information on affiliates from Orbis (Bureau van Dijk 2016b). From the financial information on affiliates, I retrieve affiliates' employment, sales, and productivity as outcome variables. In the following, I will refer to this data set as "Orbis-WMS data".

Furthermore, I obtain all acquisitions by firms in the WMS whose deal status is recorded as "complete" or "assumed complete" from the Zephyr database by Bureau van Dijk. Overall, I identify 836 cross-border acquisitions and complement them with unconsolidated financial information for the acquisition targets. I refer to the merged data set as "Zephyr-WMS data".

### 2.3.2 MiDi

While Bureau van Dijk's Historical Ownership Database offers global coverage of ownership links, financial information on affiliates is sometimes incomplete and may therefore not be representative of all affiliates. To address this concern, I merge the management scores of German firms in the WMS to the Microdatabase Direct Investment (MiDi, Deutsche

Bundesbank 2016).[6] The MiDi data span the years 1999 to 2014. As of 2002, information on stakes of at least 10 percent in a firm with a balance sheet total of more than 3 million euros has to be reported to the German Central Bank. The reporting criteria have been consistent since 2002 and I use data from 2002 to 2014. The main advantage over Bureau van Dijk data is that the MiDi data include detailed balance sheet information on affiliates and information on their employment and sales. Reporting of FDI activity is mandatory, subject to passing the reporting threshold.[7] From now on, I will refer to this data set as "MiDi-WMS data".

### 2.3.3 BSD

The Business Structure Database (BSD, Office for National Statistics 2017) provided by the Office for National Statistics (ONS) contains almost all economic activity in the UK. For example, in 2004 it was estimated that firms in the BSD captured 99 percent of economic activity in the UK. The BSD distinguishes between firms (enterprises) and local units (plants). The data span the years 1997 to 2016. I merge the British firms in the WMS sample to the BSD data to identify acquisitions of local units through firms in the WMS that are part of a multinational business group.[8] The UK is the country with the largest sample size in the WMS. Enterprises may themselves be part of a business group and I consider only acquisitions in which the business group as well as the enterprise that owns a local unit change simultaneously. The BSD contains limited information on local units, such as the industry code and employment. Hereafter, I will refer to this data set as "BSD-WMS data".

### 2.3.4 Summary Statistics

Table 2.1 shows summary statistics for global ultimate owners in the Orbis-WMS data. In 2007, the average multinational parent company owned approximately 10.4 affiliates. The distribution of affiliate ownership is right-skewed with a median of three affiliates. The management z-score of global ultimate owners with above median affiliates is 0.21 which suggests that better managed parents own more affiliates. The mean employment of global ultimate owners in 2007 was 2,150. Again, the employment distribution is right-skewed with a median employment of 468.

[6] Matching of the WMS data with the anonymized firm identifier in the German Central Bank data was performed by the Research Data and Service Center of the Deutsche Bundesbank (for details, see Schild, Schultz, and Wieser 2017).

[7] The Foreign Trade and Payments Acts ("Außenwirtschaftsgesetz") and the Foreign Trade and Payments Regulation ("Außenwirtschaftsverordnung") define the reporting criteria (for details, see Schild and Walter 2016).

[8] The matching of the WMS data with the anonymized firm identifier in the BSD was performed by the ONS.

The affiliates in the Orbis-WMS sample had on average 129 employees and sales of 61 million US dollars in 2007.

## 2.4 Estimation and Discussion

For each regression, I standardize the management z-score such that its distribution is standardized to mean 0 and standard deviation 1 for the global ultimate owners in the respective data set.[9] Hence, a unit increase in the management z-score can be interpreted as a one standard deviation increase in management practices. I make the management z-score consistent with other data over time as explained in Table 2.A.1. All regressions include interviewer fixed effects as noise controls, although I suppress them in the following notation for brevity.

### Selection into FDI

First, I investigate whether better managed firms are more likely to be global ultimate owners or select into global ultimate ownership. As better management practices are associated with higher productivity and the most productive firms select into FDI (Helpman, Melitz, and Yeaple 2004), one might expect that better managed firms are more likely to set up an affiliate abroad. I define a dummy variable equal to one, if a firm is a global ultimate owner that owns an affiliate abroad in any year between 2007 and 2014 according to the Historical Ownership Database.

$$\begin{aligned}\mathbb{1}(GUO^{FDI}_{ijc,intyear}) = \beta_0 + \beta_1 \times \text{management}_{i,intyear} + \delta_j + \alpha_c \\ + \lambda_{intyear} + \phi' \times X_{i,intyear} + \epsilon_{ijc,intyear}.\end{aligned} \tag{2.1}$$

The regression conditions on industry fixed effects at the three-digit level which are measured using the SIC classification and country fixed effects. In the cross-sectional regression in equation (2.1), i is the index for a WMS firm, j the index for industry affiliation, c indexes the country of residence and intyear denotes the survey wave in which the interview was held. Furthermore, the vector $X_i$ controls for the share of employees with a college degree, which is a measure of the skill intensity of the firm, and the shares of production exported and outsourced.

[Table 2.2 here]

[9] For example, the mean of management scores for global ultimate owners in the Orbis-WMS data is 3.09 and the standard deviation is 0.67. For the MiDi-WMS data I normalize according to the distribution of German firms that are global ultimate owners of another company. For BSD-WMS data at the ONS, I normalize the management score to the distribution of enterprises with at least one plant.

The fact that multinationals are better managed is well known and has been documented in the literature for the cross section (e.g. Bloom, Sadun, and Van Reenen 2016). The results in Table 2.2 confirm this correlation that better managed firms are more likely to be multinationals for global ultimate owners as identified in the Historical Ownership Database. A one standard deviation increase in management practices is associated with an increase of 2.74 percent in the likelihood of being a global ultimate owner. The correlation also remains positive and significant when adding firm controls for the skill intensity of firms and the shares of production exported and outsourced. All firm controls have the expected positive sign and the correlations for the skill intensity of the firm and the share of production exported are significant at one percent.

### Management Practices and the Location Decision

I now investigate, whether there is an association between country-level management practices and the decision as to in which countries multinationals own an affiliate. For each pair of the twenty-three countries considered in this paper, I construct the management gap between origin and destination country. For this purpose, I decompose the management score in a country k into a within and between firm component, following Bloom, Sadun, and Van Reenen (2016) and Olley and Pakes (1996):

$$M^k = \sum_i M_i \times \text{empl}_i = \sum_i \left[(M_i - \overline{M_i}) \times (\text{empl}_i - \overline{\text{empl}_i})\right] + \overline{M_i}. \tag{2.2}$$

The first term in the decomposition is a between firm reallocation term that weights an individual firm's deviation from the average management score of the country by its deviation in employment share from the average employment share in the WMS sample of the respective country. The second term is the unweighted mean of management practices across firms within a country. In the following, I define the management gap as the difference between origin country o and destination country d:

$$\text{management gap}_{od} = M^o - M^d. \tag{2.3}$$

Since the management score is unavailable for most affiliates, the country-level management score is a proxy for the average level of management practices of a representative domestic firm in a given destination country.[10] A representative company with a high source-country management score relative to the destination country will have positive

[10] I calculate the country management score considering only observations of domestic firms including domestic multinationals but excluding affiliates of multinationals' with headquarters located in a foreign country.

expected gains by transplanting its practices to affiliates in a destination country with a lower average level of management practices. Therefore, the decision to invest should be positively related to the management gap. I examine this hypothesis in the following specification:

$$\mathbb{1}(\text{investment}^{FDI}_{ijodt}) = \beta_0 + \beta_1 \times \text{management}_{it} + \beta_2 \times \mathbb{1}(\text{positive management gap}_{od}) + \delta_j + \alpha_o + \gamma_d + \phi' \times X_{od} + \epsilon_{ijodt}. \quad (2.4)$$

The vector $X_{od}$ includes common gravity controls such as distance, common language, colonial relationship, and contiguity. Additionally, I control for a dummy that is equal to one if the GDP per capita is higher in the origin than in the destination country, i.e. there is a positive GDP per capita gap.[11] I estimate this cross-sectional regression using data from 2007.

[Table 2.3 here]

The estimated coefficients for the gravity controls have the expected signs. The decision to invest in a given country is negatively related to bilateral distance and positively related to sharing a common language, a colonial relationship, and a common border. More developed countries are more likely to invest into less developed countries, as the positive coefficient on the dummy for a positive GDP per capita gap suggests. The decision to invest into a given destination is positively related to the management z-score of the firm and the management gap between origin and destination country (column 1). In line with the hypothesis, a positive management gap is associated with a statistically significant increase by seven percent to invest into a given destination country. There are on average potential gains from sharing management practices with the destination country, when the management gap is positive. The size of the coefficient is approximately the same as the coefficient on sharing a common language.

The positive correlation between the investment decision and the differences in management practices between source and destination country also holds for the sub-components of the management z-score. When controlling for all sub-components jointly, there is a positive significant association of the investment decision with the country gap between origin and destination in operations, people, and target practices. The association is strongest for the gap in people management practices, which indicates that firms prefer to invest in locations where there are expected gains from people management practices.

[11] Gravity controls were retrieved from CEPII and GDP per capita data from the World Bank database. See Appendix for details.

### Affiliate Firm Size and Productivity

In this section, I analyze the association between parent management practices and affiliate firm size and productivity. The idea is that, because management practices have been shown to be positively associated with the size and productivity of firms surveyed themselves, the transplantation of best management practices from parents to affiliates will lead to a positive association between parent management practices and affiliate size and productivity. While the WMS does not deliberately survey management practices for both the parent and its affiliate in general, I observe a management score in 35 parent-affiliate relationships for both the parent and the affiliate.

Figure 2.2 reveals that there is a positive correlation between the management scores of parents and their affiliates, i.e. a high correlation of management practices for members of the same multinational business group. The correlation is positive and highly significant after conditioning on country fixed effects for parents and affiliates.[12] The scatter plot in Figure 2.2 underpins the idea that there is a positive relationship between the management score of the parent and its affiliate, possibly due to the sharing of management practices. However, Figure 2.2 does not reveal anything about the direction of transplantation. The management literature suggests that knowledge flows more from multinational parents to their affiliates than the other way around (Gupta and Govindarajan 2000). Therefore, I assume that multinational parents share their management practices with their affiliates. This assumption provides a rationale for studying the correlation between parent management practices and affiliate outcomes.[13]

As a next step, I investigate the association between the parent management z-score and affiliate outcomes. The following regression specification posits a relationship between the management score of the parent and affiliates' outcomes:

$$\ln(\text{outcome}_{apjodt}) = \beta_0 + \beta_1 \times \text{management}_{pt}^{parent} + \delta_j + \lambda_t + \gamma_{od} + \epsilon_{apjodt}. \tag{2.5}$$

The outcome variables considered are employment, sales, and labor productivity.[14] In the Orbis-WMS data set, employment is available for 2,525 affiliates, sales are available for 1,945 affiliates, and labor productivity can be calculated for 1,540 affiliates.

As the size of affiliates is potentially small, detailed financial information is not available for all affiliates. Therefore, I chose labor productivity as a baseline productivity

[12]The correlation is similar when not conditioning on country fixed effects.

[13]Bloom et al. (2018a) use the "Management and Organizational Practice Survey" that measures management practices for the first time on a large scale in the context of the US manufacturing census. They show that management practices not only vary between firms, but that 40 percent of the variation in management practices is within firms.

[14]I winsorize all outcomes at the 1st and 99th percentile of their distribution to mitigate the impact of outliers. The results are qualitatively similar when not winsorizing.

measure. Alternatively, I run a regression of sales as the dependent variable and estimate a Cobb-Douglas production function by controlling for employment, the book value of tangible fixed assets, industry, and source-destination country fixed effects. Then I calculate as a fourth outcome the Solow residual from the Cobb-Douglas estimation, which I denote as $\hat{\mu}_{apjodt}$ in the tables. The Solow residual from a Cobb-Douglas production function can be estimated for 1,454 affiliates.

Since management practices measured at the affiliate level are not available, I cannot control for affiliate management practices. Aside from industry fixed effects ($\delta_j$) and time fixed effects ($\lambda_t$) the specification controls for origin-destination fixed effects ($\gamma_{od}$). Note that origin-destination fixed effects absorb common gravity controls such as distance. Furthermore, they allow me to study the association between parents' management practices and affiliates' outcomes for a given source-destination country pair. In particular, the setup enables me to document the heterogeneity of management practices within a FDI source country that is masked in the analysis by Heyman, Norbäck, and Hammarberg (2019), who use source-country management fixed effects to study Sweden as a FDI destination market. Cross-sectional regressions of management practices on source-country fixed effects for global ultimate owners reveal that only 10 to 14 percent of the variation in management practices can be explained by source-country differences (Table 2.A.2).

[Table 2.4 here]

I begin by describing the results for the Orbis-WMS data set (Table 2.4). There is a significant positive correlation between better parent management practices and all affiliate outcomes. Since the dependent variable in equation (2.5) is the natural logarithm, I can interpret the difference of a one standard deviation increase in management practices as the percentage change of the left-hand side variable. A one standard deviation increase in parent management practices is associated with an increase of 12.3 percent in affiliate employment. The magnitude of the correlation is larger for sales (27.9 percent) and less pronounced for productivity (7.4 percent). The interquartile range of the management z-score corresponds to 1.28 standard deviations. Hence, moving from the 25th to the 75th percentile in management practices is associated with an increase in affiliate employment of 15.8 percent and labor productivity of 9.5 percent.

The results look similar for the MiDi-WMS data in terms of affiliate employment. The estimate suggests that a one standard deviation increase in management practices is associated with an increase in employment of 13.2 percent (Table 2.A.4). The size of the point estimate for sales is significant but smaller compared to the Orbis-WMS sample. Therefore, there is no significant positive correlation between parent management practices and affiliate productivity (Table 2.A.4, columns 3 and 4). One possible reason is that there are more affiliates in the lower levels of the corporate hierarchy in the MiDi-WMS data compared to the Orbis-WMS data, which is an important dimension of heterogeneity as I will discuss later.

The estimated correlation of parent management practices with affiliate productivity in the Orbis-WMS data is large, but attenuated compared to the estimate of the management score on firms' productivity itself, which is four times as large (Bloom and Van Reenen 2010).[15] The estimates for employment suggest a pass-through of the correlation between parent management practices and parent employment to the correlation of parent management practices and affiliate employment of approximately 46 percent.[16]

So far, the analysis has considered cross-sectional regressions. As a next step, I introduce a fixed-effects specification.

$$\begin{aligned}\ln(\text{outcome}_{apjod,intyear}) = \beta_0 + \beta_1 \times \text{management}^{parent}_{p,intyear} \\ + \nu_a + \lambda_{intyear} + \epsilon_{apjod,intyear}.\end{aligned} \tag{2.6}$$

In this specification $\nu_a$ denotes an affiliate fixed effect that controls for time invariant affiliate characteristics.

[Table 2.5 here]

As the Historical Ownership Database from Bureau van Dijk are not available before 2007, I estimate equation (2.6) using the MiDi-WMS sample only. The long time series in the MiDi-WMS sample allows me to exploit the panel of management score which is available for 48 percent of German global ultimate owners. The results show a positive, marginally significant association of within parent management changes and within employment changes. A one standard deviation change in parent management practices is associated with a growth in affiliate employment of six percent. The within correlation of parent management practices and affiliate sales is positive but insignificant. As for the cross-sectional sample estimation in the MiDi-WMS sample, there is no significant correlation of changes in parent management practices and changes in affiliate productivity. This might be due to a limited number of observations and a limited and possibly noisy variation in management practices over time. Furthermore, it is not clear what the true time lag is to transplant management practices within firm boundaries. As Bloom

[15]In Bloom and Van Reenen (2010) a one standard deviation increase in management practices is associated with an increase in labor productivity of 0.299 log points.

[16]When I estimate the correlation between parent management practices and parent employment for the set of global ultimate owners, the coefficient on the management z-score is 0.265 (Table 2.A.3). Therefore, the coefficient for affiliate employment (0.123) is about 46 percent of the coefficient on parent management practices for parent employment as an outcome variable.

et al. (2013) document, firms continued adopting management practices until six months following the diagnostic phase in their experimental study and the spillovers across plants within treated firms continued years later (Bloom et al. 2018c). The significance for affiliate employment as opposed to affiliate sales and productivity could also be due to the fact that sales-based productivity (TFPR) is only a noisy estimate of TFPQ as it contains information on input and output prices and markups (Hsieh and Klenow 2009).

### Acquisitions

The data for WMS firms with the Bureau van Dijk identifier from Zephyr that covers mergers and acquisitions goes back to 1997. When defining the sample, I focus on new acquisitions and exclude stake increases in existing parent-affiliate relationships. Finally, I consider only deals with a "complete" or "assumed complete" status. There are 836 cross-border acquisitions to which I can merge financial information. To increase the sample size, I identify acquisitions by both shareholders and global ultimate owners.[17]

Following the methodology of Bandiera et al. (2017), I estimate the dynamic effects of parent management practices on affiliate performance through an event-study design with the following difference-in-differences model:

$$\begin{aligned}\ln(\text{outcome}_{apjodqt}) = {} & \beta_0 + \beta_1 \times \mathbb{1}(\text{takeover}^{post}_{1-3\text{years}}) + \beta_2 \times \mathbb{1}(\text{takeover}^{post}_{4-6\text{years}}) \\ & + \beta_3 \times \text{management}^{parent}_{pq} \times \mathbb{1}(\text{takeover}^{post}_{1-3\text{years}}) \\ & + \beta_4 \times \text{management}^{parent}_{pq} \times \mathbb{1}(\text{takeover}^{post}_{4-6\text{years}}) \\ & + \lambda_t + \nu_a + \epsilon_{apjodqt}.\end{aligned} \tag{2.7}$$

The specification controls for affiliate and time fixed effects and for two dummies, which are equal to one, one to three years and four to six years post-acquisition. The total treatment window includes six years pre- and post-acquisition as well as the acquisition year. The index q denotes the acquisition year. I use the most recent parent interview information at the acquisition year as parent controls. The coefficients of interest are $\beta_3$ and $\beta_4$, which capture the correlation of parent management practices and acquisition targets' outcomes one to three and four to six years post-acquisition.

[Table 2.6 here]

The coefficient estimates for $\beta_3$ and $\beta_4$ show that there is a negative correlation between parent management practices and affiliate employment and a positive correlation between parent management practices and affiliate productivity. The association between affiliate

[17] In Figure 2.1 company A is a global ultimate owner and companies B, C, and D are shareholders.

sales and parent management practices is near zero. Due to the small sample size the correlations are noisily estimated (Table 2.6). However, the size of the point estimates suggests that sizable changes may occur in relation to management practices post-acquisition.

When I restrict the sample to observations in which the difference between the interview year and the year of the acquisition is less than six, the coefficients on employment and labor productivity are significant (Table 2.A.5). This sample contains approximately 70 percent the all acquisitions in Table 2.6. The rationale for this sample restriction is that managerial capital depreciates, and the information contained in management scores more than five years before or after the acquisition date is a noisy estimate. Bloom, Sadun, and Van Reenen (2016) estimate a depreciation rate of 12.9 percent, which would suggest that after five years fifty percent of the original managerial capital is depreciated. The magnitude of the correlations is striking. A one standard deviation increase in management practices implies approximately a 17.9 percent increase in productivity one to three years post-acquisition. Columns 1 and 2 show that better managed parents improve labor productivity mostly by reducing employment. The first period estimate is marginally significant at the 10 percent level and suggests a 15.9 percent decrease in acquisition target employment for a one standard deviation increase in parent management practices, while the second period coefficient four to six-year post-acquisition is significant at the five percent level and suggests a 20.6 percent decrease in employment for a one standard deviation increase in parent management practices.

As an alternative, I consider acquisitions of domestic *plants* in the UK. I identify these through the Business Structure Database (BSD) as a change in ownership of a plant between companies in which both the enterprise and business group change simultaneously. In so doing, I obtain 723 acquisitions by multinationals in the WMS in the BSD-WMS sample. I identify takeovers of plants by either domestic or foreign multinationals in the WMS to maximize the sample size.[18] Thereby, I can base my estimation for the dynamic effects of parent management practices on affiliate employment on a larger sample compared to the acquisitions in the Zephyr-WMS data. I consider employment as an outcome in the BSD data.

In terms of employment, I find similar effects to those in the Zephyr-WMS sample when considering the larger sample of BSD-WMS acquisitions. As before, I define two dummies that take value one for one to three years and four to six years post-acquisition respectively, where the first dummy includes the year of the ownership change. The total treatment window includes six years pre- and post-acquisition as well as the acquisition year. The coefficients of interest are the interactions of the management z-score with these

[18] Results are qualitatively similar when restricting the sample to foreign multinationals.

two dummies that capture the dynamic effects of parent management practices on plant employment post-acquisition.

$$
\begin{aligned}
\ln(\text{empl}_{apjodqt}) = {} & \beta_0 + \beta_1 \times \mathbb{1}(\text{takeover}^{post}_{1-3\text{years}}) + \beta_2 \times \mathbb{1}(\text{takeover}^{post}_{4-6\text{years}}) \\
& + \beta_3 \times \text{management}^{parent}_{pq} \times \mathbb{1}(\text{takeover}^{post}_{1-3\text{years}}) \\
& + \beta_4 \times \text{management}^{parent}_{pq} \times \mathbb{1}(\text{takeover}^{post}_{4-6\text{years}}) \\
& + \beta_5' \times \text{X}^{parent}_{pq} \times \mathbb{1}(\text{takeover}^{post}_{1-3\text{years}}) \\
& + \beta_6' \times \text{X}^{parent}_{pq} \times \mathbb{1}(\text{takeover}^{post}_{4-6\text{years}}) \\
& + \nu_a + \delta_j + \lambda_t + \epsilon_{apjodqt}.
\end{aligned}
\tag{2.8}
$$

[Table 2.7-2.8 here]

The first column controls for time fixed effects and the subsequent columns add interviewer fixed effects, affiliate industry fixed effects, the logarithm of parent employment, and the parent's export share as controls. The later controls for parent characteristics address the concern that the change in affiliate employment is due to a change in market size which suggests a scale effect as opposed to parent management practices. However, a parent's employment and export share may themselves be a function of parent management practices and therefore the results have to be interpreted with caution.

The point estimates for $\beta_2$ suggest that multinationals generally decrease employment post-acquisition in this sample. The tendency to decrease employment is more pronounced for better managed parents. There is no significant effect one to three years post-acquisition. The point estimates for $\beta_4$ turn out negative four to six years post-acquisition. Depending on the specifications, the point estimates suggest a reduction in employment by seven to fourteen percent. The coefficients in columns 1 to 4 are all marginally insignificant for the second period post-acquisition. When I estimate similar regressions as in equation (2.8) with the sub-component of the WMS related to people management as treatment, the results turn out stronger (Table 2.8). People management is the sub-component of the management score that one would expect to be most relevant for employment decisions. Indeed, all specifications are marginally significant and in some cases at the five percent level. The estimates suggest that a one standard deviation increase in the parent people management practices implies an eleven (column 1) to nineteen percent (column 4) decrease in plant employment.

The findings from the Zephyr-WMS and BSD-WMS estimations highlight that better managed foreign firms might be more willing to restructure their staff, e.g. through people management that is based on removing poor-performing people and identifying and distilling talent. Better managed firms are more willing to take tougher decisions after they acquire a firm or a plant and reduce employment. The results on acquisitions are particularly relevant for multinational business groups as acquisitions account for a significant share of global FDI flows. For example, the value of cross-border acquisitions was 62.4 percent of global investment flows in 2006 (UNCTAD 2007).

### Mechanism: Causal Evidence on Management Practices and Intra-firm Spillovers

While it is very challenging to find plausibly exogenous variation in management practices as in Giorcelli (2019), I relate the findings to the experimental evidence in Bloom et al. (2013) and Bloom et al. (2018c).

The positive association between management practices and firm performance was causally identified by Bloom et al. (2013), who designed a randomized controlled trial (RCT) in India and found that there was a causal relationship between better management practices and productivity. They show that treatment plants that were offered free consulting through a diagnostic and an implementation phase not only took up management practices themselves (a 37.8 percentage point increase of practices adopted) but also non-experimental plants in treatment firms showed a significant increase in the adoption of management practices (a 17.5 percentage point increase). Bloom et al. (2018c) revisit their RCT experiment to ask whether management interventions have long lasting effects. The non-experimental plants in treatment firms that adopted fewer practices from 2008 to 2010 continued to adopt practices reaching adoption rates very similar to the experimental plants in treatment firms, which suggests substantial intra-firm spillovers from sharing knowledge about management practices eliciting to convergence in adoption rates between non-experimental plants and experimental plants (Bloom et al. 2018c, Figure 1). This experimental finding underpins the idea of sharing managerial knowledge that leads to a transfer of good management practices across plants and is the key mechanism to my empirical approach. The intervention not only had a positive treatment effect on the adoption of management practices and productivity, but firms of treatment plants increased the number of plants by 0.259 compared to the control group three years following the intervention (extensive margin). This finding is in line with the positive correlation of parent management practices and the number of affiliates global ultimate owners possess.

### Heterogeneity in the Portability of Management Practices across Countries

In this section, I analyze heterogeneity by making use of the cross-sectional variation in the data as opposed to acquisitions due to the larger number of affiliates in the cross-section. I shed further light on factors that potentially weaken or strengthen the correlation between parent management practices and affiliate outcomes. More specifically, I consider heterogeneity with respect to income differences across countries, physical distance between the affiliate and the parent, and the position of the affiliate in the corporate hierarchy. Due to the greater cross-country variation in the Orbis-WMS data compared to the MiDi-WMS data, I report the estimates using this data set as a baseline and briefly compare the results to the ones in the MiDi-WMS data.

### GDP per Capita Differences

Related to the idea of the management gap, I define the GDP per capita gap as follows:

$$\text{GDP p.c. gap}_{od} = \text{GDP p.c.}_o - \text{GDP p.c.}_d. \tag{2.9}$$

I introduce a dummy equal to one when the GDP per capita is higher in the origin country compared to the destination country.

$$\begin{aligned} \ln(\text{outcome}_{apjodt}) = \beta_0 &+ \beta_1 \times \text{management}_{pt}^{parent} \\ &+ \beta_2 \times \text{management}_{pt}^{parent} \times \mathbb{1}(\text{Positive GDP per capita gap}_{od}) \\ &+ \delta_j + \lambda_t + \gamma_{od} + \epsilon_{apjodt}. \end{aligned} \tag{2.10}$$

[Table 2.9 here]

The estimates for $\beta_2$ are large and significant which suggests that the correlations between parent management practices are much stronger for affiliate sales and productivity when the source country is more developed than the destination country. The point estimate for $\beta_2$ implies a 11.7 percent increase in affiliate labor productivity for a one standard deviation increase in parent management practices which is 4.2 percent larger than the baseline estimate in Table 2.4. On the other hand, there are no differences in employment. Potentially, the benefits from transplanting management practices are higher in less developed countries, if management practices are a production factor that contributes significantly to aggregate total factor productivity as claimed by Bloom, Sadun, and Van Reenen (2016). The results suggest that the benefits that parents can reap from transplanting management practices are related to the level of development of the destination country. The findings are very similar in the MiDi-WMS sample. In Table 2.A.6 the interaction term is positive and significant for affiliate labor productivity and the Solow residual but insignificant for affiliate sales. The estimation suggests that opening up to FDI can have positive effects due to the inflow of better management practices through multinational affiliates. The evidence in Bloom et al. (2018a) shows that there are also potential indirect gains through management spillovers due to learning from incumbents from the arrival of multinational firms.

### Distance

An obvious cost-increasing factor of transplanting management practices internationally is distance. Within France, Charnoz, Lelarge, and Trevien (2018) found that the expansion of the French high-speed rail increased affiliate size through the reduction of communication costs, especially for business trips. Giroud (2013) shows that plants which experience a reduction in travel time to the headquarters, due to the opening of new airline routes, increase investment and productivity. Kalnins and Lafontaine (2013) establish a causal link between establishments' distance to headquarters and their longevity. Physical distance increases the cost of communication, monitoring, and travel costs for managers from the headquarters to their affiliates. I define four distance bins such that the number of affiliates is more or less balanced across bins.[19]

$$\begin{aligned}\ln(\text{outcome}_{apjodt}) = {} & \beta_0 + \beta_1 \times \text{management}_{pt}^{parent} \\ & + \sum_{m=2}^{4} \gamma_m \times \text{management}_{pt}^{parent} \times \mathbb{1}(\text{Dist. bin}_{od}^{m}) \\ & + \delta_j + \lambda_t + \gamma_{od} + \epsilon_{apjodt}.\end{aligned} \tag{2.11}$$

[Table 2.10 here]

Although not statistically distinguishable from the base category, the negative coefficients on the interactions suggest that the correlations between parent management practices and affiliate productivity are attenuated for affiliates' sales, productivity, and the Solow residual. The total effect ($\beta_1 + \gamma_m$) on the correlations for affiliates located further than 1,000 km away from the parent is statistically not distinguishable from zero for affiliate productivity, which suggests that the positive association between parent management practices and affiliate productivity decreases with distance. The effect on the correlations of parent management practices and affiliate employment and sales is diminished in the MiDi-WMS sample (Table 2.A.7). It is likely that multinationals may still decide to invest abroad for reasons other than the portability of management practices such as market access or technology upgrading in the affiliates.

[19]The distance bins are 0-1,000 km, 1,000-3,000 km, 3,000-6,000 km, and more than 6,000 km. I omit the category between 0 and 1,000 km to interpret the estimates of the other dummies relative to the shortest distance.

### Corporate Hierarchy

Finally, I investigate heterogeneity with respect to the position of the affiliate in the corporate hierarchy. I distinguish between affiliates in which the global ultimate owner has a direct stake and affiliates in which the global ultimate owner does not participate directly, but indirectly through a firm it owns. In Figure 2.1, affiliate B is in the first level of the corporate hierarchy, i.e. a direct link, whereas the global ultimate owner company A does not own a stake in affiliates D and F, which are at the higher levels of the corporate hierarchy and which I classify as indirect links. For the clear majority, i.e. approximately 95 percent, of ownership links in the Historical Ownership Database the global ultimate owner owns a direct stake in the affiliate.

$$\begin{aligned}\ln(\text{outcome}_{apjodt}) = \beta_0 &+ \beta_1 \times \text{management}_{pt}^{parent} + \beta_2 \times \mathbb{1}(\text{Direct ownership link}_{ap}) \\ &+ \beta_3 \times \text{management}_{pt}^{parent} \times \mathbb{1}(\text{Direct ownership link}_{ap}) \\ &+ \delta_j + \lambda_t + \gamma_{od} + \epsilon_{apjodt}.\end{aligned} \tag{2.12}$$

[Table 2.11 here]

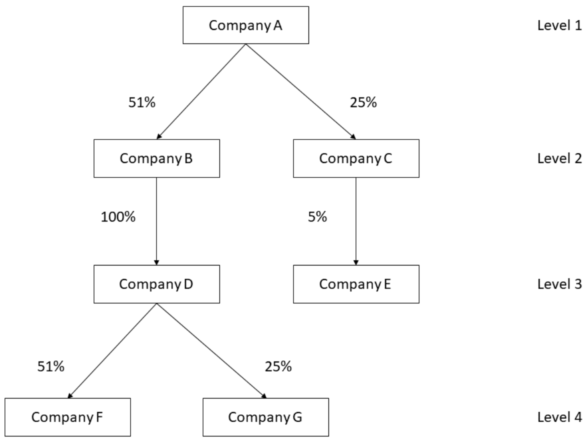
Directly owned affiliates are generally significantly smaller in terms of employment and sales in the Orbis-WMS data. The correlation of parent management practices with affiliate productivity is strengthened when the affiliate is at the first level of the corporate hierarchy (Table 2.11). Again, the results are strikingly similar in the MiDi-WMS data (Table 2.A.8). About 62 percent of affiliates were directly owned in the MiDi-WMS data in 2006. On average affiliates in the first level of the corporate hierarchy are smaller in terms of employment and sales, and less productive. The estimate for the interaction term $\beta_3$ is positive and highly significant for affiliates' sales, labor productivity, and the Solow residual. An immediate connection in the corporate hierarchy may be associated with lower monitoring costs of the affiliates through the headquarters.

## 2.5 Conclusion

Understanding the mechanisms underlying productivity gains from international integration in business groups is among the most interesting questions in an increasingly intertwined globalized world. This paper introduces the idea of transplanting management practices from parents to affiliates as an explaining factor.

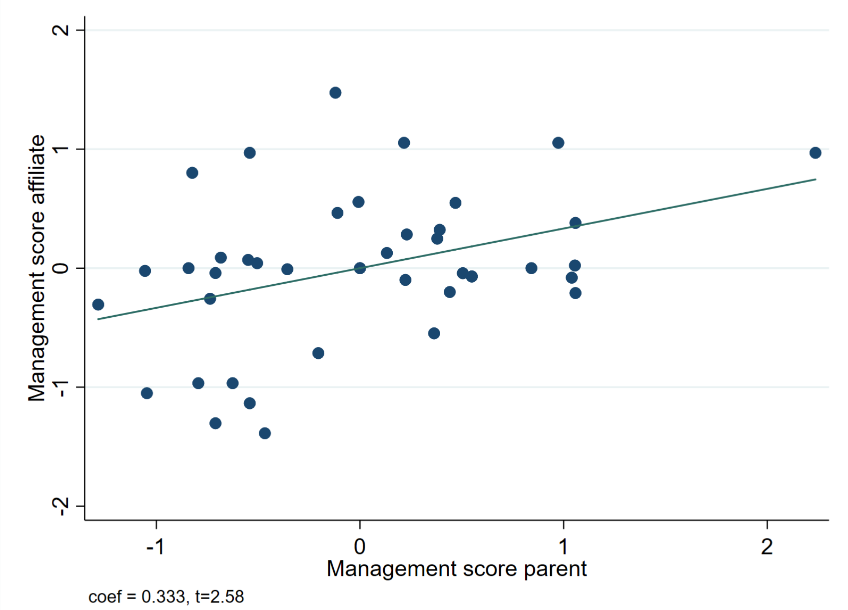
Drawing on a unique sample of management data obtained through individual interviews, I further augment the WMS data set by constructing the complete ownership tree of corporate relationships. In so doing, I can quantify the role of management practices for selection into corporate relationships. I find a positive association of better parent management practices and the management gap between origin and destination country with the decision to invest abroad. By supplementing the ownership tree with affiliates' financial data, I further investigate the role of parent management practices on affiliate performance both for existing relationships and for new relationships made through acquisitions. The results show a sizable positive association of better management practices and affiliates' employment, sales, and productivity. One margin that increases the costs of transplanting management practices across borders is physical distance. The positive correlation between affiliate productivity and parent management practices is corroborated when the affiliate is at the first level of the corporate hierarchy and the source country is more developed than the destination country. These findings highlight that the channel of transplanting management practices is of particular relative importance when contemplating the welfare effects of foreign direct investment in developing and emerging economies.

Figure 2.1: Corporate hierarchy of a multinational business group




Company A is the global ultimate owner of affiliates B, D, and F.

Figure 2.2: Correlation between parent and affiliate management z-scores




The figure shows the management z-scores 35 parent-affiliate pairs in the Orbis-WMS data. The regression conditions on country fixed effects for parents and affiliates. The t-statistic is calculated using robust standard errors.

Table 2.1: Summary statistics - Orbis-WMS data

| | | **Global Ultimate Owner** |
|---|---|---|
| Variable | Mean | Number of global ultimate owners |
| Number of foreign affiliates | 10.38 | 475 |
| | (21.49) | |
| Number of employees | 2,150 | 474 |
| | (9,115) | |

| | | **Affiliate** |
|---|---|---|
| Variable | Mean | Number of affiliates |
| Labor productivity | 1,217 | 777 |
| | (12,633) | |
| Employment | 130 | 1,201 |
| | (315) | |
| Sales | 61,445 | 973 |
| | (187,976) | |

Notes: The table shows means (standard deviations). The upper panel refers to global ultimate owners surveyed in the WMS. The lower panel displays data on the affiliates. Labor productivity is defined as sales per employee. Labor productivity and sales are in thousands of US dollars. The data are from 2007.

Table 2.2: Selection global ultimate owner status - Orbis-WMS data

| | $\mathbb{1}(\text{GUO}^{FDI}_{ijc,intyear})$ | |
|---|---|---|
| Management z-score$_{i,intyear}$ | 0.0274*** | 0.0298*** |
| | (0.0061) | (0.0090) |
| Share of employees with degree$_{i,intyear}$ | | 0.0019*** |
| | | (0.0006) |
| Share of production exported$_{i,intyear}$ | | 0.0007*** |
| | | (0.0003) |
| Share of production outsourced$_{i,intyear}$ | | 0.0005 |
| | | (0.0005) |
| Country FE | Yes | Yes |
| Industry FE | Yes | Yes |
| Interview year FE | Yes | Yes |
| Firm controls | No | Yes |
| $R^2$ | 0.214 | 0.205 |
| Observations | 6,040 | 2,403 |

Notes: Estimates of equation (2.1). The unit of observation is a WMS firm i in country c and industry j that is not owned by a foreign multinational. The dependent variable is a dummy which is one if the firm is identified as a global ultimate owner in the Orbis Historical Ownership Database between 2007 and 2014. The independent variable of interest is the management z-score which is the average across all eighteen management practices. The specification includes country, industry, interview year fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the firm level. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 2.3: Parent investment decision - Orbis-WMS data

| | $\mathbb{1}(\text{investment}^{FDI}_{ijodt})$ | | |
|---|---|---|---|
| ln(distance) | $-0.0053^{***}$ | $-0.0112^{***}$ | $-0.0174^{***}$ |
| | (0.0018) | (0.0038) | (0.0040) |
| $\mathbb{1}$(Common language) | $0.0087^{***}$ | $0.0707^{***}$ | $0.0629^{***}$ |
| | (0.0023) | (0.0121) | (0.0119) |
| $\mathbb{1}$(Colonial link) | $0.0126^{***}$ | $0.0368^{**}$ | $0.0476^{***}$ |
| | (0.0031) | (0.0157) | (0.0161) |
| $\mathbb{1}$(Contiguous countries) | $0.1402^{***}$ | $0.1579^{***}$ | $0.1382^{***}$ |
| | (0.0134) | (0.0203) | (0.0206) |
| $\mathbb{1}$(Positive GDP p.c. gap) | $0.0525^{***}$ | $0.0852^{***}$ | $0.0757^{***}$ |
| | (0.0066) | (0.0136) | (0.0141) |
| Management z-score$_{it}$ | $0.0057^{***}$ | $0.0293^{***}$ | |
| | (0.0018) | (0.0082) | |
| $\mathbb{1}$(Positive management gap) | | $0.0707^{***}$ | |
| | | (0.0133) | |
| Target z-score$_{it}$ | | | 0.0126 |
| | | | (0.0121) |
| $\mathbb{1}$(Positive target gap) | | | $0.0269^{**}$ |
| | | | (0.0117) |
| People z-score$_{it}$ | | | 0.0042 |
| | | | (0.0114) |
| $\mathbb{1}$(Positive people gap) | | | $0.0761^{***}$ |
| | | | (0.0120) |
| Operations z-score$_{it}$ | | | 0.0041 |
| | | | (0.0106) |
| $\mathbb{1}$(Positive operations gap) | | | $0.0317^{**}$ |
| | | | (0.0125) |
| Monitor z-score$_{it}$ | | | 0.0134 |
| | | | (0.0122) |
| $\mathbb{1}$(Positive monitor gap) | | | 0.0198 |
| | | | (0.0126) |
| Source country FE | Yes | Yes | Yes |
| Destination country FE | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes |
| $R^2$ | 0.175 | 0.228 | 0.232 |
| Observations | 90,725 | 10,925 | 10,902 |

Notes: Estimates of equation (2.4). The unit of observation is a global ultimate owner i from country o in industry j. The dependent variable is a dummy which is equal to one if the global ultimate owner from country o invested in country d in 2007. The specification includes destination country, source country, industry, and year fixed effects. Additionally, controls for bilateral distance, common language, contiguity, colonial relationship, and a dummy equal to one if the GDP per capita gap is positive are included. The independent variables of interest are the management z-score and the management gap which is defined in equation (2.3). Column 3 controls for the four sub-components of the management z-score: target, people, operations, and monitor. Column 1 considers 191 potential destination countries and columns 2 and 3 restrict the sample to the country pairs in the WMS. Robust standard errors in parentheses, clustered at the firm level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.4: Affiliate outcomes - Orbis-WMS data

| | $\ln(\text{empl.}_{apjodt})$ | $\ln(\text{sales}_{apjodt})$ | $\ln(\text{labor prod.}_{apjodt})$ | $\hat{\mu}_{apjodt}$ |
|---|---|---|---|---|
| Management z-score$_{pt}^{parent}$ | 0.1233*** | 0.2791*** | 0.0745** | 0.0739** |
| | (0.0417) | (0.0724) | (0.0368) | (0.0350) |
| Source-destination country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| Time FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.542 | 0.500 | 0.528 | 0.010 |
| Number of affiliates | 2,527 | 1,946 | 1,541 | 1,455 |
| Number of parents | 426 | 390 | 347 | 339 |
| Observations | 8,253 | 7,017 | 5,130 | 4,826 |

Notes: Estimates of equation (2.5). The unit of observation is an affiliate a in country d, of parent p from country o, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variable is the parent management z-score which is the average across all eighteen management practices. All specifications include industry fixed effects, time fixed effects, source-destination country fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the parent level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.5: Affiliate outcomes fixed effects - MiDi-WMS data

| | $\ln(\text{empl.}_{apjod,inty.})$ | $\ln(\text{sales}_{apjod,inty.})$ | $\ln(\text{labor prod.}_{apjod,inty.})$ | $\hat{\mu}_{apjod,inty.}$ |
|---|---|---|---|---|
| Management z-score$^{parent}_{p,intyear}$ | 0.0607* | 0.0369 | −0.0171 | 0.0110 |
| | (0.0321) | (0.0331) | (0.0318) | (0.0275) |
| Time FE | Yes | Yes | Yes | Yes |
| Country FE | No | No | No | No |
| Industry FE | No | No | No | No |
| Affiliate FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.145 | 0.150 | 0.117 | 0.093 |
| Number of affiliates | 238 | 242 | 238 | 236 |
| Number of parents | 38 | 38 | 38 | 38 |
| Observations | 509 | 517 | 509 | 505 |

Notes: Estimates of equation (2.6). The unit of observation is an affiliate a in country d, of parent p from Germany, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variable is the parent management z-score which is the average across all eighteen management practices. All specifications include affiliate fixed effects, time fixed effects, and noise controls. The sample is restricted to parents with at least two different interview scores and to the respective years in which the interviews took place. Robust standard errors in parentheses, clustered at the parent level. Data source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, MiDi 2002-2014, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.6: Acquisition dynamics - Zephyr-WMS data

| | $\ln(\text{empl.}_{apjodqt})$ | $\ln(\text{sales}_{apjodqt})$ | $\ln(\text{labor prod.}_{apjodqt})$ | $\hat{\mu}_{apjodqt}$ |
|---|---|---|---|---|
| $\mathbb{1}(\text{Takeover}^{post}_{\text{1-3 years}})$ | $-0.2314^{***}$ | $-0.1634^{*}$ | 0.0727 | 0.0074 |
| | (0.0801) | (0.0852) | (0.0966) | (0.0693) |
| $\mathbb{1}(\text{Takeover}^{post}_{\text{4-6 years}})$ | $-0.3237^{***}$ | $-0.3245^{*}$ | 0.1043 | $-0.0102$ |
| | (0.1178) | (0.1646) | (0.1426) | (0.1123) |
| $\text{Management}^{parent}_{pq}$ | $-0.0833$ | 0.0430 | 0.1115 | 0.0605 |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3 years}})$ | (0.0828) | (0.0708) | (0.0970) | (0.0676) |
| $\text{Management}^{parent}_{pq}$ | $-0.1238$ | $-0.0337$ | 0.1344 | 0.0771 |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{4-6 years}})$ | (0.1000) | (0.1118) | (0.1190) | (0.0960) |
| Source-destination country FE | No | No | No | No |
| Industry FE | No | No | No | No |
| Time FE | Yes | Yes | Yes | Yes |
| Affiliate FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.021 | 0.118 | 0.219 | 0.042 |
| Number of acquisitions | 385 | 188 | 171 | 165 |
| Observations | 2,440 | 1,288 | 994 | 958 |

Notes: Estimates of equation (2.7). The unit of observation is an affiliate a in country d, of parent p from country o, industry j, acquired at date q, and the outcome is observed at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variables of interest are the interactions between the parent management z-score and two dummies capturing the dynamics post-acquisition. The dummies are equal to one, one to three years and four to six years post-acquisition respectively and zero otherwise. Robust standard errors in parentheses, clustered at the parent level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.7: Acquisition dynamics - BSD-WMS data

| | $\ln(\text{empl.}_{apjodqt})$ | | | | |
|---|---|---|---|---|---|
| $\mathbb{1}(\text{Takeover}^{post}_{\text{1-3 years}})$ | $-0.0643^{**}$ | $-0.0390$ | 0.0465 | $-0.0179$ | $-0.0798$ |
| | (0.0291) | (0.0360) | (0.1066) | (0.2092) | (0.1225) |
| $\mathbb{1}(\text{Takeover}^{post}_{\text{4-6 years}})$ | $-0.1265^{**}$ | $-0.0718$ | $-0.4180^{***}$ | $-0.4520$ | 0.0832 |
| | (0.0604) | (0.0668) | (0.0742) | (0.3058) | (0.1943) |
| Management z-score$^{parent}_{pq}$ | 0.0055 | 0.0069 | 0.0016 | 0.0029 | $-0.0554$ |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3 years}})$ | (0.0282) | (0.0346) | (0.0336) | (0.0347) | (0.0505) |
| Management z-score$^{parent}_{pq}$ | $-0.0705$ | $-0.1018$ | $-0.1176$ | $-0.1173$ | $-0.1350^{**}$ |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{4-6 years}})$ | (0.0538) | (0.0698) | (0.0743) | (0.0753) | (0.0555) |
| $\ln(\text{empl.}^{parent}_{pq})$ | | | | 0.0099 | 0.0085 |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3 years}})$ | | | | (0.0240) | (0.0183) |
| $\ln(\text{empl.}^{parent}_{pq})$ | | | | 0.0058 | $-0.0444^{*}$ |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{4-6 years}})$ | | | | (0.0490) | (0.0226) |
| Export share$^{parent}_{pq}$ | | | | | 0.0004 |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3 years}})$ | | | | | (0.0006) |
| Export share$^{parent}_{pq}$ | | | | | $0.0039^{***}$ |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{4-6 years}})$ | | | | | (0.0010) |
| Time FE | Yes | Yes | Yes | Yes | Yes |
| Interviewer FE $\times\ \mathbb{1}(\text{takeover}^{post}_{\text{1-3, 4-6 years}})$ | No | Yes | Yes | Yes | Yes |
| Industry FE $\times\ \mathbb{1}(\text{takeover}^{post}_{\text{1-3, 4-6 years}})$ | No | No | Yes | Yes | Yes |
| $R^2$ | 0.041 | 0.071 | 0.082 | 0.082 | 0.123 |
| Number of acquisitions | 723 | 723 | 723 | 723 | 464 |
| Observations | 5,838 | 5,838 | 5,838 | 5,838 | 3,598 |

Notes: Estimates of equation (2.8). The unit of observation is a plant a in the UK, of parent p from country o, industry j, acquired at date q, and the outcome is observed at time t. The dependent variable is the natural logarithm of employment. The independent variables of interest are the interactions between the parent management z-score and two dummies capturing the dynamics post-acquisition. The dummies are equal to one, one to three years and four to six years post-acquisition respectively and zero otherwise. Robust standard errors in parentheses, clustered at the parent level. Source: ONS BSD data set merged with WMS data, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.8: Acquisition dynamics people z-score - BSD-WMS data

| | ln(empl.$_{apjodqt}$) | | | | |
|---|---|---|---|---|---|
| $\mathbb{1}(\text{Takeover}^{post}_{\text{1-3 years}})$ | $-0.0623^{**}$ | $-0.0395$ | 0.1340 | 0.1024 | $-0.1064$ |
| | (0.0292) | (0.0354) | (0.1517) | (0.2493) | (0.1342) |
| $\mathbb{1}(\text{Takeover}^{post}_{\text{4-6 years}})$ | $-0.1320^{**}$ | $-0.0985$ | $-0.5207^{***}$ | $-0.4464^{*}$ | 0.1490 |
| | (0.0569) | (0.0628) | (0.0953) | (0.2683) | (0.2131) |
| People z-score$^{parent}_{pq}$ $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3 years}})$ | $-0.0055$ | $-0.0180$ | $-0.0283$ | $-0.0269$ | $-0.0134$ |
| | (0.0347) | (0.0434) | (0.0442) | (0.0463) | (0.0537) |
| People z-score$^{parent}_{pq}$ $\times\mathbb{1}(\text{takeover}^{post}_{\text{4-6 years}})$ | $-0.1145^{*}$ | $-0.1731^{**}$ | $-0.1896^{**}$ | $-0.1900^{**}$ | $-0.1286^{*}$ |
| | (0.0680) | (0.0850) | (0.0900) | (0.0913) | (0.0734) |
| ln(empl.$^{parent}_{pq}$) $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3 years}})$ | | | | 0.0045 | 0.0108 |
| | | | | (0.0244) | (0.0185) |
| ln(empl.$^{parent}_{pq}$) $\times\mathbb{1}(\text{takeover}^{post}_{\text{4-6 years}})$ | | | | $-0.0123$ | $-0.0354^{*}$ |
| | | | | (0.0425) | (0.0189) |
| Export share$^{parent}_{pq}$ $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3 years}})$ | | | | | 0.0004 |
| | | | | | (0.0007) |
| Export share$^{parent}_{pq}$ $\times\mathbb{1}(\text{takeover}^{post}_{\text{4-6 years}})$ | | | | | $0.0030^{***}$ |
| | | | | | (0.0007) |
| Time FE | Yes | Yes | Yes | Yes | Yes |
| Interviewer FE $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3,4-6 years}})$ | No | Yes | Yes | Yes | Yes |
| Industry FE $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3,4-6 years}})$ | No | No | Yes | Yes | Yes |
| $R^2$ | 0.045 | 0.077 | 0.087 | 0.087 | 0.123 |
| Number of acquisitions | 722 | 722 | 722 | 722 | 464 |
| Observations | 5,838 | 5,838 | 5,838 | 5,838 | 3,598 |

Notes: Estimates of equation (2.8) with parents' people z-score interacted as the independent variables instead of the parents' management z-score. The unit of observation is a plant a in the UK, of parent p from country o, industry j, acquired at date q, and the outcome is observed at time t. The dependent variable is the natural logarithm of employment. The independent variables of interest are the interactions of the parent people z-score with two dummies capturing the dynamics post-acquisition. The dummies are equal to one, one to three years and four to six years post-acquisition respectively and zero otherwise. Robust standard errors in parentheses, clustered at the parent level. Source: ONS BSD data set merged with WMS data, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.9: Heterogeneity GDP per capita - Orbis-WMS data

| | $\ln(\text{empl.}_{apjodt})$ | $\ln(\text{sales}_{apjodt})$ | $\ln(\text{labor prod.}_{apjodt})$ | $\hat{\mu}_{apjodt}$ |
|---|---|---|---|---|
| Management z-score$_{pt}^{parent}$ | $0.1671^{***}$ | $0.1599^{*}$ | $-0.0822$ | $-0.0575$ |
| | (0.0623) | (0.0837) | (0.0565) | (0.0568) |
| Management z-score$_{pt}^{parent}$ | $-0.0642$ | $0.1554^{**}$ | $0.1991^{***}$ | $0.1684^{***}$ |
| $\times \mathbb{1}$(pos. GDP p.c. gap) | (0.0599) | (0.0673) | (0.0589) | (0.0557) |
| Source-destination country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| Time FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.543 | 0.501 | 0.531 | 0.016 |
| Number of affiliates | 2,527 | 1,944 | 1,541 | 1,455 |
| Number of parents | 426 | 390 | 347 | 339 |
| Observations | 8,253 | 7,015 | 5,130 | 4,826 |

Notes: Estimates of equation (2.10). The unit of observation is an affiliate a in country d, of parent p from country o, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variables of interest are the parent management z-score and the interaction of the parent management z-score with a dummy, which is equal to one if the GDP per capita in the origin country is larger than in the destination country. All specifications include industry fixed effects, time fixed effects, source-destination country fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the parent level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.10: Heterogeneity distance - Orbis-WMS data

| | ln(empl.$_{apjodt}$) | ln(sales$_{apjodt}$) | ln(labor prod.$_{apjodt}$) | $\hat{\mu}_{apjodt}$ |
|---|---|---|---|---|
| Management z-score$_{pt}^{parent}$ | 0.1159 | 0.3668*** | 0.1213* | 0.1320** |
| | (0.0718) | (0.1163) | (0.0623) | (0.0522) |
| Management z-score$_{pt}^{parent}$ | 0.0352 | −0.1019 | −0.0521 | −0.0673 |
| $\times\mathbb{1}$(distance 1,000-3,000 km) | (0.0912) | (0.1146) | (0.0829) | (0.0736) |
| Management z-score$_{pt}^{parent}$ | 0.0552 | −0.1034 | −0.1298 | −0.1366 |
| $\times\mathbb{1}$(distance 3,000-6,000 km) | (0.1051) | (0.1770) | (0.1018) | (0.0863) |
| Management z-score$_{pt}^{parent}$ | −0.0475 | −0.1190 | −0.0327 | −0.0498 |
| $\times\mathbb{1}$(distance > 6,000 km) | (0.1012) | (0.1558) | (0.0936) | (0.0893) |
| Source-destination country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| Time FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.541 | 0.499 | 0.526 | 0.012 |
| Number of affiliates | 2,515 | 1,934 | 1,529 | 1,443 |
| Number of parents | 425 | 389 | 346 | 338 |
| Observations | 8,194 | 6,958 | 5,071 | 4,767 |

Notes: Estimates of equation (2.11). The unit of observation is an affiliate a in country d, of parent p from country o, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variables of interest are the parent management z-score and the interactions between the parent management z-score and dummies that are equal to one if the bilateral distance falls into the respective bin. The omitted distance bin contains observations of source-destination country pairs with physical distance of between 0 and 1,000 km. All specifications include industry fixed effects, time fixed effects, source-destination country fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the parent level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.11: Heterogeneity corporate hierarchy - Orbis-WMS data

| | ln(empl.$_{apjodt}$) | ln(sales$_{apjodt}$) | ln(labor prod.$_{apjodt}$) | $\hat{\mu}_{apjodt}$ |
|---|---|---|---|---|
| Management z-score$_{pt}^{parent}$ | 0.0056 | −0.0845 | −0.3619 | −0.3553 |
| | (0.2101) | (0.3512) | (0.2663) | (0.2341) |
| $\mathbb{1}$(Direct link) | −0.5277** | −0.4787** | −0.2671 | −0.0059 |
| | (0.2135) | (0.1961) | (0.1999) | (0.1893) |
| Management z-score$_{pt}^{parent}$ | 0.1215 | 0.3715 | 0.4457* | 0.4394* |
| ×$\mathbb{1}$(direct link) | (0.2151) | (0.3611) | (0.2684) | (0.2350) |
| Source-destination country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| Time FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.543 | 0.501 | 0.529 | 0.013 |
| Number of affiliates | 2,527 | 1,946 | 1,541 | 1,455 |
| Number of parents | 426 | 390 | 347 | 339 |
| Observations | 8,253 | 7,017 | 5,130 | 4,826 |

Notes: Estimates of equation (2.12). The unit of observation is an affiliate a in country d, of parent p from country o, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variable is the parent management z-score which is the average across all eighteen management practices. Furthermore, the specifications include the interaction between the management z-score of the parent company with a dummy which is equal to one if the affiliate is in the first level of the corporate hierarchy. All specifications include industry fixed effects, time fixed effects, source-destination country fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the parent level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

## 2.6 Appendix

**World Management Survey country list**

I obtain confidential data for countries from the World Management Survey (WMS). The data come from survey waves between 2001 and 2014. The following countries are included in the sample:

Argentina, Australia, Brazil, Canada, Chile, China, France, Germany, Great Britain, Greece, India, Italy, Japan, Mexico, New Zealand, Poland, Portugal, Republic of Ireland, Singapore, Spain, Sweden, Turkey, and the United States.

**CEPII**

Gravity variables such as bilateral distance between countries are retrieved from Centre d'etudes prospectives et d'informations internationales (CEPII) Geodist Dataset and Gravity Dataset.

Centre d'etudes prospectives et d'informations internationales (CEPII) (2017) GeoDist Dataset. Available at http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=6 (accessed on 11/10/2017).

Centre d'etudes prospectives et d'informations internationales (CEPII) (2017) Gravity Dataset. Available at http://www.cepii.fr/CEPII/en/bdd_modele/presentation.asp?id=8 (accessed on 11/10/2017).

**World Bank**

GDP per capita data were retrieved from the World Bank database (https://data.worldbank.org/indicator/) on 15/11/2017.

**Definition of the management z-score over time**

The World Management Survey is a cross section for most companies in the survey. I explain the construction of the management score over time by using the example of a firm with two management z-scores in 2006 and 2010.

Table 2.A.1: Defining the management z-score over time

| Year | Definition 1 management z-score | Definition 2 management z-score |
|---|---|---|
| 2007 | 2006 | 2006 |
| 2008 | 2006 | 2006 |
| 2009 | 2006 | 2010 |
| 2010 | 2010 | 2010 |
| 2011 | 2010 | 2010 |
| 2012 | 2010 | 2010 |
| 2013 | 2010 | 2010 |
| 2014 | 2010 | 2010 |

There are two ways of making the management score consistent with other data varying over time. First, use the most recent interview score until a new interview score is available. In the example, the second interview was held in 2010 and hence the variable changes in 2010. Alternatively, I minimize the time difference between the year of the interview and the corresponding year of ownership and financial information. Then, the management variable takes the interview score in 2010 already from 2009 as the time difference is one and smaller than the time difference of three between 2006 and 2009. I report estimates based on definition 1 in Table 2.A.1, but the results are robust to using the other definitions. Finally, one could linearly interpolate. For $x = 2007, 2008,$ and 2009 the interpolated management z-score is given by

$$management_x = management_{2006} + (x - 2006) \times \frac{management_{2010} - management_{2006}}{x - 2006}. \tag{2.13}$$

Again, the results are robust to this alternative definition of the management z-score variable over time.

Table 2.A.2: Source-country management variation - Orbis-WMS data

| | management z-score$_{\mathrm{ijct}}$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Sample period | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Source-country FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| $R^2$ | 0.141 | 0.141 | 0.138 | 0.129 | 0.103 | 0.129 | 0.123 | 0.136 |
| Observations | 475 | 488 | 487 | 453 | 433 | 403 | 402 | 382 |

Notes: The unit of observation is a global ultimate owner i from country c in industry j at time t. The dependent variable is the management z-score of the global ultimate owner. The specification includes source-country fixed effects.

Table 2.A.3: Parent employment - Orbis-WMS data

| | $\ln(\text{empl.}_{ijc,intyear})$ |
|---|---|
| Management z-score$^{parent}_{i,intyear}$ | 0.2653*** |
| | (0.0467) |
| Country FE | Yes |
| Industry FE | Yes |
| Interview year FE | Yes |
| $R^2$ | 0.364 |
| Observations | 836 |

Notes: The unit of observation is a global ultimate owner i from country c in industry j. The dependent variable is the natural logarithm of employment as stated in the WMS. The specification includes country, industry, and interview year fixed effects. The independent variable of interest is the parent management z-score. Robust standard errors in parentheses, clustered at the parent level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.A.4: Affiliate outcomes - MiDi-WMS data

| | $\ln(\text{empl.}_{apjodt})$ | $\ln(\text{sales}_{apjodt})$ | $\ln(\text{labor prod.}_{apjodt})$ | $\hat{\mu}_{apjodt}$ |
|---|---|---|---|---|
| Management z-score$^{parent}_{pt}$ | 0.1322*** | 0.1112* | −0.0258 | 0.0278 |
| | (0.0401) | (0.0633) | (0.0569) | (0.0560) |
| Time FE | Yes | Yes | Yes | Yes |
| Destination country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.407 | 0.292 | 0.466 | 0.002 |
| Number of affiliates | 795 | 808 | 795 | 787 |
| Number of parents | 80 | 80 | 80 | 80 |
| Observations | 4,570 | 4,662 | 4,570 | 4,496 |

Notes: Estimates of equation (2.5). The unit of observation is an affiliate a in country d, of parent p from Germany, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variable of interest is the parent management z-score. All specifications include industry fixed effects, time fixed effects, destination country fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the parent level. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2014, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.A.5: Acquisition dynamics - Zephyr-WMS data

| | $\ln(\text{empl.}_{apjodqt})$ | $\ln(\text{sales}_{apjodqt})$ | $\ln(\text{labor prod.}_{apjodqt})$ | $\hat{\mu}_{apjodqt}$ |
|---|---|---|---|---|
| $\mathbb{1}(\text{Takeover}^{post}_{\text{1-3 years}})$ | $-0.2249^{**}$ | $-0.1948^{**}$ | 0.1053 | 0.0192 |
| | (0.0941) | (0.0931) | (0.1146) | (0.0828) |
| $\mathbb{1}(\text{Takeover}^{post}_{\text{4-6 years}})$ | $-0.2523^{*}$ | $-0.3733^{*}$ | 0.1339 | 0.0131 |
| | (0.1381) | (0.2012) | (0.1705) | (0.1351) |
| $\text{Management}^{parent}_{pq}$ | $-0.1559^{*}$ | 0.0262 | $0.1787^{*}$ | 0.1043 |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{1-3 years}})$ | (0.0926) | (0.0814) | (0.1066) | (0.0721) |
| $\text{Management}^{parent}_{pq}$ | $-0.2059^{**}$ | $-0.0082$ | 0.1613 | 0.0968 |
| $\times\mathbb{1}(\text{takeover}^{post}_{\text{4-6 years}})$ | (0.1027) | (0.1161) | (0.1263) | (0.1011) |
| Source-destination country FE | No | No | No | No |
| Industry FE | No | No | No | No |
| Time FE | Yes | Yes | Yes | Yes |
| Affiliate FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.030 | 0.115 | 0.241 | 0.050 |
| Number of acquisitions | 269 | 140 | 127 | 123 |
| Observations | 1,851 | 1,024 | 803 | 772 |

Notes: Estimates of equation (2.7). The sample is restricted to acquisitions for which the absolute time difference between the interview year and the acquisition year is less than six years. The unit of observation is an affiliate a in country d, of parent p from country o, industry j, acquired at date q, and the outcome is observed at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variables of interest are the interactions of the parent management z-score with two dummies capturing the dynamics post-acquisition. The dummies are equal to one, one to three years and four to six years post-acquisition respectively and zero otherwise. Robust standard errors in parentheses, clustered at the parent level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.A.6: Heterogeneity GDP per capita - MiDi-WMS data

| | $\ln(\text{empl.}_{apjodt})$ | $\ln(\text{sales}_{apjodt})$ | $\ln(\text{labor prod.}_{apjodt})$ | $\hat{\mu}_{apjodt}$ |
|---|---|---|---|---|
| Management z-score$_{pt}^{parent}$ | $0.1719^{**}$ | 0.0802 | $-0.0967$ | $-0.0196$ |
| | (0.0680) | (0.0889) | (0.0739) | (0.0687) |
| Management z-score$_{pt}^{parent}$ | $-0.0676$ | 0.0518 | $0.1200^{***}$ | $0.0782^{*}$ |
| $\times \mathbb{1}$(pos. GDP p.c. gap) | (0.0693) | (0.0740) | (0.0453) | (0.0447) |
| Time FE | Yes | Yes | Yes | Yes |
| Destination country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.409 | 0.289 | 0.474 | 0.005 |
| Number of affiliates | 791 | 804 | 791 | 783 |
| Number of parents | 80 | 80 | 80 | 80 |
| Observations | 4,550 | 4,642 | 4,550 | 4,478 |

Notes: Estimates of equation (2.10). The unit of observation is an affiliate a in country d, of parent p from Germany, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variables of interest are the parent management z-score and the interaction of the parent management z-score with a dummy, which is equal to one if the GDP per capita in Germany is larger than in the destination country. All specifications include industry fixed effects, time fixed effects, destination country fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the parent level. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2014, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.A.7: Heterogeneity distance - MiDi-WMS data

| | $\ln(\text{empl.}_{apjodt})$ | $\ln(\text{sales}_{apjodt})$ | $\ln(\text{labor prod.}_{apjodt})$ | $\hat{\mu}_{apjodt}$ |
|---|---|---|---|---|
| Management z-score$_{pt}^{parent}$ | 0.2042** | 0.1630 | −0.0385 | 0.0258 |
| | (0.0918) | (0.1015) | (0.0559) | (0.0635) |
| Management z-score$_{pt}^{parent}$ | −0.1362 | −0.1864** | −0.0609 | −0.0944 |
| $\times\mathbb{1}$(distance 500-1,000 km) | (0.1123) | (0.0774) | (0.0975) | (0.0700) |
| Management z-score$_{pt}^{parent}$ | −0.0518 | −0.0258 | 0.0063 | 0.0062 |
| $\times\mathbb{1}$(distance 1,000-6,000 km) | (0.1136) | (0.1120) | (0.0666) | (0.0715) |
| Management z-score$_{pt}^{parent}$ | −0.0951 | −0.0309 | 0.0624 | 0.0501 |
| $\times\mathbb{1}$(distance $>$ 6,000 km) | (0.1009) | (0.0843) | (0.0623) | (0.0501) |
| Time FE | Yes | Yes | Yes | Yes |
| Destination country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.409 | 0.295 | 0.468 | 0.007 |
| Number of affiliates | 795 | 808 | 795 | 787 |
| Number of parents | 80 | 80 | 80 | 80 |
| Observations | 4,570 | 4,662 | 4,570 | 4,496 |

Notes: Estimates of equation (2.11). The unit of observation is an affiliate a in country d, of parent p from Germany, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variables of interest are the parent management z-score and the interactions of the parent management z-score with dummies that are equal to one if the bilateral distance falls into the respective bin. The omitted distance bin contains observations of parent-affiliate country pairs with physical distance of between 0 and 1,000 km. All specifications include industry fixed effects, time fixed effects, destination country fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the parent level. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2014, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.A.8: Heterogeneity corporate hierarchy - MiDi-WMS data

| | $\ln(\text{empl.}_{apjodt})$ | $\ln(\text{sales}_{apjodt})$ | $\ln(\text{labor prod.}_{apjodt})$ | $\hat{\mu}_{apjodt}$ |
|---|---|---|---|---|
| Management z-score$_{pt}^{parent}$ | 0.1250 | −0.0795 | −0.2135** | −0.1498* |
| | (0.1068) | (0.1174) | (0.0901) | (0.0898) |
| $\mathbb{1}$(Direct link) | −0.1156 | −0.1861 | −0.0695 | −0.0742 |
| | (0.1641) | (0.1509) | (0.1359) | (0.1147) |
| Management z-score$_{pt}^{parent}$ | 0.0318 | 0.2993*** | 0.2714*** | 0.2571*** |
| $\times\mathbb{1}$(direct link) | (0.1226) | (0.1117) | (0.1022) | (0.0891) |
| Time FE | Yes | Yes | Yes | Yes |
| Destination country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |
| $R^2$ | 0.409 | 0.302 | 0.476 | 0.022 |
| Number of affiliates | 795 | 808 | 795 | 787 |
| Number of parents | 80 | 80 | 80 | 80 |
| Observations | 4,570 | 4,662 | 4,570 | 4,496 |

Notes: Estimates of equation (2.12). The unit of observation is an affiliate a in country d, of parent p from Germany, and industry j at time t. The dependent variables in columns 1-3 are the natural logarithm of employment, sales, and labor productivity respectively. The dependent variable in column 4 is the Solow residual from a Cobb-Douglas production function estimation. The independent variable is the parent management z-score which is the average across all eighteen management practices. Furthermore, the specification includes the interaction of the parent management z-score with a dummy which is equal to one if the affiliate is in the first level of the corporate hierarchy. All specifications include industry fixed effects, time fixed effects, destination country fixed effects, and noise controls. Robust standard errors in parentheses, clustered at the parent level. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2014, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

# Chapter 3

# Evidence on the International Transmission of Crises Through Multinational Firms

## 3.1 Introduction

The business cycles of economies all over the world are positively correlated (Baxter and Kouparitsas 2005). The recent Great Recession is a stark example of this comovement. During and after the global financial crisis 2008/09, output in many economies fell in parallel and subsequently recovered slowly, as illustrated in Figure 3.1 for several advanced economies. The causes of such business cycle comovements have not been fully established. One possibility is that common shocks affect many economies at the same time, leading to correlated business cycles (Imbs 2004). An example of a common shock is a change in the cost of a commonly used input, such as oil. Another possibility is that economic linkages between countries transmit shocks from one country to the global economy (Frankel and Rose 1998).

In this paper, we present causal evidence on one channel through which a country-specific financial shock can become a global crisis: the internal networks of multinational firms. We identify an exogenous shock to the credit supply of multinational parent corporations located in Germany. We then show that affiliates of shocked parents, located all over the world, experienced a reduction in their sales after their German parent was hit by the credit supply shock. The evidence indicates that both real and financial linkages between parents and affiliates were responsible for the international transmission. Back-of-the-envelope calculations suggest that the crisis transmission channel we analyze is important for aggregate outcomes, since the international affiliates of foreign multinational firms account for a large share of output in many economies.[1]

Identifying whether shocks to parent corporations causally affect international affiliates is difficult. The key empirical challenge is that multinational firms and their affiliates are subject to common shocks. For example, if both affiliates and parents operate in the same industry and the industry experiences a global reduction in demand, then attributing the positive comovement between parents and affiliates to shock transmission from parents to affiliates would be spurious. We overcome the empirical challenge by identifying a shock to the credit supply of some German parent corporations that did not simultaneously affect their international affiliates. The credit supply shock was a lending cut by Commerzbank, a large German bank, during the 2008/09 financial crisis. After experiencing significant losses on its international investments, Commerzbank reduced its lending to German firms. A body of evidence suggests that frictions on credit markets make it difficult for firms to switch lenders when their bank cuts lending (for example, Chodorow-Reich 2014; Bentolila, Jansen, and Jiménez 2018). Hence, parent corporations with pre-crisis dependence on Commerzbank were more strongly exposed to Commerzbank's lending cut (Huber 2018).[2]

Our empirical strategy compares the international affiliates of German parents exposed to Commerzbank's lending cut to the affiliates of German parents with little exposure to Commerzbank. Confidential data from a credit rating agency allow us to identify which German parents were more exposed to Commerzbank. We match the bank-parent relationship data to a unique dataset from the German Central Bank. These data report the balance sheets of all international affiliates of German multinational firms, including information on affiliate loans to the parent, affiliate liabilities toward the parent, and equity that the parent holds in each affiliate. Before the Great Recession, the foreign direct investment of German firms was the third-largest in the world. This means the data contain a large sample of international affiliates, located all over the world.

We present four sets of results. The first set of results studies the effect of the lending cut on the bank debt of multinational parent corporations located in Germany. When Commerzbank cut lending in 2008, the bank debt of firms with higher dependence on Commerzbank dropped sharply. It remained persistently low until 2015. This result shows that parents were not able to find other banks easily, suggesting that frictions in credit markets play an important role even for large, multinational firms. From 2011, parents dependent on Commerzbank significantly increased their trade credit, i.e. the

[1] Affiliates with parent corporations in another country produced 24.3 percent of value added by non-financial firms in the European Union in 2014. 13.3 percent came from affiliates with parents in other EU member states and 11 percent from affiliates with parents outside the EU. In the United States, 6.5 percent of value added in the private sector was produced by affiliates with parents outside the United States in 2014. Data sources: BEA and Eurostat (2018).

[2] None of the information on individual German banks was provided by the German Central Bank. The data sources for bank-specific information are the annual reports of the banks and Huber (2018).

debt they received from other firms. This suggests that, after a few years, parents were able to partially offset the financial shock by using other sources of funding. The first set of results confirms and extends the findings of Huber (2018), who showed that firms' bank debt fell after Commerzbank's lending cut, using a sample of generally smaller, domestically active German firms. While Huber (2018) studies the direct and indirect employment effects of the lending cut on German firms, we go on to tackle a very different question: the transmission of a credit supply shock from multinational parents to their international affiliates.

In the second set of results, we focus on the international affiliates of German multinationals. We compare the sales growth of affiliates whose German parents were hit by Commerzbank's lending cut to the sales growth of affiliates whose German parents were less dependent on Commerzbank. Sales growth is an interesting outcome, because it indicates potential production constraints faced by firms and because the aggregate value of product sales for final use equals GDP. We show that there was no association between affiliate sales growth and parent Commerzbank dependence until Commerzbank's lending cut. Once Commerzbank reduced lending in 2008, the sales of affiliates whose parents were more dependent on Commerzbank dropped sharply. Their sales recovered partially in the following years, but still remained lower for three years. After 2011, the recovery was complete, with no more association between affiliate sales and parent Commerzbank dependence.

Our rich data allow us to rule out that key sources of common shocks affect our results. Specifically, we non-parametrically control for time-invariant differences across affiliates as well as common shocks to all affiliates located in a country, to all affiliates in an industry, to affiliates of different sizes, and to affiliates with higher pre-crisis leverage. We carry out two additional robustness checks. First, while we cannot directly observe the affiliates' bank relationships, we can analyze separately all countries where Commerzbank did not have a foreign branch. The effect of parent Commerzbank dependence on affiliate sales is similar, which indicates that affiliates' direct exposure to Commerzbank cannot explain the results. Second, we find no evidence that the effect differed for affiliates located in Asia, the European Union, or the United States. This suggests that the effects are not driven by one particular region, but that we have identified a robust channel that transmits localized shocks to the global economy.

The third set of results concerns the mechanisms through which a shock to parent credit supply affected affiliate sales. We show that the transmission occurs through both financial and real channels. Regarding financial channels, we find that parents dependent on Commerzbank withdrew equity from their affiliates and that affiliates raised long-term lending to the parent from 2008 until 2015. Both lower equity and increased lending suggest that affiliates became financially constrained due to the credit supply shock to their parent. Liabilities to non-parents did not change from 2008 to 2010 and increased slightly from 2011. This suggests that affiliates raised outside financing only from 2011, which is also when their sales improved.

To test whether real channels also played a role, we examine short-term claims on parents by affiliates. These claims are a commonly used proxy for trade credit, because they include outstanding payments for inputs sent from the affiliate to the parent. We find that short-term claims on the parent fell after Commerzbank cut lending, which suggests that parents demanded fewer products from their affiliates. We also examine the balance sheet item of other short-term assets (excluding claims on parents). This item includes the sum of several production-related assets, for example trade credit to non-parents and inventory holdings of raw materials. These other short-term assets initially fell, but recovered fully after 2011. The full recovery of other short-term assets suggests that affiliates' production resumed from 2011, consistent with the recovery in sales. We find that sales only fell for affiliates that had either positive long-term loans to the parent or positive short-term claims on the parent before the crisis. This is consistent with an important role for both long-term loans and trade credit in driving the sales drop from 2008 to 2010.

In the fourth set of results, we approximate the consequences of Commerzbank's lending cut on aggregate sales in a number of countries. The average affiliate in a country outside Germany experienced a decrease in sales of approximately 10 percent, due to the international transmission of Commerzbank's lending cut from parents to affiliates. Using a back-of-the-envelope calculation, we estimate the percentage drop in aggregate sales that was caused by the reduction in affiliate sales.[3] We find that there were large effects on aggregate sales in countries where German affiliates play an important role in the aggregate economy. For example, aggregate sales in the Czech Republic fell by 0.31 percent, in Austria by 0.28 percent, and in Poland by 0.23 percent. We also explore the effects of a more widespread financial shock. For example, consider a financial shock of similar size to Commerzbank's lending cut that hits all parents located in countries outside the United States. Such a shock could reduce aggregate sales in the US non-financial private sector by 1.03 percent, solely because the internal networks of multinationals transmit the shock to affiliates located in the United States. A similar shock hitting parents outside the European Union could lower sales by non-financial firms in the European Union by 2.49

[3]For all these calculations, we assume that there were no general equilibrium effects that affected other firms in the country as a result of the decrease in affiliate sales, that policy did not endogenously respond to the decrease in affiliate sales, and that the exchange rate did not adjust.

percent. These numbers suggest that the international transmission of shocks through the internal networks of multinationals may have large effects on aggregate outcomes.

This paper contributes to several literatures. First, a literature has analyzed the international transmission of financial crises. Several empirical papers show that banks with international operations transmit shocks through cross-border, internal capital markets (Peek and Rosengren 1997; Peek and Rosengren 2000; Cetorelli and Goldberg 2012; Popov and Udell 2012; Schnabl 2012; de Haas and van Lelyveld 2014; Ongena, Peydró, and van Horen 2015). We study a different channel for the international transmission of financial shocks: the international linkages of multinational firms. We causally show that this channel exists, that it can depress real outcomes internationally for up to three years, and that it may have large aggregate implications. While we use a local banking crisis as the initial shock to parents, the mechanisms we document may not be specific to banking shocks. Any financial shock to parents may lead to similar global consequences as the ones we document in this paper.

A second related literature analyzes firms with international linkages, through trade or affiliates. Several papers argue that the growth of firms with trade linkages to a given country or with affiliates in a given country is more correlated with the business cycle of that country (di Giovanni, Levchenko, and Mejean 2014; Kleinert, Martin, and Toubal 2015; Cravino and Levchenko 2017; di Giovanni, Levchenko, and Mejean 2018). These papers typically use cross-sectional research designs, by testing whether the growth of firms is more correlated with the aggregate growth of connected countries (conditional on industry and region fixed effects). A recent paper by Boehm, Flaaen, and Pandalai-Nayar (2019) estimates a low short-run elasticity between domestic and imported inputs, by analyzing Japanese affiliates in the US in the months immediately after the 2011 Japanese earthquake. Our paper contributes to this literature by identifying the *causal* effects of a shock in one country on the growth of firms in other countries over many years. Three aspects of our approach are important. First, our quasi-experimental strategy overcomes the concern that unobservable, common shocks explain the comovement between firms in one country and affiliates in another country. The evidence suggests there is indeed cause for this concern. For example, Guadalupe, Kuzmina, and Thomas (2012) report that productive parents acquire more productive foreign firms as affiliates. Our data similarly show that larger parents have larger affiliates. Hence, parents and affiliates are non-randomly matched on observables, which suggests they may also be exposed to common unobservable shocks. Second, we shed light on the role of both financial and real linkages in the transmission of shocks, thanks to our rich data on parent-affiliate linkages. We thereby move beyond estimating the effects of only real input-output linkages. Third, we highlight the dynamic nature of international shock transmission, by showing how the growth of firms evolves from the year of the initial shock until seven years later.

This paper also adds to the literature on the existence and operations of multinational firms (Ramondo, Rappoport, and Ruhl 2016).[4] A number of papers show that firms use internal capital markets to reallocate resources in response to shocks (Desai, Foley, and Forbes 2008; Boutin et al. 2013; Almeida, Kim, and Kim 2015; Giroud and Mueller 2015; Kalemli-Özcan, Kamil, and Villegas-Sanchez 2016; Giroud and Mueller 2017b; Santioni, Schiantarelli, and Strahan 2017). We contribute to this literature by presenting new, causal evidence on the internal operations of multinationals. In particular, our contributions lie in explicitly observing changes in cross-border positions between parents and affiliates, studying the effects of a shock to parents' credit supply (and thereby a shock to the core of the whole organization), and in documenting the dynamic responses of affiliates over time. Our results imply that intra-firm trade and financial linkages are important margins for the cross-border readjustment of multinationals in response to shocks. The possibility to diversify internationally and to carry out this type of readjustment may be one reason why multinationals exist.

The following section explains the identification strategy. Section 3.3 describes the data. Section 3.4 presents the empirical results. Section 3.5 concludes.

## 3.2 Identification and Institutional Details

### 3.2.1 Identification Strategy

This paper investigates whether multinational firms contribute to the international transmission of crises by estimating how a shock to a multinational parent corporation in its home country causally affects the performance of its affiliates in other countries. The main identification challenge is that common shocks may simultaneously affect parent corporations and their international affiliates. For example, following a global decrease in the demand for cars, a German car manufacturer would sell fewer cars. At the same time, the international affiliates of the German carmaker would sell fewer cars due to lower demand. Even in the absence of a causal transmission from parent to affiliates, we would observe a positive correlation between parent and affiliate growth, but this would not be causal evidence that multinationals transmit crises internationally.

This paper overcomes the identification challenge by isolating a shock that affected a few multinational parent corporations located in Germany without simultaneously directly

[4] Alfaro and Chen (2012) find that foreign-owned establishments outperformed other firms during the Great Recession, while Alviarez, Cravino, and Levchenko (2017) report that multinationals and their affiliates grew more slowly.

impacting their international affiliates. This shock is an exogenous lending cut by Commerzbank, a large German bank, during the financial crisis of 2008/09. Existing evidence suggests that German firms of all sizes depend on the loan supply of their relationship banks (Huber 2018). Hence, firms for which Commerzbank was an important relationship bank experienced an exogenous reduction in their bank loan supply during the financial crisis.

Our empirical approach uses the pre-crisis Commerzbank dependence of German parents as proxy for their exposure to Commerzbank's lending cut. Specifically, we compare the growth of international affiliates, whose German parents were dependent on Commerzbank for financial services, to the growth of other affiliates, whose parents had no pre-crisis relationship to Commerzbank.[5] Our empirical approach identifies the causal effect of parents' exposure to the bank lending cut under a parallel-trends assumption: Affiliates whose parents had high Commerzbank dependence would have evolved in parallel to other affiliates had the parents not been affected by Commerzbank's lending cut. The institutional details we present in the following subsection support this assumption, by showing that Commerzbank's lending cut was exogenous to German parents and their international affiliates.

### 3.2.2 Commerzbank's Lending Cut

Commerzbank was the second-largest German bank before the Great Recession, with a market share of 13 percent among medium-sized firms (the Mittelstand) and 12 percent among large firms (Commerzbank annual report 2009).[6] Apart from commercial banks, such as Commerzbank, the German banking system includes cooperative credit unions and public banks (Landesbanken and savings banks). The cooperatives and public banks have a political and social mandate to upkeep lending, unlike the commercial banks, which

[5] We do not attempt to disentangle through which specific channel Commerzbank's lending cut affected parents in the first place. Instead, we estimate the reduced-form impact on parents and affiliates, where parent Commerzbank dependence serves as proxy for parent exposure to a lending cut. This approach is in line with the recent literature on credit shocks (for example, Chodorow-Reich 2014; Bentolila, Jansen, and Jiménez 2018). It is preferable because a lending cut can initially affect a parent through multiple channels. It can reduce access to bank loans, affect the interest rate on loans and deposits, reduce the length of loans, and increase uncertainty regarding future credit access. Using just one of these variables as regressor would overestimate the effect of this particular variable. Identifying the causal impact of each channel would require one separate instrument per channel.

[6] None of the information on individual banks in this section is provided by the German Central Bank. Sources are the annual reports of Commerzbank and Dresdner Bank and Huber (2018). Throughout the paper, "Commerzbank" refers to all branches that were part of the Commerzbank network in 2009, including its 2009 acquisition Dresdner Bank. Both banks suffered a significant hit in 2008. Dresdner Bank was more exposed to asset-backed securities, while Commerzbank was more exposed to failing public and institutional debt (for example, the Iceland crisis and the Lehman insolvency). Commerzbank had already decided to acquire Dresdner Bank before the crisis hit both banks (for details, see Huber 2018, Appendix B.E). Huber (2018) finds that the lending cut affected firms that had previously banked with Dresdner Bank to a similar degree as firms that had banked with Commerzbank throughout, suggesting a symmetric treatment of the banks is appropriate when analyzing the effects on bank customers.

operate for profit. This makes the group of other commercial banks the most comparable peer group to Commerzbank.

Commerzbank was strongly affected by the international financial crisis 2008/09. While Commerzbank's business model focused on Germany (with 96 percent of branches located in Germany), the bank also ran trading and investment divisions that had invested heavily into international financial markets (Commerzbank annual report 2009; Huber 2018). During the crisis years 2008 and 2009, and mainly after the Lehman Brothers insolvency in September 2008, Commerzbank suffered large losses in these divisions. Its equity capital fell by a total of 68 percent between December 2007 and December 2009 (source: Commerzbank and Dresdner Bank annual reports). The drop in equity capital was entirely due to losses and write-downs on financial instruments, as illustrated in Figure 3.2, and not caused by Commerzbank's corporate loan portfolio (Huber 2018). Write-downs on financial instruments included, for example, changes in the valuation of derivatives the bank held. Figure 3.2 shows that trading and investment income was entirely responsible for the annual income losses. Interest income, on the other hand, which includes what Commerzbank earns from lending to firms, remained on an upward trend up to 2009.

As a result of the hit from the financial crisis, Commerzbank reduced lending to its non-financial customers. Until 2007, Commerzbank's total lending to German customers had developed at a similar rate as lending by all other banks and lending by other commercial banks (Figure 3.3). In 2008 and 2009, Commerzbank's lending stock fell sharply (source: Commerzbank and Dresdner Bank annual reports). Following equity injections by the government, Commerzbank stabilized. Its lending growth from 2010 onward returned to a roughly parallel trend relative to its peer group of other commercial banks.

Huber (2018, Appendix B) provides a detailed analysis of Commerzbank's crisis, based on 110 financial analyst reports and bank reports. Key conclusions from this analysis are that the corporate loan portfolios of Commerzbank and Dresdner Bank were not riskier than other German banks', and in fact considered a source of strength by many analysts. Commerzbank had underestimated the likelihood of a systemic financial crisis in setting its trading and investment strategy in 2007 and 2008. There was no evidence for a hedging relationship between loan and trading divisions. The majority of German banks were hardly exposed to international financial markets and therefore able to continue lending, as evidenced by the increase in the lending stock of all other banks in 2008 and 2009 in Figure 3.3. A few other German banks were also affected by losses due to the financial crisis. But, unlike in the case of Commerzbank, their specific portfolio and situation make it difficult to argue their customers faced an exogenous lending cut and were not hit by other contemporaneous shocks (see Online Appendices E and F in Huber 2018).

### 3.2.3 Existing Evidence on the Firm-Level Effects of the Lending Cut

German firms traditionally form close relationships with one or a few relationship banks (in German: *Hausbanken*, literally translated as “home banks”). Since most German banks are universal banks, firms receive the full range of financial services from their relationship banks. The most important services provided by relationships banks are loans and payment transactions (Elsas 2005). German bank-firm relationships are durable, as only around 1.7 percent of firms switched banks during the years of the financial crisis (Dwenger, Fossen, and Simmler 2015). The theoretical literature has argued that relationship banks have an informational advantage when lending to their relationship customers (Sharpe 1990; Boot 2000). This reduces asymmetric information and improves banks’ monitoring capabilities. On the other hand, the informational advantage creates an adverse selection problem, making it difficult for firms to switch lenders and leaving firms dependent on their relationship banks’ loan supply.

The cost of switching lenders meant that Commerzbank’s lending cut had real effects on firms, as analyzed in detail in Huber (2018). Compared to firms with relationships to other banks, German firms dependent on Commerzbank (i.e. firms that had a Commerzbank branch as relationship bank before the crisis) reported more restrictive bank loan supply in a survey following Commerzbank’s lending cut (data from the Ifo Institute, see Table 3.A.1). They took out less bank debt and their employment, investment, and patenting grew more slowly. There is little evidence that the effects in Germany differed by firm size, consistent with results from Spain by Bentolila, Jansen, and Jiménez (2018) and the fact that European firms of all sizes depend on banks, unlike in the United States (Chodorow-Reich 2014).[7] The lending cut also had recessionary effects on the employment and output of German counties where a higher fraction of firms were dependent on Commerzbank. For the purpose of this paper, we take as a starting point the observation that Commerzbank’s lending cut was an exogenous financial shock to German firms. We then trace how this domestic shock was transmitted internationally through the international affiliates of German multinationals dependent on Commerzbank.

## 3.3 Data

This paper makes use of three datasets: information on bank-firm relationships collected by a credit rating agency, data on the international affiliates of German multinationals from the Microdatabase Direct Investment (MiDi, Deutsche Bundesbank 2017a) of the

[7]Several empirical papers from other countries also find that bank lending cuts have real effects on firm growth (Gan 2007; Khwaja and Mian 2008; Amiti and Weinstein 2011; Paravisini et al. 2015; Cingano, Manaresi, and Sette 2016; Garicano and Steinwender 2016).

German Central Bank, and corporate balance sheets of German firms (Ustan, Deutsche Bundesbank 2017b) from the German Central Bank.

### Bank-Firm relationship data

We obtain proprietary data on the names of the relationship banks (Hausbanken) of 112,344 German firms from the year 2006. The data are from the credit rating agency Creditreform, which collects the information from firm surveys and financial statements. Our main independent variable of interest measures the fraction of parent's bank relationships that are with Commerzbank:

$$\text{CB dep}_p^{parent} = \frac{\text{Num. of parent's relationship banks that are CB branches}}{\text{Total number of parent's relationship banks}}. \tag{3.1}$$

We do not have data on the bank relationships of international affiliates. However, in a robustness check, we ensure that affiliate dependence on Commerzbank cannot explain the effects, by testing whether the effects differ for affiliates in countries where Commerzbank operated international branches.

### MiDi

The MiDi contains detailed information on the international affiliates of German multinationals. The data are collected by the German Central Bank as part of its supervisory duties. They are available to researchers for on-site use in Frankfurt under strict guidelines. German firms legally have to report an affiliate to the German Central Bank if they hold at least 10 percent of an affiliate's shares and if the affiliate's total assets exceed 3 million Euro. These reporting criteria have been constant since 2002, so we use data from 2002 until 2015, the most recent year in the data.[8] The MiDi includes the balance sheet, sales, employment, and industry of the affiliates. A unique feature of the data is that it also contains balance sheet information on the linkages between foreign affiliates and parents. We can see short-term claims on the parent by the affiliate, long-term loans from affiliate to parent, the total liabilities owed to the parent by the affiliate, and equity invested by the parent.[9] Data are reported once per year.

Our estimation sample includes all affiliates that were directly owned by a German firm in 2006. We remove all affiliates in the financial sector from the sample. Using a unique firm identifier, we match the bank relationship data to the parent corporations in

[8]The Foreign Trade and Payments Acts ("Außenwirtschaftsgesetz") and the Foreign Trade and Payments Regulation ("Außenwirtschaftsverordnung") define the reporting criteria (for details, see Schild and Walter 2017). Other papers that use these data include Muendler and Becker (2010) and Tintelnot (2017).

[9]There is no distinction between long- and short-term liabilities toward the parent. We use the balance sheet position "nominal capital paid by parent" to measure the equity stake of the parent in the affiliate.

MiDi.[10] We match the relationship banks for 26.4 percent of parents in the MiDi database. The parents we match owned 48.6 percent of all affiliates recorded in the MiDi data in 2006. These affiliates were responsible for 70.8 percent of total sales by affiliates in the MiDi data in 2006. Overall, there are 2,695 international affiliates in our matched dataset, owned by a total of 655 German multinational parents.

### Ustan

To get financial information on German parent corporations, we use the Ustan database from the German Central Bank. Ustan reports balance sheets and profit-loss accounts of non-financial firms. The data are collected by the German Central Bank as a byproduct of its lending activity. A few firms do not report total liabilities in Ustan in 2006, so we supplement Ustan with data from Bureau van Dijk Financials for these firms. Ustan contains 407 of the 655 multinational parent corporations in MiDi. Ustan is also available for the years 2002 to 2015.

### Summary Statistics

We report summary statistics for parent corporations in Table 3.1. The average parent in 2006 had 1,142 employees, annual sales of 395 million Euro, total assets of 832 million Euro, a leverage ratio of 46.9 percent, and 3.8 international affiliates. Figure 3.4 shows that about 40 percent of multinational parents have zero Commerzbank dependence. The mean Commerzbank dependence is 0.23. There is no linear relationship between parent size and Commerzbank dependence. Parents with Commerzbank dependence between 0.31 and 0.5 were larger than the average, while parents with Commerzbank dependence between 0.51 and 1 were smaller.[11] Bank debt, trade credit (lending from other firms), and leverage were balanced across all bins of Commerzbank dependence.

The average affiliate in 2006 had around 196 employees, annual sales of 54 million Euro, and total assets of 93 million Euro (Table 3.2). The table suggests there is no linear relationship between parent Commerzbank dependence and any of the firm observables. For example, the sales of affiliates whose parents had Commerzbank dependence from 0.3 to 0.5 were the largest, with around 65 million Euro on average. Leverage was well balanced across all ranges of parent Commerzbank dependence. The average leverage of

[10]Matching of the bank-firm relationship data with the anonymized firm identifier in the German Central Bank data was performed by the Research Data and Service Center of the Deutsche Bundesbank (for details, see Schild, Schultz, and Wieser 2017).

[11]Similar information is reported in Huber (2018, Appendix). Parents with strictly positive Commerzbank dependence were on average larger than parents with zero Commerzbank dependence. This effect arises mechanically, since larger firms have more relationship banks, and are therefore also more likely to have a relationship to a Commerzbank branch.

affiliates was 51.8 percent, somewhat higher than the average leverage of parents (46.9 percent). The ownership share, i.e. the share of equity held by parents, was well balanced across all ranges of parent Commerzbank dependence and had an average of 87.6 percent.

We examine whether the affiliates of parents with positive Commerzbank dependence operated in different industries or countries, compared to the affiliates of parents with zero Commerzbank dependence.[12] The four most common industries in the sample are: wholesale and retail trade; manufacturing; real estate, renting, and business activities; and transport, storage, and communication.[13] Table 3.3 shows that the distribution of industries is similar across both groups. The correlation of industry shares between the two groups is high, at 0.89. Affiliates of parents with positive Commerzbank dependence are slightly more common in manufacturing, while affiliates of parents with zero Commerzbank dependence are more likely to operate in real estate, renting, and business activities. The Commerzbank annual report 2008 contains similar data for the industry breakdown of Commerzbank's corporate borrowers.

The geographic distribution of affiliates is remarkably similar in both groups, which is reflected in a correlation of country shares across the two groups of 0.98. The most common location of affiliates is the United States, followed by France, Italy, the Netherlands, and the United Kingdom. Apart from the United States and China, the most common countries are in Europe. This suggests that a gravity equation holds for the location of German affiliates.

Overall, the summary statistics suggest that affiliates whose parents had high Commerzbank dependence were not fundamentally different from other affiliates. This corroborates our empirical approach, which assumes that affiliates of parents with high Commerzbank dependence would have developed in parallel to other affiliates, had their parents not experienced a lending cut.

[12]We do not report data by bins of Commerzbank dependence because the disclosure rules of the German Central Bank do not allow us to report statistics for cells that contain only a few firms.

[13]Industries are defined according to the NACE 1.1 one-digit classification.

## 3.4 Results

### 3.4.1 The Effect of Commerzbank's Lending Cut on Parent Corporations

To examine the effect of parent Commerzbank dependence on parent outcomes, we use a difference-in-differences specification:

$$\ln(y_{pt}) = \sum_{\tau=2002}^{2015} \beta_\tau \times \text{CB dep}_p^{parent} \times \mathbb{1}(t=\tau) + \gamma_p + \lambda_t + \sum_{\tau=2002}^{2015} \phi'_\tau \times X_p \times \mathbb{1}(t=\tau) + \epsilon_{pt}, \tag{3.2}$$

where subscript p indexes the parent and t indexes time. The indicator function $\mathbb{1}(t=\tau)$ is one if the time index t is equal to $\tau$ and zero otherwise. The first outcome variable $y_{pt}$ we analyze is parent bank debt.[14] The independent variable of interest is CB $\text{dep}_p^{parent}$, which measures the fraction of the parent corporation's bank relationships that are with Commerzbank branches in 2006. We estimate the effect of Commerzbank dependence in every year from 2002 to 2015. We use 2006 as the baseline year, because it is the final year before the crisis in the United States mortgage market. The coefficients of interest $\beta_\tau$ measure the effect (in log points) of parent Commerzbank dependence in the given year.

The specification includes additional control variables. Firm fixed effects, $\gamma_p$, account for time-invariant differences across parents. Time fixed effects $\lambda_t$ control for macroeconomic shocks that affect all firms in a given year. Additionally, we include a vector of parent-specific control variables $X_p$. All these controls are measured in 2006 and interacted with year dummies. The controls in $X_p$ are deciles of firm sales, industry fixed effects[15], dummies for whether the parent had a foreign affiliate in Asia, the European Union, or the United States, and deciles of firm leverage (defined as liabilities/assets). Firm heterogeneity in size (Fort et al. 2013), leverage (Giroud and Mueller 2017a), exposure to certain countries, and industry-specific shocks explain differences in firm growth in recent years. By including these control variables and interacting them with year dummies, we ensure that spurious correlations between parent Commerzbank dependence and these variables

[14] We winsorize all dependent variables at the 1st and 99th percentiles of their distribution to mitigate the impact of outliers. The results are similar without winsorizing. Since the outcome variables contain some zeros, we add 1 to all outcome variables throughout the paper. In a robustness check, we use a different transformation of the outcome variable, the inverse hyperbolic sine. Table 3.A.2 shows the results are essentially unchanged. The inverse hyperbolic sine of y is defined as $\text{IHS}(y) = ln(y + (y^2+1)^{\frac{1}{2}}) \approx ln(2) + ln(y)$ (except for very small y), so that first differences can be interpreted as approximate log changes (Burbidge, Magee, and Robb 1988; MacKinnon and Magee 1990; Chen 2013; Arcand, Berkes, and Panizza 2015).

[15] The industries are defined according to the NACE 1.1 one-digit classification. They are: mining and quarrying; manufacturing; electricity, gas, and water supply; wholesale and retail trade; transport, storage, and communication; financial intermediation; real estate, renting, and business activities; other community, social, and personal service activities; agriculture, hunting, and forestry; construction; hotels and restaurants.

do not bias the estimates. Standard errors are clustered at the parent level to account for serial correlation of unobserved parent-level shocks over time.

Figure 3.5 examines the effect of Commerzbank dependence on parent bank debt, conditional on all the control variables. We plot the estimated coefficients $\beta_\tau$ and the associated 90 percent confidence intervals for every year. We scale the coefficients in the figure by the average Commerzbank dependence of parents in the sample, which was 0.23. Hence, we plot the effect of Commerzbank's lending cut for the average parent in our sample. The main identification assumption is that parents with high Commerzbank dependence would have grown at the same rate as other parents, had Commerzbank not cut lending. In the years before Commerzbank's 2008 lending cut, the effects of Commerzbank dependence on bank debt are small and statistically insignificant. This result corroborates our identification strategy because it suggests that parents with higher Commerzbank dependence were on similar trends to other firms before 2008. It is particularly noteworthy that in the 2003 recession higher Commerzbank dependence is not associated with lower bank debt growth. This implies that parents dependent on Commerzbank were not more cyclical in general.

When Commerzbank cut lending in 2008, the bank debt of parents with higher Commerzbank dependence dropped sharply compared to other firms. It subsequently remained low until 2015, with no sign that the bank debt of firms dependent on Commerzbank converged to the level of other firms. Hence, Commerzbank's lending cut persistently lowered the bank debt of parents.

We test the robustness of the graphical analysis by specifying:

$$\ln(y_{pt}) = \beta \times \text{CB dep}_p^{parent} \times d_t^{08\text{-}15} + \gamma_p + \lambda_t + \phi' \times X_p \times d_t^{08\text{-}15} + \epsilon_{pt}, \tag{3.3}$$

where $d_t^{08\text{-}15}$ is a dummy for the years 2008 to 2015 and $\beta$ is the average log difference in bank debt for firms dependent on Commerzbank after 2008, relative to firms with zero dependence on Commerzbank. The specification also includes firm fixed effects, time fixed effects, and firm-level control variables interacted with $d_t^{08\text{-}15}$. The results are in Table 3.4. The first column presents a specification that only controls for firm and year fixed effects. The subsequent columns add controls for firm size, industry, affiliate locations, and leverage. The point estimates are stable in all columns. The specification with all controls suggests that the bank debt of the average firm in the sample fell by 34.7 log points due to Commerzbank's lending cut. The estimate is statistically different from zero at the 10 percent level.[16]

Apart from bank debt, trade credit (lending from other firms) is an important source of external financing for German firms. We study the effect of Commerzbank's lending cut on trade credit in Figure 3.6. There is no association between Commerzbank dependence and trade credit in the years before the lending cut, further supporting our identification strategy. There is a marginal increase in the years 2008 to 2010, followed by a large upward jump in 2011. Subsequently, trade credit remained high from 2011 to 2015. The regression results in Table 3.5 confirm the conclusions from the graphical analysis. We test separately whether there was a change in trade credit from 2008 to 2010 or after 2011. This means we interact the measure of parent Commerzbank dependence twice: first, with $d_t^{08\text{-}10}$, a dummy for the years 2008 to 2010, and second, with $d_t^{11\text{-}15}$, a dummy for the years 2011 to 2015. There is no significant evidence that trade credit increased between 2008 and 2010. The point estimate is relatively small. However, there is a large and significant increase in trade credit between 2011 and 2015. This suggests that, a few years after Commerzbank's lending cut, parents dependent on Commerzbank substituted trade credit for the lost bank debt. Since the point estimate on trade credit is smaller than on bank debt and since total trade credit was on average less than total bank debt, trade credit did not make up for all of the reduction in bank debt, however.

Huber (2018) shows that German firms dependent on Commerzbank reduced their bank debt after Commerzbank cut lending. The results in this section confirm and extend this result. Three insights are new here. First, the effect on bank debt existed for the parent organizations of multinational firms. This means that, in the German context, lending cuts affect the financing structure of large firms with international operations, and not just small and medium-sized enterprises. Second, the effect on bank debt persisted until 2015. Third, parents were able to raise trade credit to partially compensate for the reduction in bank debt, albeit with some delay.

### 3.4.2 The Transmission to International Affiliates

This section investigates whether the shock to parents' credit supply affected their international affiliates. We estimate the following specification for affiliate a of parent p, located

[16] The point estimate for the decrease in parent bank debt is larger than the decrease in Commerzbank's total lending stock, which was around 17 percent (Huber 2018). One possible explanation is that firms affected by Commerzbank's lending cut voluntarily reduced borrowing from banks after the lending cut, because they were "scarred" by the experience of Commerzbank's lending cut. A literature shows that firms use less external financing when their managers personally experienced a credit crisis (Graham and Narasimhan 2004; Malmendier, Tate, and Yan 2011). There is also anecdotal evidence that the financial crisis 2008/09 led German firms to conclude that relying on bank debt was too risky. Hence, many firms now prefer other forms of financing, such as trade credit or internal financing (Fuchsbriefe 2018). It is important to note, however, that the 90 percent confidence interval does not exclude that the effect of parent bank debt is the same as the magnitude of Commerzbank's lending cut.

in country c, at time t:

$$\ln(y_{apct}) = \sum_{\tau=2002}^{2015} \beta_\tau \times \text{CB dep}_p^{parent} \times \mathbb{1}(t=\tau) + \gamma_a + \lambda_t + \sum_{\tau=2002}^{2015} \phi'_\tau \times X_{ac} \times \mathbb{1}(t=\tau) + \epsilon_{apct}. \tag{3.4}$$

The specification includes affiliate fixed effects ($\gamma_a$) to control for time-invariant differences across affiliates and time fixed effects ($\lambda_t$) to control for global macroeconomic shocks. $X_{ac}$ is a vector of affiliate-level controls, measured in 2006. We control for: fixed effects for deciles of affiliate size; industry; whether the affiliate is located in Asia, the European Union, or the United States; and deciles of leverage. Standard errors are clustered at the parent level.

The independent variable of interest is parent Commerzbank dependence, CB $\text{dep}_p^{parent}$. We scale the coefficients in the figure by the average Commerzbank dependence of parents in the sample, which was 0.23. The first dependent variable $y_{apct}$ we consider is affiliate sales.[17] Figure 3.7 plots the relationship between affiliate sales and parent Commerzbank dependence, relative to the pre-crisis baseline year 2006. The identification assumption is that, in the absence of Commerzbank's crisis, there would have been no association between parent Commerzbank dependence and affiliate sales. There are no statistically significant coefficients for the years before 2008 and the point estimates are small. This finding suggests that affiliates whose parents had high Commerzbank dependence were on parallel trends to other affiliates. After Commerzbank cut lending to German parents in 2008, affiliate sales fell sharply. There was a partial recovery in 2009, although the sales of affiliates whose parents were more dependent on Commerzbank remained lower than those of other affiliates in 2009 and 2010. The individual point estimate for 2008 is statistically different from zero at the 5 percent level and the point estimates for the years 2009 and 2010 are statistically different from zero at the 10 percent level. From 2011, the coefficients on parent Commerzbank dependence are insignificant and relatively small. Overall, the graph suggests that Commerzbank's 2008 lending cut lowered the sales of international affiliates from 2008 to 2010, and that affiliate sales had recovered by approximately 2011.[18]

The following specification estimates the effect of parent Commerzbank dependence separately for two periods, from 2008 to 2010 and from 2011 to 2015:

$$\begin{aligned}\ln(\text{sales}_{apct}) &= \beta_1 \times \text{CB dep}_p^{parent} \times d_t^{08\text{-}10} + \beta_2 \times \text{CB dep}_p^{parent} \times d_t^{11\text{-}15} \\ &\quad + \gamma_a + \lambda_t + \phi'_1 \times X_{ac} \times d_t^{08\text{-}10} + \phi'_2 \times X_{ac} \times d_t^{11\text{-}15} + \epsilon_{apct}.\end{aligned} \tag{3.5}$$

[17] As above, we winsorize all dependent variables at the 1st and 99th percentile and add 1 to the outcome variable. The results are robust to not winsorizing and to using the inverse hyperbolic sine instead of adding 1 (see Table 3.A.2).

[18] Figure 3.A.1 in the Appendix controls for country fixed effects instead of whether the affiliate is in Asia, the European Union, or the United States. The pattern of results is similar.

We interact the measure of parent Commerzbank dependence with the indicator for 2008 to 2010, $d_t^{08\text{-}10}$, and the indicator for 2011 to 2015, $d_t^{11\text{-}15}$. There are two reasons for how we define the periods. First, the survey in Table 3.A.1 and the narrative evidence in Section 3.2.2 suggest that firms dependent on Commerzbank suffered from restrictive lending from 2008 to 2010. Second, Figure 3.7 implies that affiliate sales recovered around 2011. The vector $X_{ac}$ contains fixed effects for size deciles, industry, country, and leverage deciles. All controls are interacted with the indicator variables for the two time periods.

Table 3.6 presents the results, using affiliate sales as outcome. The estimated effects of parent Commerzbank dependence are stable in all specifications. The controls lower the standard errors considerably, but have little impact on the point estimates. The specification with all controls is in column 5. The point estimate for the effect of parent Commerzbank dependence from 2008 to 2010 is statistically significant at the 10 percent level. It implies that the sales of affiliates whose parents had average Commerzbank dependence were on average 9.7 log points lower between 2008 and 2010, relative to affiliates whose parents had zero Commerzbank dependence. The estimate for the effect of parent Commerzbank dependence from 2011 to 2015 is small, positive, and statistically insignificant. This suggests that affected affiliates recovered after 2011. These results are consistent with the graphical analysis. They suggest that Commerzbank's crisis had real effects in countries outside Germany for three years, due to the shock transmission through the internal networks of multinational firms.

Table 3.A.3 presents results using employment as outcome. The effect of parent Commerzbank dependence from 2008 to 2010 is negative, implying a reduction of 4.5 log points, but the effect is imprecisely estimated. Hence, there is some suggestive evidence that affiliate employment responded negatively to parent Commerzbank dependence, although the standard errors do not allow rejecting the null hypothesis of no effect. The effect of parent Commerzbank dependence on employment from 2011 is small, positive, and statistically insignificant (at 1.1 log points), consistent with the finding that affiliate sales recovered from 2011.[19]

### 3.4.3 Mechanisms Underlying the Transmission to International Affiliates

Having analyzed the effect of parent Commerzbank dependence on affiliate sales, we now turn toward investigating the mechanisms through which financial shocks to parents can affect affiliates. To do so, we estimate versions of equation (3.5), using a number of affiliate

[19]We also examined the extensive-margin effect of parent Commerzbank dependence on the exit of affiliates. We find no evidence that affiliates of parents with higher Commerzbank dependence were more likely to exit after the lending cut.

balance sheet items as dependent variables.

The results are in Table 3.7. The top row of the table lists the dependent variable of the respective specification. Columns 1 and 2 examine the asset side of the affiliate balance sheet. The first column reports the effect of parent Commerzbank dependence on long-term loans to the parent. The point estimates imply that affiliates whose parents had average Commerzbank dependence increased long-term loans to their parents by 8.7 log points from 2008 to 2010 (significant at the 10 percent level). This finding is consistent with an efficient internal capital market. As parents faced a shock to credit supply, affiliates stepped in and provided financing. The effect on long-term loans to the parent from 2011 to 2015 remains positive and implies a 10.2 log points increase, although the effect is imprecisely estimated. Column 2 shows a negative effect of parent Commerzbank dependence on short-term claims on parents by affiliates. The coefficient is significant at the 5 percent level and implies a decrease of 18.8 log points. Short-term claims within firms are a commonly used proxy of input-output flows between parents and affiliates (for example, Overesch 2006). A decrease in short-term claims on the parent suggests that there was a decrease in internal trade from affiliates to parents. A likely reason is that there was a decrease in the demand for the affiliates' products by parents, which led to reduced trade flows from affiliates to parents from 2008 to 2010. The coefficient for 2011 to 2015 is statistically insignificant and implies a smaller decrease of 14.4 log points. The partial recovery of short-term claims on the parent from 2011 suggests that parents slightly increased their demand for internal inputs from 2011. This may partially explain why affiliate sales were only lower from 2008 to 2010 and subsequently recovered.

Columns 3 analyzes affiliate liabilities. The data from the German Central Bank do not differentiate between long- and short-term liabilities to the parent, unlike in the case of assets. Hence, column 3 reports the effect on total liabilities owed to parents by affiliates. The point estimates for both 2008 to 2010 and 2011 to 2015 are positive and statistically insignificant, suggesting that total liabilities to the parent did not fall significantly. Column 4 examines equity invested by parents into affiliates. The point estimate for 2008 to 2010 implies a 4.7 log point decrease in equity invested by parents, but it is imprecisely estimated. The point estimate for 2011 to 2015 implies a 7.4 log point reduction in equity and is significant at the 10 percent level. Column 4 suggests that parents significantly and persistently reduced the equity they held in their affiliates.

Table 3.8 analyzes whether affiliates compensated for the effects of Commerzbank's lending cut on their balance sheet through other channels. We find no significant effect on other long-term assets (excluding long-term loans to non-parents). The coefficients are positive both from 2008 to 2010 and from 2011 to 2015 (column 1). Hence, affiliates did not cut lending to non-parents or reduce other asset holdings to make up for increased lending to parents. The effect on other short-term assets (excluding short-term claims on parents) is negative and statistically significant from 2008 to 2010 (column 2). This suggests that affiliates may have produced less for other, non-parent trading partners after Commerzbank's lending cut because they became financially constrained. Alternatively, affiliates may have reduced their inventory holdings of raw materials because the parent demanded fewer products from the affiliate. The effect on other short-term assets disappears from 2011, as the coefficient is positive and insignificant from 2011 to 2015 (column 2). The full recovery of other short-term assets suggests that affiliates' production recovered from 2011. This finding is consistent with the full recovery of sales from 2011.

Liabilities to non-parents (column 3) and equity from non-parents (column 4) hardly changed from 2008 to 2010, suggesting that initially affiliates were not able to use other sources of funding to compensate for the loss of equity funding by parents. Liabilities to non-parents (column 3) were 2.9 log points higher from 2011 to 2015, although the effect is imprecisely estimated. This indicates that affiliates may have raised debt from non-parents to finance their sales recovery from 2011.

The evidence so far indicates that after Commerzbank's lending cut affiliates had to lend more to their parents, that affiliates faced lower demand by parents for internal trade, and that parents withdrew equity from the affiliates. Next, we carry out tests for heterogeneity by affiliate characteristics in the effect on sales. The aim is to investigate whether loans to parents and lower internal firm trade were likely mechanisms for the drop in affiliate sales. We estimate specifications of the following type:

$$\begin{aligned}\ln(\text{sales}_{apct}) = {} & \beta_1 \times \text{CB dep}_p^{parent} \times d_t^{08\text{-}10} + \beta_1' \times \text{CB dep}_p^{parent} \times d_t^{08\text{-}10} \times \text{het}_{ac} \\ & + \omega \times \text{het}_{ac} \times d_t^{08\text{-}10} + \beta_2 \times \text{CB dep}_p^{parent} \times d_t^{11\text{-}15} + \gamma_a + \lambda_t \\ & + \phi_1' \times X_{ac} \times d_t^{08\text{-}10} + \phi_2' \times X_{ac} \times d_t^{11\text{-}15} + \epsilon_{apct}.\end{aligned} \tag{3.6}$$

We use the indicator variable $\text{het}_{ac}$ to identify whether a firm falls in a given heterogeneity category. $\beta_1$ estimates the effect of Commerzbank dependence from 2008 to 2010 on affiliates that do not fall into the given heterogeneity category. $\beta_1'$ measures the additional effect from 2008 to 2010 on affiliates that fall in the category. This specification controls for shocks that may affect all affiliates in a given heterogeneity category (independent of their parents' Commerzbank dependence), by including the indicator for the heterogeneity category interacted with the indicator for 2008 to 2010. The specification also contains all the controls from earlier.

The first category of heterogeneity we consider in Table 3.9 is whether affiliates had positive long-term loans to their parent on their 2006 balance sheets. Column 1 shows that the effect from 2008 to 2010 on affiliates with zero long-term loans to their parent in 2006 is negative, but statistically insignificant. The additional effect from 2008 to 2010 on affiliates with positive long-term loans to the parent is negative and statistically significant at the 5 percent level. These results suggest that affiliates who already had an existing lending relationship to their parent suffered significantly larger declines in sales from 2008 to 2010. A possible explanation is that parents had already set up financial linkages to these affiliates with existing long-term loans to the parent, allowing parents to borrow more easily from these affiliates.

The second column studies heterogeneity in whether affiliates had positive short-term claims on their parents on their 2006 balance sheets. Firms with positive short-term claims were likely suppliers of inputs to the parent and thereby reliant on parents' demand for internal trade. We find that the effect on affiliate sales from 2008 to 2010 is negative, small, and insignificant for affiliates with zero short-term claims on the parent in 2006. But the additional effect from 2008 to 2010 on affiliates with positive short-term claims in 2006 is negative and significant at the 10 percent level. Hence, the sales of affiliates with positive internal trade flows to parents fell more strongly. These findings imply that internal trade links played an important role in transmitting the effects of Commerzbank's lending cut to international affiliates.

### 3.4.4 Robustness Checks

We carry out a number of robustness checks for the effect of parent Commerzbank dependence on affiliate sales. In the first column of Table 3.10, we exclude from the sample all countries where Commerzbank had a branch.[20] The estimates are similar in this smaller sample. This implies that the effects are not driven by affiliates' direct exposure to Commerzbank's lending cut, through the bank's international branches. Another piece of evidence against a direct exposure of affiliates to the lending cut is that affiliates' liabilities toward non-parents did not change. If their bank debt had fallen, this should result in a negative effect on liabilities toward non-parents.

We control for the number of relationship banks of the parent in column 2 of Table 3.10. We include fixed effects for whether the parent had 1, 2, 3, 4, or more than 4 relationship banks. The coefficients remain stable and the effect from 2008 to 2010 is significant at the 10 percent level. Adding fixed effects for the parent's industry in column 3 makes little difference to the point estimates and raises the significance from 2008 to 2010 to the 5 percent level.

[20] Foreign branches are listed in Commerzbank's 2009 annual report.

In column 4, we replace the measure of parent Commerzbank dependence by an indicator for whether the parent had any relationship to Commerzbank. The coefficients imply effects of similar magnitude to our baseline treatment. The effect from 2008 to 2010 is significant at the 5 percent level.

In Table 3.A.4, we interact the measure of parent Commerzbank dependence with indicators for Asia, the European Union, and the United States. We find no significant difference in the effects for affiliates located in any of these regions. This suggests that the effects we have estimated were not driven by affiliates in a particular region or shocks to a particular region, but that we have identified a robust channel through which localized shocks can affect the global economy.

The final robustness check examines how affiliates developed if their parents depended on other German banks that may have suffered losses during the crisis. We study three groups of other banks, inspired by discussions in the media and in the academic literature: Landesbanken affected by the financial crisis 2008/09[21]; savings banks that owned Landesbanken affected by the crisis (Hochfellner et al. 2015; Popov and Rocholl 2015); and other German banks with trading losses during the crisis.[22] In Table 3.A.5, we find no evidence that affiliates whose parents depended on any of these banks experienced lower sales growth between 2008 and 2010. These results are consistent with Huber (2018, Appendices E and F), who discusses why the trading losses at other German banks did not have real effects on firms.

### 3.4.5 Aggregate Implications of the International Transmission

We present a back-of-the-envelope calculation to measure the effect of a financial shock in one country on aggregate sales in another country. Specifically, we calculate the change in aggregate sales in country c due to the exposure of German parents to Commerzbank's lending cut:

$$\begin{aligned}
&\left(\text{Change in total sales due to CB dep of German parents}\right)_c = \\
&\hat{\beta}_1 \times \left(\text{Average parent CB dep for affiliates of German parents}\right)_c \\
&\times \left(\text{Total sales of affiliates of German parents in 2006}\right)_c .
\end{aligned} \tag{3.7}$$

The first term on the right-hand side of equation (3.7) is an estimate of $\beta_1$ from equation (3.5). It represents the effect of parent Commerzbank dependence on affiliate sales from

[21] The affected Landesbanken were BayernLB, HSH Nordbank, Landesbank Baden-Württemberg, Sachsen LB, and WestLB.

[22] We use the banks listed in Table 1 of Dwenger, Fossen, and Simmler (2015), which is taken from Hüfner (2010). These banks are Deutsche Bank, DZ Bank, IKB, HypoVereinsbank, and KfW. We do not include the affected Landesbanken listed there, since we analyze them separately.

2008 to 2010. We multiply $\hat{\beta}_1$ by the average Commerzbank dependence of the German parents of all affiliates in country c. By multiplying the first two terms on the right-hand side of equation (3.7), we approximate the percentage effect of Commerzbank's lending cut on the sales of the average affiliate of a German multinational in country c.[23] We then multiply this effect by the total sales of affiliates of German multinationals in country c in 2006. We measure total sales of German affiliates by aggregating the 2006 sales of all affiliates in the MiDi.

This calculation identifies the change in total sales due to the international transmission of Commerzbank's lending cut through multinationals, if changes in affiliate sales did not have general equilibrium effects on other firms in country c, if policy did not endogenously respond to the decrease in affiliate sales, and if the exchange rate did not adjust (as in the case of countries in the Eurozone). The calculation might underestimate the true total effect if input-output linkages propagated the reduction in affiliate sales to other firms in country c (Acemoglu, Akcigit, and Kerr 2016; di Giovanni, Levchenko, and Mejean 2018). On the other hand, the calculation might overstate the total effect if demand shifted from affected affiliates to unaffected firms, if monetary and fiscal policy became expansive, or if the exchange rate adjusted.

Table 3.11 presents the results of the aggregation exercise for a number of countries. We scale the total sales drop by the aggregate sales of non-financial firms in the given country in 2009. The impact of Commerzbank's lending cut on sales growth (in percent) is most pronounced in European countries close to Germany, where German affiliates account for a large fraction of total sales. For example, total sales fell by 0.31 percent in the Czech Republic, by 0.28 percent in Austria, and by 0.23 percent in Poland.[24] The effect is modest in the United States (0.02 percent), because German affiliates play a small role in the US economy.[25] The mean decrease in sales in the nine most common locations of German affiliates in Table 3.11 was 0.12 percent and the median was 0.06 percent.

We can also use our estimates to calculate the decrease in total sales in one country due to a financial shock that hits the parents of all affiliates located in that country. For example, consider a financial shock to the parents of all affiliates in the United States that did not directly affect any firms in the United States. Assume this shock to parents was of a similar magnitude to Commerzbank's lending cut. Such a shock would lower the sales of each affiliate located in the United States by 0.097 log points (point estimate from Table

[23]Table 3.6, column 5 reports the estimate $\hat{\beta}_1$ that we use for this calculation, scaled by the average Commerzbank dependence of all parents in the sample. For the aggregation exercise in this section, we scale the effect by the country-specific average Commerzbank dependence of the parents of all affiliates in country c.

[24]Apart from the countries listed in Table 3.11, there is also a significant drop of aggregate sales in Hungary, by 0.21 percent.

[25]We scale the total sales drop in the US by the aggregate sales in 2007.

3.6, column 5). The share of non-financial private sector sales by international affiliates of multinational firms in the United States was 10.68 percent in 2007, according to data from the BEA and the Census Bureau. Therefore, the financial shock hitting all parents would have reduced total sales by all firms in the US private sector by 1.03 percent, solely due to the international transmission of the financial shock through the internal networks of multinationals. A similar calculation for the European Union implies that sales in the EU non-financial private sector would have fallen by 2.49 percent. These numbers suggest that the international transmission of financial shocks through multinationals can have economically significant effects on aggregate outcomes.

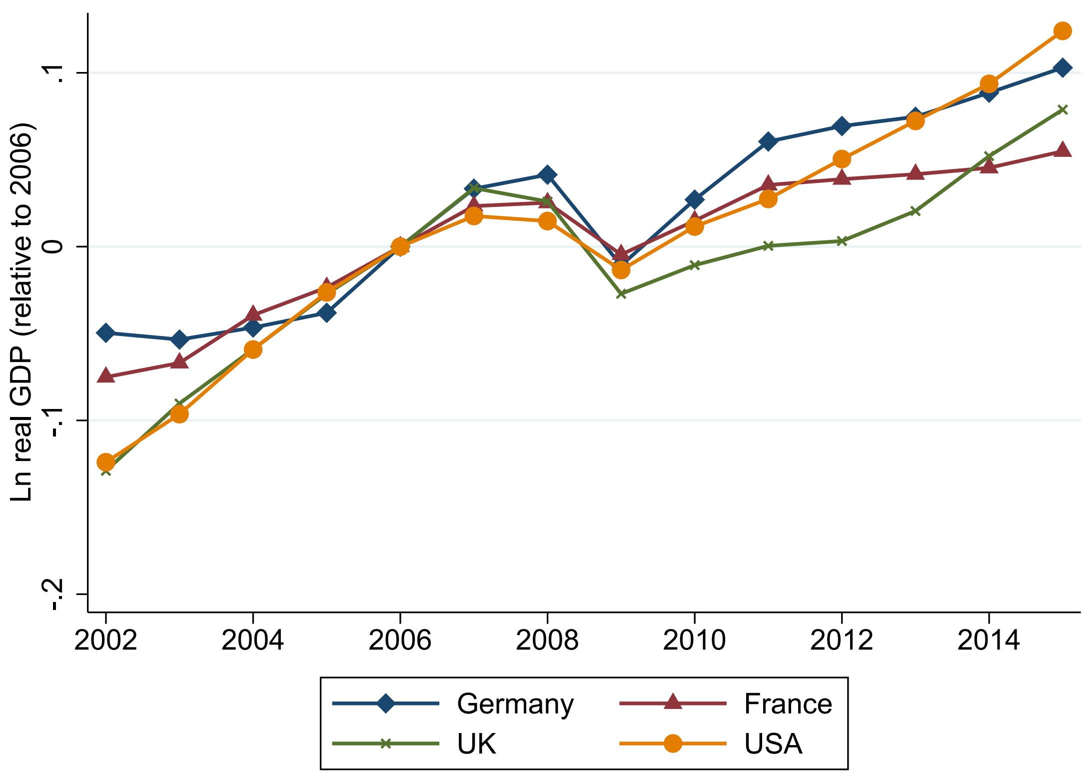
## 3.5 Conclusion

Understanding how financial shocks in one country affect the global economy is an important question in international, financial, and macroeconomics. The empirical challenge in identifying international transmission mechanisms is that most shocks do not hit one country in isolation. Instead, common shocks affect firms and countries that are connected through trade linkages or through the networks of multinational firms.

This paper overcomes the identification challenge by identifying an exogenous shock to the credit supply of multinational parent corporations located in Germany. We analyze unique data on the internal linkages of parents and their international affiliates. We show that the affiliates of parents hit by the credit supply shock experienced lower sales growth. Likely mechanisms for the effect on international affiliates' sales were a reduction in the equity of affiliates held by parents, a drop in intra-firm trade, and increased need for affiliates to lend to their parents. Taken together, our results document how multinationals transmit financial shocks from one country to the global economy.

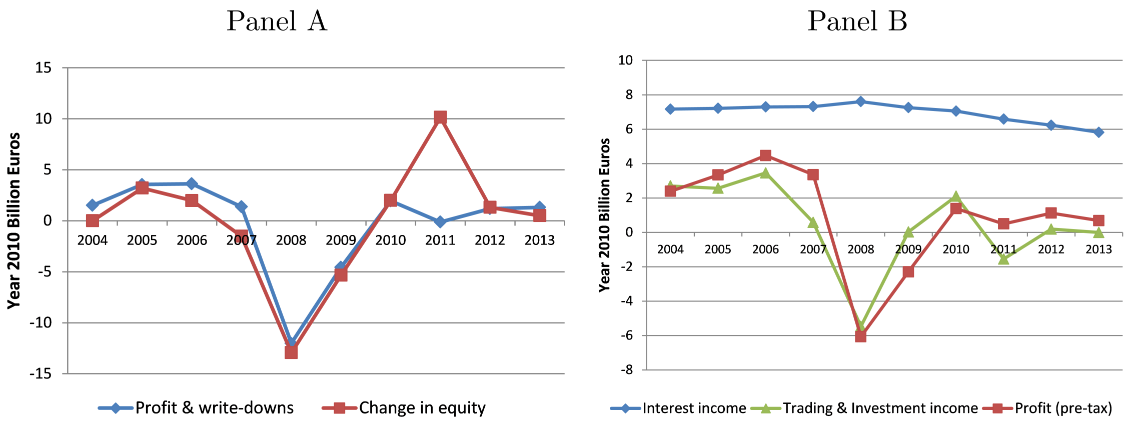
The findings in this paper contribute to the policy debate on the merits of multinational firms. Multinationals are able to smooth out negative shocks that hit them in their home country by withdrawing funds from their international affiliates. On the other hand, they thereby transmit the crises from their home countries to the global economy. The results in our paper suggest that if global economic integration through multinational firms continues, global business cycles may become even more synchronized in future.

Figure 3.1: GDP in advanced economies



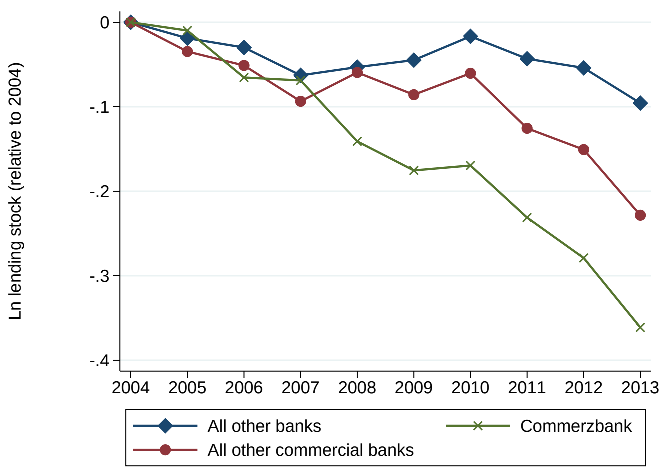

Notes: The figure shows log GDP, relative to 2006, in France, Germany, the United Kingdom, and the United States. Data source: IMF and own calculations.

Figure 3.2: Commerzbank's equity capital, write-downs, and profits



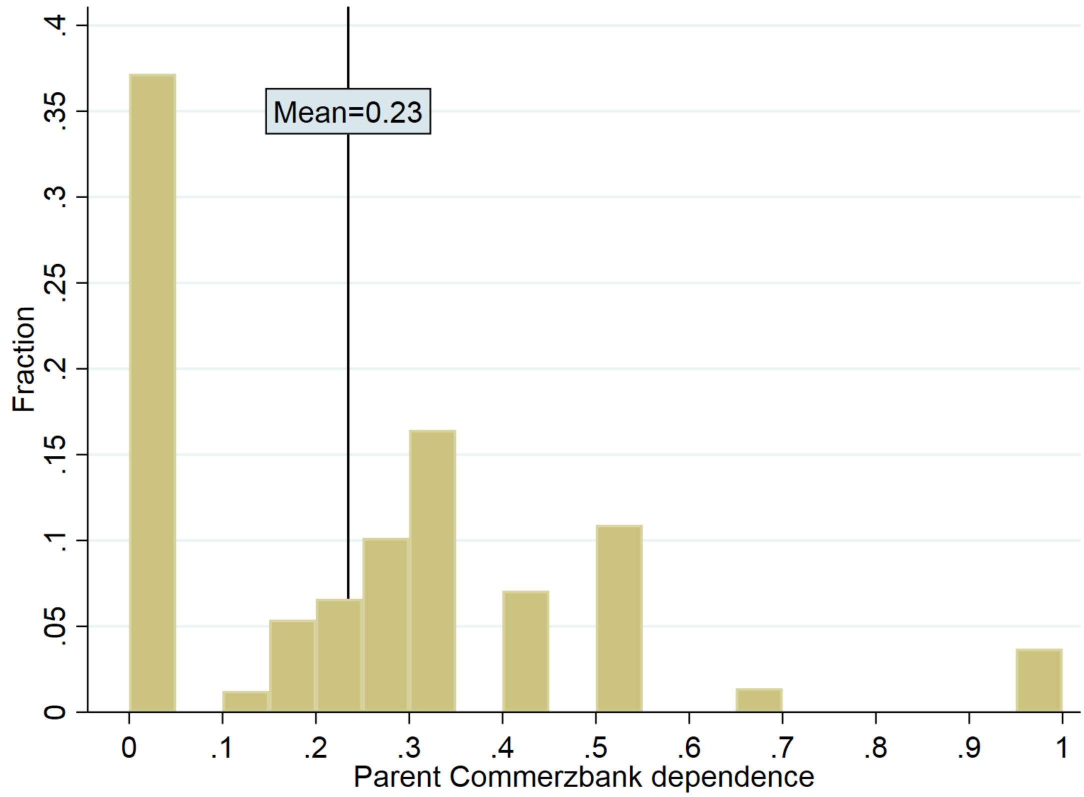

Notes: The left panel shows Commerzbank's profits and write-downs and equity capital. Write-downs arise from changes in revaluation reserves, cash flow hedges, and currency reserves. Panel B shows the composition of Commerzbank's profits. Interest income is interest received from loans and securities minus interest paid on deposits. Trading and investment income is the sum of net trading income, net income on hedge accounting, and net investment income. Pre-tax profit is interest income plus trading and investment income minus costs. The values are in year 2010 billion Euro. The positions of Commerzbank and Dresdner Bank for the years before the 2009 take-over are aggregated. The figure is taken from Huber (2018). Data source: bank annual reports and own calculations.

Figure 3.3: The lending stock of German banks



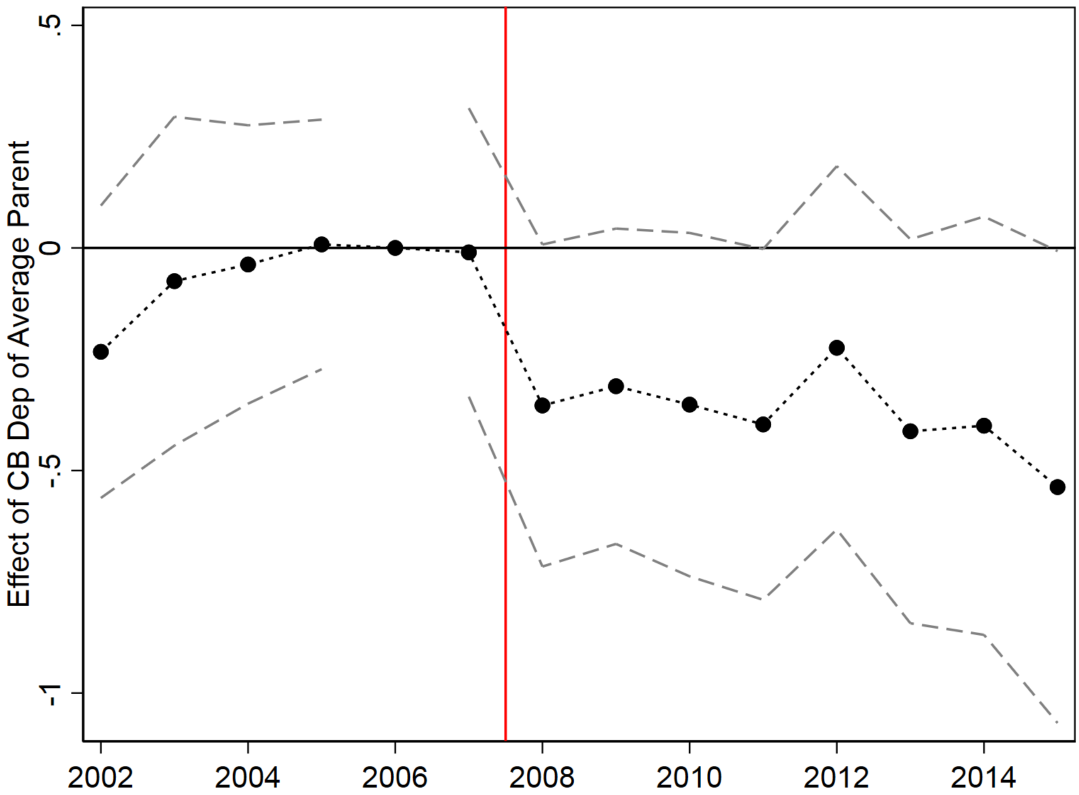

Notes: The figure plots the log lending stock to German non-financial customers, relative to the year 2004. The values are in year 2010 billion Euro. The data for Commerzbank include lending by branches of Commerzbank and Dresdner Bank. The lending stock for the years before the 2009 take-over is calculated as the sum of Commerzbank and Dresdner Bank's lending stock, using data from the annual reports. For all other banks, aggregated data from the Deutsche Bundesbank on German banks are used and lending by Commerzbank is subtracted. For all other commercial banks, lending by Commerzbank, the savings banks, the Landesbanken, and the cooperative banks is subtracted. The figure is taken from Huber (2018).

Figure 3.4: Parent Commerzbank dependence



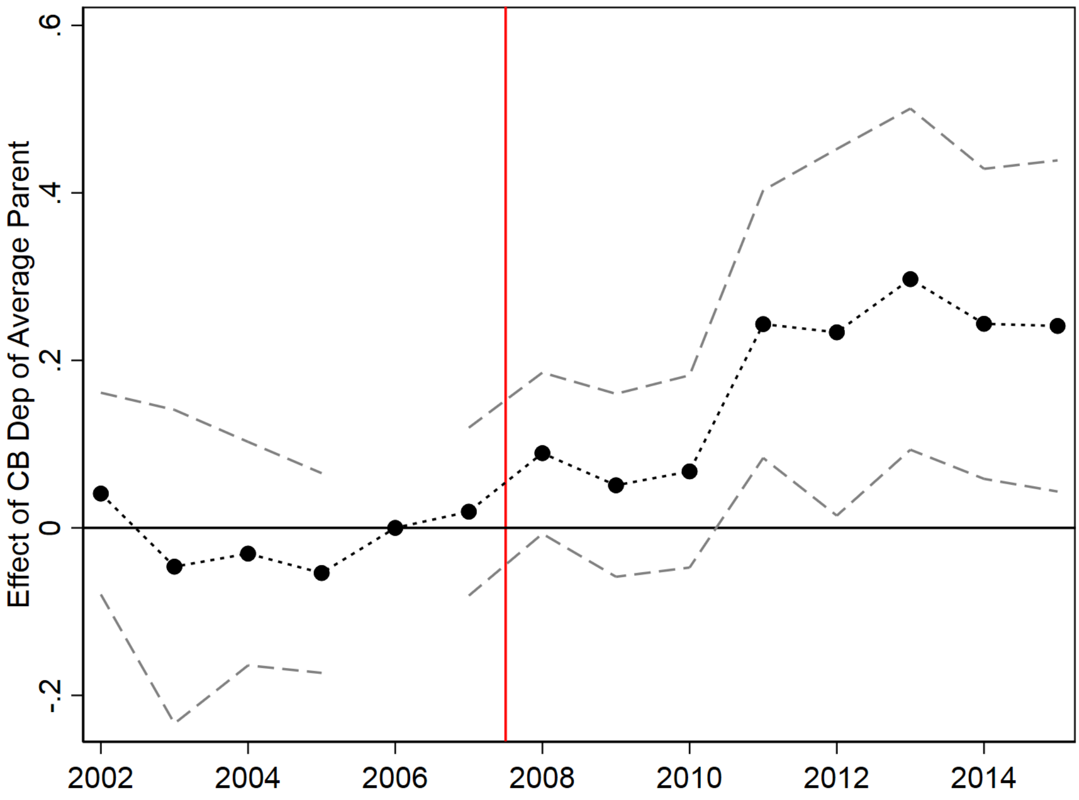

Notes: The figure shows a histogram of Commerzbank dependence for the 655 German parents in our dataset in 2006. Data source: Research Data and Service Centre (RDSC) of the Deutsche Bundesbank, Microdatabase Direct Investment (MiDi) 2002-2015, own calculations.

Figure 3.5: Impact of Commerzbank dependence on parent bank debt



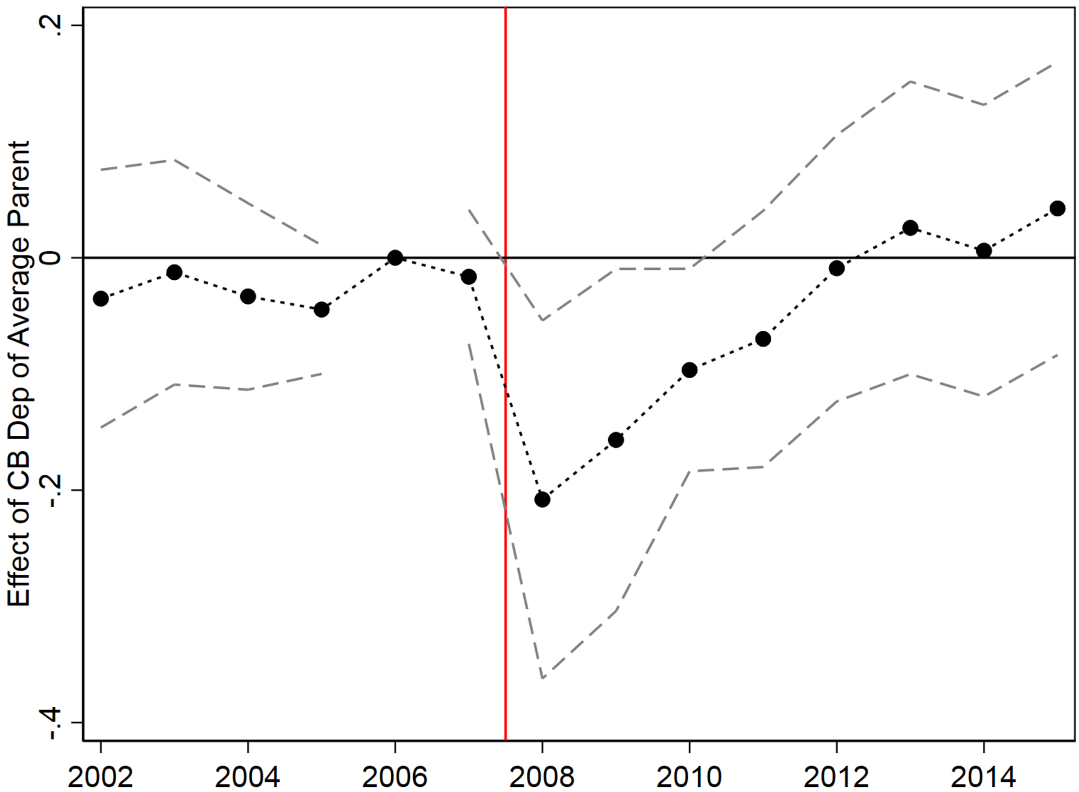

Notes: This figure plots estimates of $\beta_\tau$ from equation (3.2). All coefficients are scaled to reflect the effect on a parent with average CB dep, which was 0.23. The following time-invariant control variables are calculated for parents in the year 2006 and interacted with a full set of year dummies: industry fixed effects (NACE one-digit 1.1. classification), fixed effects for size deciles using the distribution of sales, fixed effects for deciles of leverage, and fixed effects for whether the parent had an affiliate in Asia, the EU, or the US. The dashed line displays 90% confidence intervals. The outcome variable is ln(parent bank debt+1). The panel is unbalanced. Data source: RDSC of the Deutsche Bundesbank, Ustan 2002-2015, own calculations.

Figure 3.6: Impact of Commerzbank dependence on parent trade credit




Notes: This figure plots estimates of $\beta_\tau$ from equation (3.2). All coefficients are scaled to reflect the effect on a parent with average CB dep, which was 0.23. The following time-invariant control variables are calculated for parents in the year 2006 and interacted with a full set of year dummies: industry fixed effects (NACE 1.1. one-digit classification), fixed effects for size deciles using the distribution of sales, fixed effects for deciles of leverage, and fixed effects for whether the parent had an affiliate in Asia, the EU, or the US. The dashed line displays 90% confidence intervals. The outcome variable is ln(parent trade credit+1). The panel is unbalanced. Data source: RDSC of the Deutsche Bundesbank, Ustan 2002-2015, own calculations.

Figure 3.7: Impact of parent Commerzbank dependence on affiliate sales




Notes: This figure plots estimates of $\beta_\tau$ from equation (3.4). All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. The following time-invariant control variables are calculated for affiliates in the year 2006 and interacted with a full set of year dummies: industry fixed effects (NACE 1.1. one-digit classification), fixed effects for size deciles using the distribution of sales, fixed effects for deciles of leverage, and fixed effects for whether the affiliate location is in Asia, the EU, or the US. The dashed line displays 90% confidence intervals. The outcome variable is ln(affiliate sales+1). The panel is unbalanced. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations.

Table 3.1: Parent summary statistics by bins of Commerzbank dependence

| | Range of parent Commerzbank dependence | | | | |
|---|---|---|---|---|---|
| | 0 | 0.01-0.30 | 0.31-0.50 | 0.51-1 | Total |
| Commerzbank dep | 0 | 0.211 | 0.400 | 0.896 | 0.235 |
| | (0) | (0.038) | (0.073) | (0.157) | (0.238) |
| Employment | 972 | 1,188 | 1,411 | 393 | 1,142 |
| | (4,502) | (4,577) | (4,959) | (1,383) | (4,575) |
| Sales | 349,843 | 388,961 | 486,493 | 152,829 | 395,394 |
| | (1,527,767) | (1,608,385) | (1,881,804) | (515,649) | (1,641,595) |
| Total assets | 535,864 | 636,072 | 1,322,907 | 578,200 | 831,892 |
| | (2,929,303) | (3,274,836) | (5,253,431) | (2,184,213) | (3,934,859) |
| Number of affiliates | 2.95 | 3.87 | 4.56 | 4.89 | 3.82 |
| | (4.56) | (6.56) | (6.88) | (9.18) | (6.23) |
| Bank debt | 73,915 | 46,438 | 60,743 | 54,447 | 59,895 |
| | (197,131) | (151,148) | (145,504) | (96,847) | (161,721) |
| Trade credit | 44,029 | 38,756 | 46,358 | 23,139 | 42,601 |
| | (159,187) | (174,205) | (142,586) | (64,090) | (155,134) |
| Leverage (%) | 46.65 | 47.13 | 46.80 | 48.65 | 46.92 |
| | (23.57) | (19.88) | (19.97) | (21.75) | (20.98) |
| Number of parents | 242 | 153 | 225 | 35 | 655 |

Notes: The table shows means (standard deviations) by bins of parent Commerzbank dependence. Bank debt, trade credit, and leverage are available in Ustan. The remaining variables come from MiDi. Leverage is defined as liabilities divided by total assets. Bank debt, sales, and total assets are in thousands of euros. The total number of parents in the bottom row refers to the number of parents in MiDi in 2006. The data are from 2006. Data source: RDSC of the Deutsche Bundesbank, MiDi and Ustan 2002-2015, own calculations.

Table 3.2: Affiliate summary statistics by bins of parent Commerzbank dependence

| | Range of parent Commerzbank dependence | | | | |
|---|---|---|---|---|---|
| | 0 | 0.01-0.30 | 0.31-0.50 | 0.51-1 | Total |
| Employment | 162 | 222 | 200 | 211 | 196 |
| | (434) | (530) | (518) | (452) | (496) |
| Sales | 42,184 | 50,003 | 65,453 | 52,495 | 54,400 |
| | (107,225) | (131,105) | (178,741) | (128,354) | (147,351) |
| Total assets | 69,818 | 75,754 | 118,448 | 97,095 | 93,160 |
| | (280,584) | (303,448) | (426,236) | (353,319) | (357,546) |
| Leverage (%) | 52.10 | 50.69 | 52.82 | 49.18 | 51.83 |
| | (33.75) | (32.18) | (34.62) | (32.74) | (33.65) |
| Short-term claims on parent (%) | 4.40 | 4.80 | 3.81 | 3.45 | 4.19 |
| | (12.51) | (12.80) | (11.17) | (10.40) | (11.91) |
| Long-term loans to parent (%) | 0.38 | 0.15 | 0.44 | 1.92 | 0.46 |
| | (3.28) | (2.19) | (3.54) | (7.04) | (3.60) |
| Liabilities toward parent (%) | 11.24 | 13.74 | 13.39 | 8.37 | 12.54 |
| | (21.01) | (22.26) | (22.26) | (16.56) | (21.60) |
| Equity from parent (%) | 14.11 | 14.07 | 15.37 | 15.13 | 14.69 |
| | (22.82) | (19.26) | (22.45) | (21.33) | (21.71) |
| Ownership share of parent in affiliate | 0.878 | 0.869 | 0.885 | 0.842 | 0.876 |
| | (0.240) | (0.235) | (0.236) | (0.276) | (0.240) |
| Number of affiliates | 721 | 676 | 1,100 | 198 | 2,695 |

Notes: The table shows means (standard deviations) by bins of parent Commerzbank dependence. Leverage is defined as liabilities divided by total assets. The reported percentages are in percent of total assets of the affiliate. Sales and total assets are in thousands of euros. The data are from 2006. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations.

Table 3.3: Distribution of affiliates by industry and country

| | CB $\text{Dep}_p^{par} = 0$ | CB $\text{Dep}_p^{par} > 0$ | Total |
|---|---|---|---|
| **Industry** | | | |
| Wholesale and retail trade | 36.77 | 36.56 | 36.62 |
| Manufacturing | 26.46 | 33.32 | 31.49 |
| Real estate, renting, and business activities | 28.69 | 16.99 | 20.11 |
| Transport, storage, and communication | 3.20 | 5.73 | 5.06 |
| Other industries | 4.87 | 7.40 | 6.73 |
| **Country** | | | |
| United States | 8.22 | 7.86 | 7.96 |
| France | 9.61 | 7.25 | 7.88 |
| Italy | 6.41 | 4.46 | 4.98 |
| Netherlands | 5.29 | 4.87 | 4.98 |
| United Kingdom | 6.27 | 4.51 | 4.98 |
| Switzerland | 6.82 | 3.85 | 4.65 |
| Spain | 5.85 | 4.06 | 4.54 |
| Austria | 6.27 | 3.80 | 4.46 |
| Poland | 3.48 | 4.41 | 4.16 |
| China | 2.09 | 4.41 | 3.79 |
| Czech Republic | 4.60 | 3.14 | 3.53 |
| Other countries | 35.10 | 47.36 | 44.09 |
| Number of affiliates | 721 | 1,974 | 2,695 |

Notes: The table displays the four most common industries (measured using the NACE 1.1. classification) and the ten most frequent countries of foreign affiliates, separately for affiliates whose parents had zero Commerzbank dependence and for affiliates whose parents had positive Commerzbank dependence. The data are from 2006. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations.

Table 3.4: Parent bank debt and Commerzbank dependence

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}15}$ | $-0.3084$ | $-0.3553^{*}$ | $-0.3617^{*}$ | $-0.3699^{*}$ | $-0.3470^{*}$ |
| | (0.2011) | (0.1904) | (0.1920) | (0.1955) | (0.1962) |
| $R^2$ | 0.007 | 0.019 | 0.030 | 0.030 | 0.041 |
| Number of firms | 407 | 407 | 407 | 407 | 407 |
| Observations | 4,495 | 4,495 | 4,495 | 4,495 | 4,495 |
| Parent FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Size bin FE $\times$ $d_t^{08\text{-}15}$ | No | Yes | Yes | Yes | Yes |
| Industry FE $\times$ $d_t^{08\text{-}15}$ | No | No | Yes | Yes | Yes |
| Affiliate location FE $\times$ $d_t^{08\text{-}15}$ | No | No | No | Yes | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}15}$ | No | No | No | No | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variable in all columns is ln(parent bank debt+1). CB $\text{dep}_p^{parent}$ measures the fraction of the parent's bank relationships that are with Commerzbank branches. All coefficients are scaled to reflect the effect on a parent with average CB dep, which was 0.23. $d_t^{08\text{-}15}$ is a dummy for the years from 2008 to 2015. The following time-invariant control variables are calculated for parents in the year 2006 and interacted with $d_t^{08\text{-}15}$: industry fixed effects (NACE 1.1 one-digit classification), fixed effects for size deciles using the distribution of sales, fixed effects for deciles of leverage, and fixed effects for whether the parent had an affiliate in Asia, the EU, or the US. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, Ustan 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.5: Parent trade credit and Commerzbank dependence

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | 0.1140* | 0.1142* | 0.0824 | 0.0823 | 0.0788 |
| | (0.0619) | (0.0657) | (0.0572) | (0.0598) | (0.0589) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | 0.2820*** | 0.2888*** | 0.2544*** | 0.2662*** | 0.2631** |
| | (0.1065) | (0.1012) | (0.0980) | (0.1019) | (0.1022) |
| $R^2$ | 0.040 | 0.058 | 0.118 | 0.120 | 0.131 |
| Number of firms | 407 | 407 | 407 | 407 | 407 |
| Observations | 4,495 | 4,495 | 4,495 | 4,495 | 4,495 |
| Parent FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Size bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | Yes | Yes | Yes | Yes |
| Industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | No | Yes | Yes | Yes |
| Affiliate location FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | No | No | Yes | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | No | No | No | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variable in all columns is ln(parent trade credit+1). CB $\text{dep}_p^{parent}$ measures the fraction of the parent's bank relationships that are with Commerzbank branches. All coefficients are scaled to reflect the effect on a parent with average CB dep, which was 0.23. $d_t^{08\text{-}10}$ and $d_t^{11\text{-}15}$ are dummies for the years from 2008 to 2010 and from 2011 to 2015, respectively. The following time-invariant control variables are calculated for parents in the year 2006 and interacted with both $d_t^{08\text{-}10}$ and $d_t^{11\text{-}15}$: industry fixed effects (NACE 1.1 one-digit classification), fixed effects for size deciles using the distribution of sales, fixed effects for deciles of leverage, and fixed effects for whether the parent had an affiliate in Asia, the EU, or the US. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, Ustan 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.6: Affiliate sales and parent Commerzbank dependence

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | −0.1286 | −0.1235 | −0.1403* | −0.0956* | −0.0967* |
| | (0.0996) | (0.0941) | (0.0826) | (0.0560) | (0.0560) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | 0.0574 | 0.0652 | 0.0486 | 0.0335 | 0.0298 |
| | (0.0613) | (0.0624) | (0.0653) | (0.0601) | (0.0583) |
| $R^2$ | 0.011 | 0.025 | 0.038 | 0.081 | 0.092 |
| Number of firms | 2,695 | 2,695 | 2,695 | 2,695 | 2,695 |
| Observations | 24,941 | 24,941 | 24,941 | 24,941 | 24,941 |
| Affiliate FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Size bin FE $\times d_t^{08\text{-}10}, d_t^{11\text{-}15}$ | No | Yes | Yes | Yes | Yes |
| Industry FE $\times d_t^{08\text{-}10}, d_t^{11\text{-}15}$ | No | No | Yes | Yes | Yes |
| Country FE $\times d_t^{08\text{-}10}, d_t^{11\text{-}15}$ | No | No | No | Yes | Yes |
| Leverage bin FE $\times d_t^{08\text{-}10}, d_t^{11\text{-}15}$ | No | No | No | No | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variable in all columns is ln(affiliate sales+1). CB $\text{dep}_p^{parent}$ measures the fraction of the parent's bank relationships that are with Commerzbank branches. All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. $d_t^{08\text{-}10}$ and $d_t^{11\text{-}15}$ are dummies for the years from 2008 to 2010 and from 2011 to 2015, respectively. The following time-invariant control variables are calculated for affiliates in the year 2006 and interacted with both $d_t^{08\text{-}10}$ and $d_t^{11\text{-}15}$: industry fixed effects (NACE 1.1 one-digit classification), fixed effects for size deciles using the distribution of sales, fixed effects for deciles of leverage, and fixed effects for the country of the affiliate. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.7: Balance sheet linkages to parent and parent Commerzbank dependence

| | (1) LT loans to parent | (2) ST claims on parent | (3) Liabilities toward parent | (4) Equity from parent |
|---|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | 0.0867* | −0.1878** | 0.0788 | −0.0465 |
| | (0.0517) | (0.0880) | (0.0859) | (0.0340) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | 0.1015 | −0.1437 | 0.0050 | −0.0743* |
| | (0.0715) | (0.1075) | (0.1319) | (0.0433) |
| $R^2$ | 0.031 | 0.059 | 0.043 | 0.100 |
| Number of firms | 2,695 | 2,695 | 2,695 | 2,695 |
| Observations | 24,941 | 24,941 | 24,941 | 24,941 |
| Affiliate FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Size bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Country FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The respective outcome is given in the column title. The outcome in column 1 is ln(long-term loans to parent+1), in column 2 ln(short-term claims on parent+1), in column 3 ln(liabilities toward parent+1), and in column 4 ln(equity from parent+1). The independent variables are explained in Table 3.6. All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.8: Balance sheet linkages to non-parents and parent Commerzbank dependence

| | (1) LT assets excl. loans to parent | (2) ST assets excl. claims on parent | (3) Liabilities excl. toward parent | (4) Equity excl. from parent |
|---|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | 0.0898 | $-0.0487^{**}$ | 0.0008 | 0.0153 |
| | (0.0739) | (0.0204) | (0.0346) | (0.0388) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | 0.0504 | 0.0024 | 0.0289 | 0.0024 |
| | (0.0793) | (0.0309) | (0.0569) | (0.0488) |
| $R^2$ | 0.047 | 0.089 | 0.067 | 0.074 |
| Number of firms | 2,695 | 2,695 | 2,695 | 2,695 |
| Observations | 24,941 | 24,941 | 24,941 | 24,941 |
| Affiliate FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Size bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Country FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The respective outcome is given in the column title. The outcome in column 1 is ln(LT assets - LT loans to parent+1), in column 2 ln(ST assets - ST claims on parent+1), in column 3 ln(liabilities - liabilities toward parent+1), and in column 4 ln(equity - equity from parent+1). The independent variables are explained in Table 3.6. All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.9: Heterogeneity by affiliate linkages to parent

| | (1) | (2) | (3) |
|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | −0.0728 | −0.0467 | −0.0369 |
| | (0.0531) | (0.0512) | (0.0498) |
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10} \times \mathbb{1}(\text{long-term loans to parent} > 0)_{2006}$ | −0.6370** | | −0.5917** |
| | (0.2540) | | (0.2636) |
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10} \times \mathbb{1}(\text{short-term claims on parent} > 0)_{2006}$ | | −0.1544* | −0.1168 |
| | | (0.0907) | (0.0867) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | 0.0330 | 0.0311 | 0.0337 |
| | (0.0586) | (0.0583) | (0.0585) |
| $R^2$ | 0.093 | 0.092 | 0.093 |
| Number of firms | 2,695 | 2,695 | 2,695 |
| Observations | 24,941 | 24,941 | 24,941 |
| Size bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Country FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| $\mathbb{1}(\text{long-term loans to parent})_{2006} \times d_t^{08\text{-}10}$ | Yes | No | Yes |
| $\mathbb{1}(\text{short-term claims on parent})_{2006} \times d_t^{08\text{-}10}$ | No | Yes | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variable in all columns is ln(affiliate sales+1). Column 1 analyzes heterogeneity by whether the affiliate had positive long-term loans to its parent in 2006. Column 2 analyzes heterogeneity by whether the affiliate had positive short-term claims on its parent in 2006. The remaining independent variables are explained in Table 3.6. All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.10: Robustness tests for the effect on affiliate sales

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | $-0.1203^{*}$ | $-0.0842^{*}$ | $-0.1032^{**}$ | |
| | (0.0675) | (0.0489) | (0.0523) | |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | $-0.0106$ | 0.0417 | 0.0163 | |
| | (0.0850) | (0.0512) | (0.0533) | |
| $\mathbb{1}(\text{CB dep}_p^{parent} > 0) \times d_t^{08\text{-}10}$ | | | | $-0.1166^{**}$ |
| | | | | (0.0642) |
| $\mathbb{1}(\text{CB dep}_p^{parent} > 0) \times d_t^{11\text{-}15}$ | | | | 0.0438 |
| | | | | (0.0823) |
| $R^2$ | 0.168 | 0.094 | 0.093 | 0.091 |
| Number of firms | 1,020 | 2,695 | 2,695 | 2,695 |
| Observations | 9,371 | 24,941 | 24,941 | 24,941 |
| Affiliate FE | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes |
| Size bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Country FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes | Yes |
| Parent number of banks FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | Yes | No | No |
| Parent industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | No | Yes | No |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variable in all columns is ln(affiliate sales+1). Column 1 restricts the sample to affiliate locations in which Commerzbank did not have a branch. Columns 2 and 3 add fixed effects for the number of the parent's relationship banks and parent industry, respectively. Column 4 uses an indicator for whether the parent had any relationship to Commerzbank as treatment variable. The remaining independent variables are explained in Table 3.6. The reported coefficients in columns 1 to 3 are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. To ease comparison of the magnitudes, the coefficients in column 4 are scaled by the fraction of parents with a relationship to Commerzbank, which was 0.65. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

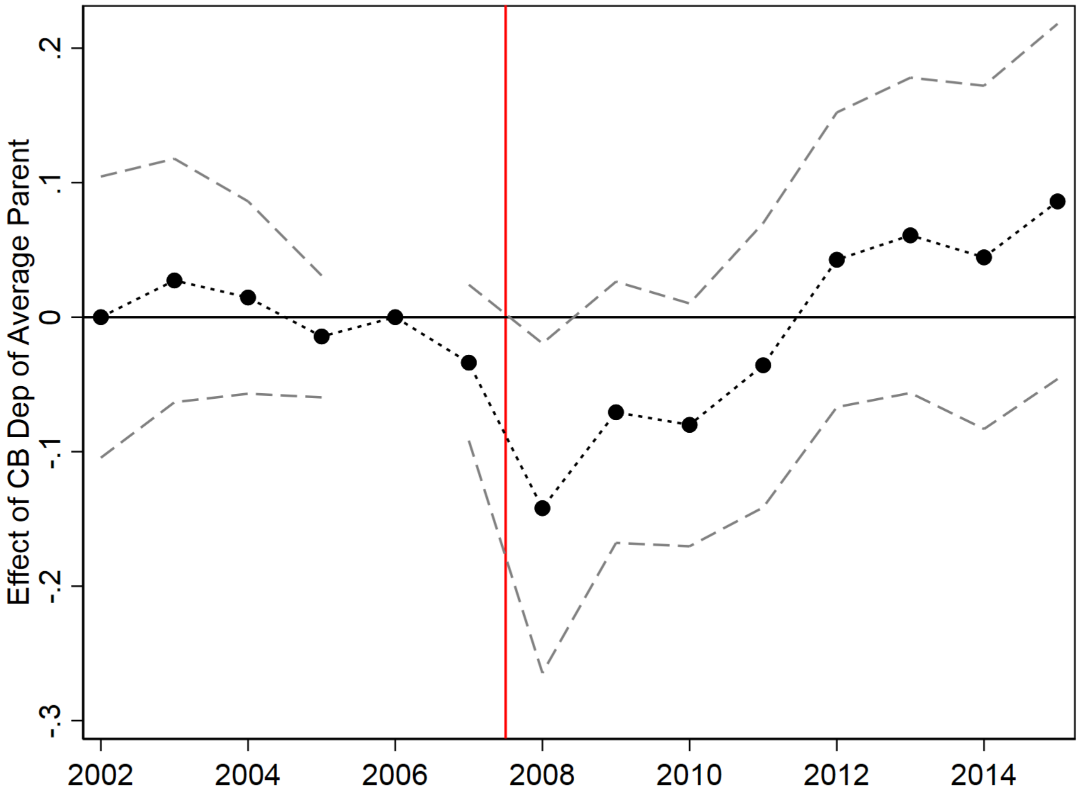
Table 3.11: Total decrease in sales

| Affiliate country | |
|---|---|
| Czech Republic | 0.31 |
| Austria | 0.28 |
| Poland | 0.23 |
| Netherlands | 0.08 |
| Spain | 0.06 |
| United Kingdom | 0.06 |
| France | 0.05 |
| Italy | 0.03 |
| United States | 0.02 |
| Mean | 0.12 |
| Median | 0.06 |

Notes: The table reports the estimated percent decrease in aggregate sales by non-financial firms in the listed country due to the transmission of Commerzbank's lending cut through the networks of multinational corporations. The mean and median are for the listed countries. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. Aggregate sales data for the European Union are from Eurostat and for the US from the Census Bureau.

## 3.6 Appendix

Figure 3.A.1: Impact of parent Commerzbank dependence on affiliate sales




Notes: This figure plots estimates of $\beta_\tau$ as in Figure 3.7 but controls for country fixed effects instead of affiliate location effects for Asia, the EU, and the US. All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. The following time-invariant control variables are calculated for affiliates in the year 2006 and interacted with a full set of year dummies: industry fixed effects (NACE 1.1. one-digit classification), fixed effects for size deciles using the distribution of sales, fixed effects for deciles of leverage, and fixed effects for the country of the affiliate. The dashed line displays 90% confidence intervals. The outcome variable is ln(affiliate sales+1). The panel is unbalanced. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations.

Table 3.A.1: Survey among German firms on bank loan supply

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| YEAR | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
| Firm CB dep | -0.111 | -0.095 | -0.473** | -0.316* | 0.059 | 0.379** |
| | (0.157) | (0.140) | (0.190) | (0.182) | (0.197) | (0.184) |
| Dep var from 2006 | 0.631*** | 0.522*** | 0.380*** | 0.365*** | 0.335*** | 0.206*** |
| | (0.041) | (0.047) | (0.051) | (0.055) | (0.055) | (0.050) |
| Observations | 856 | 988 | 1,032 | 946 | 898 | 503 |
| $R^2$ | 0.460 | 0.371 | 0.204 | 0.213 | 0.207 | 0.199 |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |
| State FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Size bin FE | Yes | Yes | Yes | Yes | Yes | Yes |
| ln age | Yes | Yes | Yes | Yes | Yes | Yes |

Notes: This table reports estimates from cross-sectional regressions for different years at the firm-level. The outcome variable is the answer to the question: "How do you evaluate the current willingness of banks to grant loans to businesses: cooperative (coded as 1), normal (0), or restrictive (-1)?" It is standardized to have zero mean and unit variance. The coefficients are interpreted as the standard deviation increase in banks' willingness to grant loans from increasing Commerzbank dependence by one. The control variables include fixed effects for 36 industries, 16 federal states, 4 size bins (1-49, 50-249, 250-999, and over 1,000 employees in the year 2006), and the ln of firm age. Standard errors are clustered at the level of the county. Data source: Ifo Institute and own calculations. The table is taken from Huber (2018). * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 3.A.2: Robustness to using the inverse hyperbolic sine as outcome

| | (1) | (2) |
|---|---|---|
| | IHS(bank $\text{debt}_{pct}$) | IHS($\text{sales}_{apct}$) |
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}15}$ | $-0.3702^*$ | |
| | (0.2081) | |
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | | $-0.1035^*$ |
| | | (0.0595) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | | 0.0293 |
| | | (0.0618) |
| $R^2$ | 0.041 | 0.089 |
| Number of firms | 407 | 2,695 |
| Observations | 4,495 | 24,941 |
| Parent FE | Yes | No |
| Affiliate FE | No | Yes |
| Year FE | Yes | Yes |
| Size bin FE $\times d_t^{08\text{-}15}$ | Yes | No |
| Size bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | Yes |
| Industry FE $\times d_t^{08\text{-}15}$ | Yes | No |
| Industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | Yes |
| Affiliate location FE $\times$ $d_t^{08\text{-}15}$ | Yes | No |
| Country FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}15}$ | Yes | No |
| Leverage bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variables are the inverse hyperbolic sines, defined as IHS(y) $= \ln(y + (y^2+1)^{\frac{1}{2}})$. The outcome in column 1 is IHS(parent bank debt). The outcome in column 2 is IHS(affiliate sales). The independent variables are explained in Table 3.4 (column 1) and Table 3.6 (column 2). All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi and Ustan 2002-2015, own calculations. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table 3.A.3: Affiliate employment and parent Commerzbank dependence

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | −0.0313 | −0.0286 | −0.0355 | −0.0449 | −0.0447 |
| | (0.0340) | (0.0331) | (0.0318) | (0.0329) | (0.0328) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | 0.0064 | 0.0132 | 0.0186 | 0.0116 | 0.0109 |
| | (0.0369) | (0.0357) | (0.0354) | (0.0348) | (0.0350) |
| $R^2$ | 0.010 | 0.022 | 0.036 | 0.073 | 0.078 |
| Number of firms | 2,695 | 2,695 | 2,695 | 2,695 | 2,695 |
| Observations | 24,941 | 24,941 | 24,941 | 24,941 | 24,941 |
| Affiliate FE | Yes | Yes | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes | Yes | Yes |
| Size bin FE × $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | Yes | Yes | Yes | Yes |
| Industry FE × $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | No | Yes | Yes | Yes |
| Country FE × $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | No | No | Yes | Yes |
| Leverage bin FE × $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | No | No | No | No | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variable in all columns is ln(affiliate employment+1). CB $\text{dep}_p^{parent}$ measures the fraction of the parent's bank relationships that are with Commerzbank branches. All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. $d_t^{08\text{-}10}$ and $d_t^{11\text{-}15}$ are dummies for the years from 2008 to 2010 and from 2011 to 2015, respectively. The independent variables are explained in Table 3.6. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.A.4: Heterogeneity by affiliate region

| | (1) | (2) | (3) |
|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | $-0.1054^{**}$ | $-0.0913$ | $-0.0748$ |
| | (0.0507) | (0.0600) | (0.0635) |
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10} \times \mathbb{1}$(Affiliate in Asia) | 0.0525 | | |
| | (0.1135) | | |
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10} \times \mathbb{1}$(Affiliate in EU) | | $-0.0393$ | |
| | | (0.0602) | |
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10} \times \mathbb{1}$(Affiliate in US) | | | $-0.0550$ |
| | | | (0.1020) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | 0.0302 | 0.0300 | 0.0301 |
| | (0.0584) | (0.0584) | (0.0583) |
| $R^2$ | 0.092 | 0.092 | 0.092 |
| Number of firms | 2,695 | 2,695 | 2,695 |
| Observations | 24,941 | 24,941 | 24,941 |
| Size bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Country FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variable in all columns is ln(affiliate sales+1). The table analyzes heterogeneity by whether the affiliate was located in Asia, the European Union, or the United States. The remaining independent variables are explained in Table 3.6. All coefficients are scaled to reflect the effect on an affiliate whose parent had average CB dep, which was 0.23. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3.A.5: Affiliate sales and parent dependence on other German banks

| | (1) | (2) | (3) |
|---|---|---|---|
| CB $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | $-0.0983^{*}$ | $-0.0746$ | $-0.1034^{*}$ |
| | (0.0552) | (0.0577) | (0.0551) |
| Landesbank in crisis $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | $-0.0217$ | | |
| | (0.0498) | | |
| Affected savings bank $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | | $0.0820^{**}$ | |
| | | (0.0362) | |
| Other banks with trading losses $\text{dep}_p^{parent} \times d_t^{08\text{-}10}$ | | | $-0.0398$ |
| | | | (0.0430) |
| CB $\text{dep}_p^{parent} \times d_t^{11\text{-}15}$ | 0.0298 | 0.0289 | 0.0295 |
| | (0.0584) | (0.0583) | (0.0584) |
| $R^2$ | 0.092 | 0.092 | 0.092 |
| Number of firms | 2,695 | 2,695 | 2,695 |
| Observations | 24,941 | 24,941 | 24,941 |
| Affiliate FE | Yes | Yes | Yes |
| Year FE | Yes | Yes | Yes |
| Size bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Industry FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Country FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |
| Leverage bin FE $\times$ $d_t^{08\text{-}10}$, $d_t^{11\text{-}15}$ | Yes | Yes | Yes |

Notes: The table reports estimates from OLS panel regressions. The panel is unbalanced. The outcome variable in all columns is ln(affiliate sales+1). The table tests whether parent dependence on other banks had an effect on affiliates, as explained in the main paper. Landesbank in crisis $\text{dep}_p^{parent}$ measures parent dependence on BayernLB, HSH Nordbank, Landesbank Baden-Württemberg, Landesbank Sachsen, and WestLB. Affected savings bank $\text{dep}_p^{parent}$ measures parent dependence on affected savings banks that owned the affected Landesbanken. Other banks with trading losses $\text{dep}_p^{parent}$ measures parent dependence on other German banks with trading losses during the financial crisis 2008/09, as listed in Table 1 of Dwenger, Fossen, and Simmler (2015) and in Hüfner (2010), excluding the affected Landesbanken. The remaining independent variables are explained in Table 3.6. All coefficients are scaled by 0.23, which is the average dependence on Commerzbank of parents. $R^2$ is the within-firm $R^2$. Standard errors are clustered at the parent level. The data are for the years 2002 to 2015. Data source: RDSC of the Deutsche Bundesbank, MiDi 2002-2015, own calculations. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

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