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CENTRO STUDI LUCA D'AGLIANO  
DEVELOPMENT STUDIES WORKING PAPERS

N. 329

March 2012

**Crossing Industrial Borders:  
German Manufactures as Services Exporters**

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# Crossing Industrial Borders: German Manufacturers as Services Exporters\*

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March 2012

## Abstract

Manufacturing firms increasingly engage in service trade activities. Micro-level data show that German manufacturers account for roughly 25% of German cross-border producer service exports. I have found that particular construction, engineering, and R&D services are exported. The machinery industries and automobile and chemicals producers dominate the overall pattern. The types of services exported vary strongly across industries. Furthermore, export activities are concentrated on a few large exporters. Service exports of advertising, data processing, and R&D services are found to likely support foreign affiliates of firms. However, these headquarter services are only infrequently observable. Much more important are construction and engineering services exported by machinery firms. These might represent installation and maintenance services exported to complement the supply of machinery. Beyond the support of foreign affiliates of firms, R&D services exports might be also important to transfer knowledge between unaffiliated firms at different stages of the value chain.

Keywords: services exports, manufacturing sector, goods trade, multinational firms

JEL classification: D22, F14, F23, L80

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\*I thank Horst Raff and Holger Görg and the participants of several workshops and seminars for their helpful comments. I am also grateful to Kim Adenau and Simon Lohner for the preparation of the service trade data and to the Bundesbank for granting access to the data and for the valuable support in handling it. Finally, I thank Eike Berner for advice in handling the Eurostat data. My research benefited from the financial support of the “Deutsche Forschungsgemeinschaft” (DFG) and the “Globalization, Investment, and Services Trade” (GIST) Marie Curie Initial Training Network funded by the EU’s Seventh Framework Programme. I am solely responsible for any errors.

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# 1 Introduction

Services trade has become an increasingly important issue in economic literature. On the one hand, this is due to its increasing economic importance. In 2007, the share of services in GDP in the OECD had grown to roughly 75%. Furthermore, cross-border trade of services accounted for about 20% of total trade and amounted to \$ 3.3 trillion in 2007 (Francois and Hoekman, 2010). This development makes service trade liberalization a potential source of economic welfare gains. Hence, there are several efforts to organize trade liberalization, for instance, in the negotiations on the “General Agreement on Trade in Services” (GATS) (WTO, 2011) or the EU-Service-Directive (EU, 2006). This process should be guided by profounded academic advice that can be provided only with a deeper understanding of the services trade. On the other hand, empirical research is facilitated through the increasing quality of empirical data in recent years. The time span of available data, the level of disaggregation, and the completeness of the information is increasing and allows a deeper understanding of existing services trade relationships. This may allow for the development of more sophisticated services trade models in the future.

For future empirical research, in particular, the linkages between the manufacturing and services sectors in economies and the consequences for international trade will be an important issue. For instance, Daniels (2000) emphasizes that there are very dynamic links and synergies between service and manufacturing activities in an economy, which are, however, hardly analyzed and understood in the context of international trade. Regarding the manufacturing sector, Preissl (2007) points out that services play an increasing role for manufacturers as inputs in the production and organisation processes, but are important also as outputs. Escaith (2008) supports this notion and states that the share of services in total trade would increase from 20% to nearly 50% if trade was measured in terms of direct and indirect value added. Gage and Leshner (2005) even summarize that it becomes more and more difficult to categorize firms either as manufacturers or service firms, because services became so important in the entire value-added chain.

The existing international trade literature dealing with the interrelationship of manufacturing and services mainly focuses on services as inputs, which can be both imported and sourced domestically. In particular, the access to high quality business services are found to be important for competitiveness of both manufacturers and services firms (e.g., Francois and Wörz, 2008; Nordas, 2010; Wolfmayr, 2008). Furthermore, Debaere et al. (2010) find that the availability of local services to Irish firms may facilitate their access to international material input markets. Following this reasoning, manufacturers should mainly appear as services importers in trade data. However, Kelle and Kleinert (2010) find that manufacturers are also often services exporters. They show in their firm level analysis using services trade micro data of the Deutsche Bundesbank that producer services export activities in

Germany are often carried out by manufacturing firms. These accounted for about 25% of cross-border export volumes in their sample for 2005. I have found in a comparable set of producer services that the share of manufacturing firms in total cross-border exports was especially high for R&D services (80%), engineering (75%), and construction services (70%).<sup>1</sup> Total services exports of manufacturers amounted to nearly 30 billion Euros in 2005.<sup>2</sup> Altogether, the service exports from manufacturing firms increased by roughly 75% between 2001 and 2005 in Germany, while cross-border imports increased by only 6% and goods exports by about 25% during this period. Obviously, service exports became increasingly important for the manufacturing sector.<sup>3</sup>

Nevertheless, both the theoretical and empirical literature dealing with service exports of manufacturers is relatively sparse. One explanation to observe manufacturers that sell both goods and services, highlighted by Horn and Shy (1996), is the bundling of goods and services. They point out that firms might bundle goods with complementary services to enhance the perceived value of the products firms are selling or to differentiate their products from competitors. This idea is, for instance, supported by an analysis of Stille (2003), who examines service activities of the German machinery and electrics industries. He reports that it has become quite common in these industries that firms provide several complementary services to their products like installation, maintenance of products, or the provision of electronic systems to use them. Those complementary services accounted for about 20% of the sales in these two industries in 2000. Additionally, a further increase of this share was expected to occur, because complementary services were perceived as a growing source of competitive advantage of firms. Thus, the ability to provide high-quality complementary services to exported goods could be an important source of international competitiveness of manufacturers.

A second motive for manufacturers to provide services in foreign countries might be the support of foreign affiliates. Those services are often denoted as headquarter services in the literature. They play an important role in the well-known knowledge-capital model, for instance, in Markusen (2002). In this model, multinational enterprises (MNEs) decide where to locate headquarter and production units. Knowledge-capital serves as a public good internal to the firm and is transferred to foreign affiliates. Examples of this knowledge-capital are patents or trademarks sustained by R&D. Furthermore, firms may transfer organizational capabilities to

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<sup>1</sup>The group of engineering services includes engineering, architectural, maintenance, and technical support services. Construction services account also for installation and assembly services, which are likely particularly important for manufacturing firms. Table 9 in the Appendix provides a complete list of all services regarded.

<sup>2</sup>The total volume of service exports by German firms from all sectors amounted to roughly 100 billion Euros in 2005.

<sup>3</sup>The strong increase of exports was particularly driven by engineering services, which were showing a volume more than three times larger in 2005 than in 2001.

their affiliates to coordinate and plan activities in different markets or support production and distribution. These activities may show up as trade in management or advertising services or, more generally, as business services (e.g., Davies, 2005; Godart et al., 2009).

Beyond these two motives, many further ways in which service export activities of manufacturers can be explained might be considered. For instance, firms could also be diversified suppliers of both goods and services. In this case the goods and services supply of firms are likely independent from each other.<sup>4</sup> Despite the large variety of possible motives for manufacturers to export services, these have thus far only been scarcely analyzed with firm level trade data in the international trade literature.<sup>5</sup> However, it might be useful to obtain a deeper understanding of these activities of firms for at least three reasons. First, understanding the links between service and manufacturing activities of firms might be important to obtain a deeper knowledge about the ways firms operate in modern international markets. Second, in a next step be, this might used to identify relevant service trade barriers that affect firms and the costs and benefits to reduce them. The more important service activities are for manufacturers, the more promising are the efforts to facilitate international trade with services. Third, analyzing service exports of manufacturers might also contribute to a deeper understanding of the determinants of the international competitiveness of firms. The more products are bundled with complementary services, the more important is the ability to provide these services to foreign customers to be competitive in international markets (Horn and Shy, 1996).

The goal of the present paper is to show first insights into the cross-border service export activities of German manufacturers and, in particular, to raise questions and important issues for future research. To conduct the analysis, I use a firm level service trade dataset for German firms from the *Deutsche Bundesbank* for 2005, which contains service trade transactions from the Balance of Payments Statistics (BoPS). I combine this data with information about foreign manufacturing and distribution affiliates of firms from the Micro Database Direct Investment (MiDI) and industry level goods trade data from Eurostat (2009).<sup>6</sup> The analysis is carried out in two steps. First, I describe the data and show the types of services exported by manufacturers, the industries involved, which services are important in the respective industries, and how firm heterogeneity affects the pattern of service exports. Second, I analyze the possible motives that might be driving the services export activities

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<sup>4</sup>Bernard et al. (2009) and Mayer et al. (2011) develop theoretical frameworks that can explain the operation of multi-product or multi-service firms in international markets.

<sup>5</sup>Lennon (2009) finds with sector level trade data that there is a complementary relationship between goods and services trade flows between countries.

<sup>6</sup>I exclude foreign affiliate sales of services from the analysis, which represent Mode 3 exports in the GATS and were generally available in the MiDI dataset, and focus on cross-border exports (WTO, 2011). On the one side, this is to facilitate the analysis, while on the other side, it is because affiliate sales of manufacturers appear to be very scarce for the regarded services. See Section 2 for more details about the data.

of firms. To do this, I first show how and to what extent the observable pattern is related to foreign affiliates of firms. Then I apply a regression analysis and analyze both the service export participation decision of firms and the intensive margin of service sales. This aims at identifying the relationship of service export activities with foreign affiliates sales of firms in the destination countries and goods trade of industries. Analyzing these relationships will be helpful to uncover potential driving forces of services exports and to obtain a basic idea of whether services are rather exported as headquarter, complementary services or other reasons.

Generally, I find that data processing, advertising, and R&D services represent likely headquarter services. However, headquarter services play a rather minor role in explaining service export activities of firms. Most service exports are conducted independent of foreign affiliates of firms. Instead, I have found some evidence that machinery firms might export complementary installation and maintenance services to exported products. Furthermore, R&D services exports presumably often have the function to support the international knowledge flow between firms. However, the presented evidence about the role of complementary and R&D services is only weak due to data limitations. Further research is necessary to obtain more precise results.

The rest of the paper is organized as follows: Section 2 presents some details about the dataset used and its construction. Section 3 provides descriptive statistics about the types of services exported, the different manufacturing industries conducting them, and characteristics of exporting firms, and discusses possible motives to export services. Section 4 analyzes important determinants of service exports of manufacturers in a regression analysis. Section 5 concludes and summarizes issues for future research.

## 2 Construction of the Dataset

The dataset is constructed by merging two firm-level datasets of the Deutsche Bundesbank. These contain nearly the entire population of German service traders. The first dataset records service transactions between residents and non-residents, collected to compile the BoP-Statistics. For every service transaction between a German resident firm and a non-resident, with a value higher than 12,500 Euros, firms report to the Deutsche Bundesbank their sector classification, the partner country for the transaction, the classification of the transaction they conducted, and the value of the transaction (Deutsche Bundesbank, 2009). The annual data are available for the period from 2001 to 2010. These service transactions in the BoP-Statistics include the three GATS modes 1, 2, and 4, defined by the WTO (2011).<sup>7</sup> These three modes cannot be distinguished in the dataset, because only

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<sup>7</sup>Mode 1 contains cross-border trade transactions. Both the supplier and the consumer of the service stay in their home country and interact, for instance, through the Internet or the post and

the transactions, their value, and the type of service are collected in the data. Thus, I summarize all of these transactions in the category cross-border exports.

Every reporting firm in the BoP-Statistics has been given a firm identifier from the Bundesbank. The same identifier is used in the MIDI (Micro Database Direct Investment) dataset. The MIDI dataset provides a detailed breakdown of the foreign assets and liabilities of German multinational firms abroad and German affiliates of foreign multinational firms (Lipponer, 2009).<sup>8</sup> The database contains information on all foreign affiliates of German multinational firms. The comprehensive database includes the balance sheet data of foreign affiliates, including their sales, employment, and total assets in each of over 180 destinations. It also includes information on both the sector of activity of the parent firm and the affiliate at the NACE rev-1 two- or three-digit level, and covers activities between 1989 and 2009.

I use the MIDI dataset to account for the manufacturing and distribution affiliates of firms. The manufacturing affiliates are classified the same way as the German manufacturing parents, as presented in Table 2. Furthermore, I classify all affiliates with the Nace-code 500 (“sales, repair of motor vehicles”), 510 (“wholesale trade”) or 520 (“retail trade”) as distribution affiliates. Furthermore, the MIDI dataset provides information about service affiliate sales of firms. These are generally used to account for service exports through commercial presence, which is mode three in the GATS definition. Hence, combining the BoP-data and the MIDI gives a dataset with comprehensive information about service trade activities of German firms in all four GATS modes.

I aggregate the service transactions from the BoPS to eleven service categories, which mainly include producer services.<sup>9</sup> The first seven sectors are at the Nace rev-1 two-digit level: construction, transport, auxiliary transport, post & telecommunications, insurance, data processing, and R&D services. I split up the four business services into management services, engineering, advertising, and personnel services using the three-digit level classification. Table 9 in the Appendix gives an overview of the kind of services included in the different categories and how these match the classification of services in both datasets.

I only use data for 2005 throughout the entire paper and restrict the sample to manufacturing firms. There are 1,625 German manufacturers in the sample that sell services abroad either through cross-border or foreign affiliate sales in 2005. These firms account for 15,273 observations at the firm-service-country level for

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telecommunication infrastructure. Mode 2 includes service trade transactions when consumers move abroad and consume a service in the foreign country. Mode 4 transactions are cases in which a service supplier moves temporarily abroad as a natural person and provides a service to a foreign customer.

<sup>8</sup>German foreign direct investment is defined as direct or indirect ownership or control by a single German entity of at least ten percent of the voting rights or capital shares of an incorporated foreign firm or the equivalent interest in an unincorporated foreign firm.

<sup>9</sup>This facilitates the handling of the different service activities collected in the BoPS and comparing the analyzed services with other datasets like the MIDI dataset.

cross-border producer service exports and 91 for foreign service affiliate sales. Thus, foreign affiliate sales represent only 0.6% of the observations. Overall, cross-border exports of manufacturers amount to 28.0 billion Euros and foreign affiliate sales total 5.2 billion Euros.<sup>10</sup> In the following, I restrict the sample to cross-border sales and denote them as services exports. On the one side, this facilitates the analysis.<sup>11</sup> On the other side, foreign service affiliates are economically less important for German manufacturers in the underlying sample. Dropping the firms with only service affiliate sales reduces the number of firms to 1,612. These account for 15,273 cross-border export observations.

### 3 Descriptive Statistics

The following section provides deeper insights into the service export activities of German manufacturers by collecting stylized facts. First, I show the types of services exported and their relative importance for the manufacturing sector. Second, I examine the industry affiliation of exporters and how export sales differ across industries. The third subsection combines these two perspectives and analyzes the importance of different services for different industries. In the fourth subsection, I describe different dimensions of firm level heterogeneity. Finally, I analyze the impact of foreign affiliates on the types of services exported and briefly discuss the results.

#### 3.1 Types of Services exported

To obtain a better understanding of the services trade activities of manufacturers, it is useful to look at the different types of services that firms are exporting. As already mentioned in the data description, the sample contains eleven types of producer services. Table 1 shows the relative importance of these different services for service exports of manufacturers. The first column presents the number of cross-border export observations for the different types of services. The second column shows the share of the observations in the total number of observations. Columns three and four provide the same information for export sales.

I find that construction services are exported most frequently, with a share of

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<sup>10</sup>The latter comprise mainly data processing (1.4 billion Euros), auxiliary transport (1.3 billion Euros), and R&D (1.0 billion Euros). Note that I have dropped nearly 1,000 firms that are classified as holding companies, but that could be assigned to a group of manufacturing firms. These firms show foreign service affiliates sales of 2.8 billion Euros but no cross-border exports of services.

<sup>11</sup>The motives of firms to set up a foreign affiliate might be different compared to cross-border service sales. For instance, the affiliate could provide services to the parent firm, which would display some kind of outsourcing activities of firms.

Table 1: Service Sector Variation in Services Exports of German Manufacturers 2005 (billions of Euros, number)

Service Type	Export Observ.	Share (%)	Export Sales	Share (%)
Construction	4,162	27.3	5.87	21.0
Transport	32	0.2	0.00	0.0
Auxiliary Transp.	723	4.7	2.44	8.7
Post & Telecom	49	0.3	0.01	0.0
Insurance	285	1.9	0.11	0.4
Data Processing	1,124	7.4	1.05	3.7
R & D	2,222	14.5	8.15	29.1
Management	1,898	12.4	2.62	9.4
Engineering	2,855	18.7	6.76	24.1
Advertising	1,111	7.3	0.57	2.0
Personnel	812	5.3	0.45	1.6
Total	15,273	100.0	28.0	100.0

Sources: BoP (2009), author's computation.

27.3% on total observations (column two).<sup>12</sup> The second most important service exported are engineering services (18.7%), followed by R&D (14.5%) and management services (12.4%). Considering export sales instead of the number of observations, I find R&D exports dominating, with a share of 29.0% on export sales (column four). The second most important services type is engineering services (24%), and the third most important category is construction services (21%). These three types of services account for nearly 75% of the 28.0 billion Euro service exports. Advertising and, in particular, management services are relatively more important when the number of observations is regarded, but they show only rather small values of sales.

Furthermore, I have found that transport, post & telecom and insurance services are hardly exported at all by manufacturers. Beyond economic reasons, one explanation for this result could be that the BoPS do not account for some services. Stille (2003) reports that in the case of sold machinery, only for about 50% of the sales were the product and the additionally provided complementary services billed separately in 2000. However, if services were not billed separately from the product price, these would not appear in the BoPS data. Thus, the data likely underestimate services exports of firms.

<sup>12</sup>Unfortunately, I cannot identify installation or assembly services explicitly, which likely often appear in the construction services group, due to the data aggregation.

Table 2: Number of German Manufacturers and Service Exporters and Sales by Industry in 2005 (number, %)

Industry	Firms in Germany	Services Exporter	Share in Exporters (%)	Share in Exports (%)	Exp. Particip. Share Ind. (%)
Food	5,245	36	2.2	0.6	0.7
Publishing & Printing	2,515	88	5.5	1.7	3.5
Chemicals	1,397	161	10.0	14.1	11.5
Rubber & Plastic	2,687	61	3.8	1.4	2.3
Mineral Products	1,778	31	1.9	0.3	1.7
Basic Metals	904	38	2.4	0.2	4.2
Metal Products	6,258	103	6.4	1.1	1.6
Machinery & Equip.	6,014	574	35.6	15.2	9.5
Elect. Machinery	1,954	106	6.5	19.6	5.4
TV & Comm. Equ.	559	56	3.4	4.6	10.0
Scient. Instruments	2,112	145	9.0	4.2	6.9
Automobile	1,007	74	4.6	18.9	7.3
Oth. Transp. Equ.	313	54	3.3	12.7	17.3
Furniture	1,555	25	1.6	0.3	1.6
Total	38,134	1,612	100.0	100.0	4.2

Sources: BoP (2009), Stat. Yearbook (2007), author's calculations.

### 3.2 Industries exporting

The present subsection investigates the industry affiliation of service exporters and their contribution to service exports. To assign firms to the different industries, I use the sector classification of the firms in the dataset on the Nace-rev 1 two-digit level. Table 2 shows the number of German firms in the different industries (column one) with more than 20 employees in 2005. The data are from the Statistical Yearbook (2007). Column two presents the number of firms exporting services from at least one of the eleven services categories in the sample. Columns three and four contain each industry's share of the total number of service exporters and the volume of cross-border service exports. The ratio of service exporters to the total number of firms in the industry (service export participation ratio) is displayed in column five.

Table 2 shows the industries with at least 20 service exporting firms. Most of the 1,612 service exporting firms come from the machinery and equipment industry, with a share of 35% (column three), followed by the chemical industry, with 10% of firms and the scientific instruments producers (9.0%). With respect to the volume of exports (column four), the electrical machinery producers dominate with

a share of 19.7%, followed by the automobile industry (18.9%), the machinery and equipment (15.2%), the chemicals industry (14.1%), and the “other transport equipment” industry (12.7%). These five industries account for about 80% of the services exports.

The Statistical Yearbook (2007) shows that these five industries also dominate goods exports of the German manufacturing sector. They account for about 70% of the foreign sales of goods produced in Germany by the manufacturing sector.<sup>13</sup> This points to a positive relationship between the international goods and service export activities of industries. Furthermore, these five industries can be classified as high-tech industries (e.g., Hatzichronoglou, 1997), which implies that service exports might be more important for knowledge-intensive industries.

Altogether, only a few German manufacturers sell services abroad. The average service exporter participation ratio is 4.2% (column five).<sup>14</sup> Wagner (2007) states for a comparable sample of German manufacturers with more than 20 employees that roughly 60% of the firms exported goods in 2004. This ratio is much larger than the service export participation. Obviously, even many goods exporting firms do not export any services at all. However, the underlying BoP-Statistics likely underreported the true volume of service exports and exporters as already stated above.

### 3.3 Types of Services exported by Industry

So far, I have highlighted the dominance of R&D, engineering and construction services in exports, and I found that a few high-tech industries account for the majority of service export activities of manufacturers. The following subsection analyzes whether there is heterogeneity across different industries concerning the kind of services exported.

Table 3 shows the three most important services exported by a given manufacturing industry. I display results for the total sample of manufacturers and for the five most important industries that I highlighted above. The second column shows the type of service with the largest share on total service exports of the firms in the respective industries, which are given in column eight. The third column shows its share in exports of this industry. Columns four to seven give the same information for the second and third most important services.

Generally, table 3 shows that the types of services exported are obviously strongly shaped by the individual activities of the respective industries. In the machinery and

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<sup>13</sup>Following the definition in the Statistical Yearbook (2007), these goods are sold directly to a foreign country or to German intermediary firms that sell them abroad.

<sup>14</sup>This value is upward biased, because the Statistical Yearbook (2007) accounts only for firms with more than 20 employees. A less restrictive measurement in the Statistical Yearbook (2008) counts 296,811 firms in the manufacturing sector in 2005. Using this value reduces the service export participation ratio to 0.5%.

Table 3: Most important Types of Service Exports in Different Industries in 2005, (billions of Euros, %)

Industry	Most imp.	Share (%)	Second imp.	Share (%)	Third imp.	Share (%)	Total Exp. of Industry
Manufacturing	R&D	29.1	Eng.	24.1	Constr.	21.0	28.0
Chemicals	Eng.	47.1	R&D	35.4	Manag.	12.2	3.95
Machinery & Equipment	Constr.	62.1	Eng.	23.3	R&D	6.6	4.26
Electr. Mach.	Constr.	50.0	Eng.	20.2	Data	10.7	5.50
Motor Vehicles	R&D	79.8	Manag.	7.0	Eng.	6.8	5.31
Other Transp.	Aux. Trans.	63.5	Eng.	26.3	R&D	5.0	3.56

Sources: BoP (2009), author's calculations.

equipment industry (line three), you see mainly construction service exports, with a share of 62% of total service exports (columns two and three). Together with engineering services (columns four and five), these account for roughly 85% of the export sales. In the electric machinery sector (line four), next the dominating construction and engineering services, I have found relatively large data processing exports. The share of 10.7% in cross-border exports is still small, but much larger than for the entire sample of firms (3.7%). These findings confirm the observations of Stille (2003). He states that installation, maintenance, and other technical support services are important services provided by the machinery and electric industries. These are likely represented in the BoPS data by construction and engineering services, but they are not clearly identifiable because of the data aggregation.<sup>15</sup> Furthermore, he finds that providing the software needed to use the exported machines or training the staff that uses the software is particularly important in the electric machinery sector. This is in line with finding the data processing service exports by this industry.

The automobile industry's service export activities (line five) are dominated by R&D services, with a share of around 80%. The transfer of technological knowledge concerning production procedures or the design of motor vehicles seem to be important for the international activities of this industry. The "other transport equipment" industry (line six) provides mostly auxiliary transport services. Further disaggregating the data shows that the repairing of transport vehicles, which reside in Germany to be repaired, can primarily be found here.<sup>16</sup> Logistic services and other supporting activities are less important. In all industries, engineering services play an important role, in particular in the chemical industry (line two). Obvi-

<sup>15</sup>This statistical caveat is taken into account in the NACE rev. 2, which explicitly reports installation and maintenance of machinery. However, this information is not available in the used datasets.

<sup>16</sup>These activities are collected within the KNZ 560 in the BoPS (Deutsche Bundesbank, 2009).

ously, transferring technological knowledge and know-how to foreign customers by providing engineering and technical consultancy services is a widespread activity of German manufacturers.

Altogether, the findings of different types of services exported by industries suggests that the service trade barriers for firms might differ across industries. One source for these differences are the different modes of supply that used to provide the respective services. Construction and engineering services might mainly rely on mode four transactions because workers and engineers need to travel abroad to install or maintain exported machines, for instance. R&D services, however, could be often provided through mode one, because the results of research can be more easily transferred through the post & telecom infrastructure. Auxiliary transport services mainly represent mode two transactions, when foreign transport firms use domestically provided repairing services.<sup>17</sup> Thus, different industries might be affected completely differently by service trade liberalization agreements in the GATS, because these distinguish the different modes of service supply (e.g., Francois and Hoekman, 2010).

## 3.4 Firm level Heterogeneity

### 3.4.1 Large and Small Firms

So far, I have shown that industry characteristics strongly influence the pattern of service exports by manufacturers. However, the international trade literature states that beyond industrial characteristics, firm or within-industry heterogeneity is more important to explain the trade pattern (e.g., Eaton et al., 2004). One important result is that trade is strongly dominated by few large trading firms. This evidence can be found also for services trade (e.g., Breinlich and Criscuolo, 2011; Kelle and Kleinert, 2010). Table 4 gives information about the heterogeneity of German manufacturing service exporters related to the size of their export activities. I add up total service exports at the level of the firm and rank the firms in the ten deciles depending on the volume of their sales.

The first important result is that there is very pronounced concentration of export activities. The firms in the 10th decile, which are the 10% largest firms, account for 91% of total service exports (columns one and two).<sup>18</sup> Second, columns three and four show that the concentration is driven by both extensive margins. The number of countries a firm is serving is on average 6.8 (column three) and the number of service types a firm is exporting is 1.9 (column four). Both margins

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<sup>17</sup>See also the WTO Web page for discussions about the role of different modes for different types of services (WTO, 2011).

<sup>18</sup>The large concentration can also be found when single industries are considered. The share of sales of firms in the 10th decile ranges from 77% in the machinery & equipment industry to 97% for the automobiles and electric machinery producers.

Table 4: Deciles of Service Export Sales 2005 (million Euro, number)

Decile	Exports (mill. Euro)	Share (%)	Average Number of		No. of	No. of Manuf.
			Countr. Served	Serv. Types	MNEs	Affil. per Firm
1	3.34	0.0	1.20	1.08	19	0.26
2	8.89	0.0	1.56	1.14	15	0.29
3	19.3	0.1	2.40	1.26	18	0.34
4	36.9	0.1	2.73	1.45	23	0.40
5	69.4	0.2	4.39	1.79	35	1.19
6	136.3	0.5	5.75	1.88	39	0.68
7	252.9	0.9	7.88	1.88	38	0.73
8	521.0	1.9	10.2	2.31	42	0.61
9	1,448.2	5.5	11.1	2.68	56	0.67
10	25,500.0	91.1	21.0	3.65	54	4.61
Total	28,000.0	100.0	6.81	1.91	339	1.08

Sources: MIDI (2007), BoP (2009), author's computations.

strongly increase from the 1st to the 10th decile.<sup>19</sup> Obviously, manufacturing firms that export services are strongly internationalized. This suggests that these belong also to the dominating goods exporters in their industries. Unfortunately, I am not able to analyze this because there is thus far no possibility to combine the underlying service trade data with goods trade data at the firm level.

Table 4 shows that 339 of the exporting firms had at least one manufacturing affiliate in 2005 (column five). Thus, roughly 20%, 339 out of 1,612, of the service exporters are manufacturing MNEs. Regarding the distribution of MNEs over the different deciles reveals that the MNEs are relatively equally distributed in the ten deciles. Obviously, not only MNEs dominate service exports. This may indicate that also the so called small- and medium-sized enterprises (SMEs), which are found to play an important role for the strong performance of Germany in goods exports, are among the largest service exporters.<sup>20</sup> Nevertheless, column six reveals that the larger service exporters have on average much more manufacturing affiliates than the smaller ones.

<sup>19</sup>The intensive margin is contributing even more to the concentration and is on average nearly 350 times larger for firms in the 10th compared to the 1st decile.

<sup>20</sup>For instance, Barba Navaretti et al. (2010) find that the concentration of goods exports on few large firms is less pronounced in Germany compared to other important EU countries, which points to a more important role of SMEs.

Table 5: Foreign Affiliate Activities of Service Exporting and Non-Exporting MNEs, 2005 (number)

Manufact. MNEs	No. of Manuf. Affil. per Firm	No. of Manuf. Affil. per Cou.	No. of Distrib. Affil. per Firm	No. of Firms
Service Exporter	5.12	1.39	3.15	339
Non-Exporter	1.95	1.13	1.01	838

Sources: MIDI (2007), BoP (2009), author's calculations.

### 3.4.2 Service Exporting and Non-Exporting MNEs

The previous section highlighted that only a few service exporters are also manufacturing MNEs. This raises the question how many of the German MNEs export services at all. I have found in the MIDI dataset that 1,177 manufacturers had at least one foreign manufacturing affiliate in 2005. However, only 30% of them, 339 out of 1,117, are exporters of services as well.<sup>21</sup> Thus, many manufacturing MNEs do not export any services at all. This fact appears to contradict the theory of multinational firms, which states that international knowledge and capability transfer between the headquarter and the production units of a firm are an essential part of the international business of MNEs. However, this result should be interpreted with caution, because headquarter services might not appear in the data. For instance, it could be that affiliates do not pay the headquarter for providing headquarter services and, consequently, these services do not appear in the data.

Beyond these limitations of the data to capture the real economic relations, I have found that service exporting MNEs show larger foreign activities through affiliates than non-exporters. Table 5 gives insights into the size of different foreign activities of MNEs that export services (line one) and firms that do not (line two). It shows that, on average, the service exporters have nearly three times more manufacturing affiliates than non-exporters (column one), which is mainly driven by having affiliates in more countries (column two). Furthermore, these firms also show three times more distribution affiliates (column three). Obviously, large MNEs with affiliates in many countries are more likely also services exporters than smaller MNEs.

<sup>21</sup>Note that there are about 800 holding firms that have manufacturing affiliates abroad, but that have no cross-border service exports. Accounting for them would increase the share of MNEs that does not export services.

## 3.5 What are Motives to export Services?

### 3.5.1 The Impact of Manufacturing and Distribution Affiliates in the Destination

In the following section, I analyze how the types of services exported are affected by foreign affiliates of firms. This may help to identify which role headquarter services play in explaining services exports and which services might represent them. I account for manufacturing and distribution affiliates of firms because both are economically relevant.

In general, the number of observations in which a firm exports a service to a country with a foreign affiliate is rather small compared to the cases in which the firm has no affiliate. I have found that firms have a manufacturing affiliate in the destination country for only about 12% of the 15,273 observations. Distribution affiliates of firms appear in only 9% of the observations.<sup>22</sup> Altogether, for nearly 85% of the observations, firms show neither a distribution nor a manufacturing affiliate abroad. Obviously, supporting a foreign affiliate is often not the motive for service exports of a firm. Nevertheless, the volume of service export sales is on average larger when firms have a foreign affiliate abroad. The roughly 15% of observations with an affiliate account for nearly 30% of the total service sales.

Although affiliates are scarce, they might be affecting firms' behavior. Table 6 gives some insights into the impact of foreign affiliates in a destination on the types of services exported. It is constructed in a similar manner as Table 3 and displays again the three most important services exported per industry, but it shows the share on the number of observations instead of the share on the sales. Furthermore, the observations are distinguished by whether or not a firm has an affiliate in the country to which it exports.<sup>23</sup> This allows us to check whether having an affiliate abroad induces specific types of service exports. I distinguish three scenarios: (i) whether a firm has a manufacturing affiliate, (ii) whether it has a distribution affiliate, or (iii) whether it has no affiliate in the destination. I neglect observations with both manufacturing and distribution affiliates because this approach allows me to account for different effects of different types of foreign affiliates.

To analyze the impact of foreign affiliates on the types of services exported, it is useful to compare the observations with no foreign affiliate with the observations with a foreign affiliate for the respective industries. Table 6 shows that in the chemistry industry, the three most frequently exported types of services when firms have no foreign affiliate are R&D, management, and personnel services (line three). Considering instead the observations with a manufacturing affiliate (line one) reveals that data processing services are exported relatively more frequently. When firms

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<sup>22</sup>These two groups of observations are partially overlapping. In 4% of the observations, firms have at least one manufacturing and one distribution affiliate.

<sup>23</sup>Here, I drop the other transport equipment industry because it has only a very small number of observations with a foreign affiliate in the destination country.

Table 6: Most Important Types of Services Exported when Firm has Affiliate in Country or Not in 2005 (number, %)

Industry	Affiliate in Coun.	Most imp.	Share (%)	Second imp.	Share (%)	Third imp.	Share (%)	No. of Obs.
Chemicals	Manuf.	R&D	35.9	Data	17.4	Pers.	12.1	281
	Distr.	R&D	41.7	Manag.	16.1	Adv.	13.7	168
	No	R&D	33.9	Manag.	29.1	Pers.	9.3	1,144
Machinery & Equipment	Manuf.	Constr.	37.3	R&D	15.7	Eng.	14.1	255
	Distr.	Constr.	53.0	Data	15.2	Eng.	11.6	198
	No	Constr.	58.9	Eng.	20.1	R&D	5.4	5,246
Electr. Machinery	Manuf.	Eng.	15.6	R&D	15.6	Data	15.6	199
	Distr.	Constr.	22.4	Data	18.8	Eng.	14.1	85
	No	Constr.	32.3	Eng.	23.2	Manag.	10.8	1,102
Motor Vehicles	Manuf.	R&D	42.3	Manag.	12.7	Eng.	12.0	142
	Distr.	Adv.	42.3	R&D	15.4	Manag.	15.4	104
	No	R&D	26.2	Adv.	20.0	Eng.	16.6	705

Sources: MIDI (2007), BoP (2009), author's calculations.

have distribution affiliates (line two), advertising services appear more often. This indicates that providing software to affiliates might be a relevant service provided by a headquarter to production facilities. Advertising services might instead aim at supporting the distribution of goods, which would be quite intuitive.

In the machinery and equipment industry, I find that firms most frequently export construction, engineering, and R&D services when they have no foreign affiliate in the destination (line six). The pattern for the observations with affiliates is quite similar. However, I find that data processing services are relatively more important when firms have a distribution affiliate abroad (line five) and R&D services for observations with a manufacturing affiliate (line four). Very similar results can be found for the electric machinery industry. Here, firms export R&D services almost more frequently when they have a manufacturing affiliate abroad (line seven). Furthermore, they export data processing services more frequently when they have a distribution or manufacturing affiliate (lines seven and eight). Without any affiliate (line nine), firms export construction, engineering, and management services most frequently. These results indicate that in particular R&D services are used to provide knowledge to foreign production facilities and software or data processing services to support both the distribution and production of products.

In the automobile industry, we find that firms most frequently export R&D ser-

vices, followed by advertising and engineering services when they show no foreign affiliates in the destination (line twelve). Compared to these observations, I have found that advertising services are exported relatively more often when firms have a distribution affiliate abroad (line eleven). R&D services are exported more frequently when firms have a manufacturing affiliate (line ten). This supports the notion that R&D services might be used to support foreign production of goods particularly while advertising services often support foreign distribution. However, advertising services also seem to be relevant when firms have no foreign distribution affiliate for automobile firms.

Altogether, foreign affiliates are relatively scarce and are potentially driving only a small volume of service exports of firms. Nevertheless, they positively affect both the volume of exports and the extensive margin for some types of services like data processing, R&D, and advertising services.

### 3.5.2 Discussion

The previous analysis provided a lot of descriptive information about service export activities of firms. In the present subsection, I summarize some of the evidence to formulate more specific and to determine motives and activities of firms might be driving the observable service exports of firms. This aims at supporting a deeper analysis of the determinants of service exports in the subsequent regression analysis.

First of all, the analysis so far has shown that services likely have very different functions in the international business of firms. The types of services exported vary strongly across different industries. Thus, accounting for the pronounced industry heterogeneity is an important issue to understand the activities of firms. Furthermore, some kinds of services represent headquarter services, while others seem to be independent of foreign affiliates. Hence, it is important to analyze different types of services separately, because these might represent economically different activities of firms.

The last section suggested that, in particular, data processing, R&D, and advertising services might represent, at least partially, headquarter types of services. R&D services obviously support foreign production of firms whereas advertising services aim at supporting the distribution of products. Data processing services seem to be relevant for both types of affiliates.

Beyond its role as a headquarter service, R&D services exports seem to represent further activities of firms. Table 6 reveals that they are the most frequently exported type of service for observations with no foreign affiliate for either the chemistry or automobile industry (lines three and twelve). This suggests that there might be further driving forces for R&D service exports than manufacturing affiliates. Generally, R&D services represent, to a large extent, the transfer of knowledge and information. This exchange of information can potentially be important for firms at different stages of the fragmented value chain of products. In particular,

when firms sell or buy intermediate products, it might be important that buyer and supplier share information about the design of products, for instance.<sup>24</sup> In this case, the firm's trade with intermediate products could in principle be accompanied by R&D service imports and exports of firms. This might be particularly important for motor vehicles producers. For instance, Miroudot and Ragoussis (2009) find for OECD countries that the automobile industry belongs to the industries with the largest share of traded intermediate inputs in industry's trade activities.

Surprisingly, management services also often appear when firms have no foreign affiliate, in particular, in the chemistry industry (line three). This indicates that these services have further functions than supporting foreign affiliates of firms, which would have been an intuitive interpretation. Thus, it might be important to analyze the relationship of management service exports with other activities of firms, like exporting goods, to find further explanations to observe these types of service exports.

Finally, I have found that the large share of observations of service exports without a foreign affiliate of firms in the destination can be assigned to a large extent to the two machinery industries (lines six and nine). Table 6 shows that these account for nearly 50% of the total observations without a foreign affiliate. These are strongly dominated by construction and engineering types of services. The evidence presented so far indicates that these services might be representing installation, maintenance services, and other technical support, which could be provided complementary to exported machinery. Thus, these services exports should show a positive relationship with goods exports of machinery firms to the same country. Unfortunately, it is not possible to combine the service trade data from the *Deutsche Bundesbank* with goods trade data at the firm level. To identify whether, for instance, construction services are, at least potentially, complements to exported machinery, I use goods trade data at the industry level. The following section shows how it is applied in a regression analysis of the service exports of manufacturers.

## 4 Regression Analysis

The descriptive statistics gave some ideas about the determinants of the service export pattern of manufacturers. One main result was that service exports are only slightly related to foreign affiliates of firms. However, some types of services like advertising, data processing, and R&D services seem to represent indeed, at least partially, headquarter services. In particular, installation and maintenance services of machinery firms, are more likely to represent complementary services. Altogether, services exports may have very different functions in the international business of firms.

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<sup>24</sup>This idea is in line with evidence from Baldwin and Gu (2004), who find that Canadian goods exporters often show R&D collaborations with the buyers of their products.

In the following regression analysis, I intend to analyze three issues. First, I check whether the potential headquarter services show a positive relationship with foreign affiliates of firms and whether I can identify difference types of headquarter services. Some might be supporting production whereas others support the distribution of goods. Second, I examine whether I find a positive relationship between the potential complementary services and goods exports. Third, I analyze if there might be further motives to export services identifiable by analyzing the relationship of services exports with a large share of potential explanatory variables. I begin the analysis by describing the applied estimation approach and then present the results and briefly discuss them.

## 4.1 Estimation Approach

I examine the service export behavior of firms with two different estimation approaches. First, I estimate the service export market entry decision of firms to find out what determines whether a firm exports services to a country or not. I account for all manufacturers in the sample and assume that every firm could potentially export a service to any country. I analyze this discrete choice with a probit estimation. The discrete choice variable on the left-hand side of the estimation equation is equal to zero if a firm does not export services to the country, and it is one, if the firm does.

Second, I go one step further and examine the determinants of the intensive margin of service sales with OLS methods. Variables that show significant effects for the intensive margin should be particularly important, because the intensive margin describes firm behavior more deeply within a particular country. I use the aggregated sales at the firm-service-country level and regress them on the explanatory variables, which I introduce below, using the OLS method. I account for the same variables in both regression approaches. Altogether, I expect that these affect the participation and sales decision of firms in the same direction.

To account for the foreign affiliate activities of firms in the destination of service exports, I apply different measurements. I test the dummy variables whether a firm has a manufacturing or distribution affiliate in the country, the number of the respective affiliates, and the volume of affiliate sales in the destination. These measures are highly positively correlated and should have a positive impact on service exports, in particular, for headquarter services. In the regressions presented below, I apply the manufacturing and distribution affiliate sales of a firm in a country (*Manuf. Affil. Sales* and *Distrib. Affil. Sales*) because these contain the most information about the volume of affiliate activities of firms.

The evidence shown so far suggests that only a small part of service exports are potentially provided as headquarter services to foreign affiliates. As described above, one important explanation to observe service exports of manufacturers might be that firms sell services as complements to exported goods. This is likely particularly

important for construction and engineering service exports of German machinery producers.

Unfortunately, I am not able to combine the service trade data with information about goods trade activities of German manufacturers at the firm level. Instead, I use the volume of goods exports of a particular industry to a particular country as a proxy at the industry-country level (*Goods Exports*). I apply 8-digit goods trade data from Eurostat (2009) and aggregate it to match the 2-digit Nace-rev. 1 categories of German manufacturing industries. Then, I assign this data to the respective industry-country observations. Thus, I assume that, for instance, automobiles or automobile parts are only exported by the automobile industry. Of course, this industry level measurement is only a rough proxy for goods exports of the individual firm. Its quality depends, among other things, on how much the service exporters in the sample really contribute to the goods exports of their industries. However, the descriptive facts shown above make me optimistic that these firms indeed belong to the large goods exporters in their industries, because the firms show international activities for a very large number of countries and service categories. Whenever *Goods Exports* show a significant positive sign, this provides potential evidence for a complementary relationship of service, and goods exports. However, this evidence would be only weak. Yielding stronger evidence requires the use of both goods and services export data at the firm level.<sup>25</sup>

In addition to goods exports, I account also for the imports of goods. I apply the same method as for goods exports to goods imports data from Eurostat (2009) to control for the effect of intra-industry *Goods Imports* at the industry-country level. This measure might be useful to control for further driving forces of service exports of firms beyond the idea of headquarter and complementary services.

Furthermore, the descriptive analysis suggested that firm heterogeneity plays an important role in describing the observed service export pattern. Table 4 displays that MNEs show on average larger service export activities than non-MNEs. Furthermore, I found that service exports of firms might be positively related to the number of foreign affiliates of firms. To account for these facts, I include a dummy for the MNE-status (*Manufacturing MNE*) of a firm and the number of its manufacturing affiliates (*Numb. of Manuf. Affil.*). Both reflect the firm's size and, most likely, its productivity. I expect both variables to have positive signs.

Beyond these two measurements of firm heterogeneity, I take into account whether or not a firm is also a *Service Importer*. I find that about 75% of firms are also service importers in the investigated sample. Kelle and Kleinert (2010) find that there

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<sup>25</sup>Note that even finding a positive relationship of goods and services exports at the firm level does not necessarily mean that these are complements or bundled services for an exported product. This positive relationship could arise also, for instance, when market entry costs for providing services reduce, if the firm already exported goods to the country. Furthermore, controlling for endogeneity of a firm's goods and service exports in a country would be useful. However, this is not possible with the underlying data.

might be a positive relationship between service exports and import activities of a firm. Furthermore, the literature emphasizes that importing firms are, on average, significantly more productive than not importing firms. For instance, Breinlich and Criscuolo (2011) find this effect also for services imports. Thus, taking the import-status of firms into account might be a further relevant control for heterogeneity of firms for both their services and goods exports performance. Consequently, I expect a positive sign of the dummy variable *Service Importer*. Finally, I include a dummy that indicates whether a firm belongs to a foreign owner or not (*Foreign MNE*). Firms that are foreign-owned are often found to show, ceteris paribus, larger trade activities (e.g., Breinlich and Criscuolo, 2011).

A further important group of control variables are country variables. I add usual gravity variables like GDP, GDP per capita, geographical distance, and a border dummy to control for country determinants of the firms' behavior.<sup>26</sup> These are found to be important for the service export decision of service firms in the literature, for instance, by Kelle et al. (2012). I expect a positive sign for both *GDP* and *GDP per cap*, because a larger market and a higher income level are used to foster trade, and a negative one for *Distance*, because trade becomes more costly with a larger distance. Consequently, I expect a positive sign for the *Border* dummy.

Furthermore, I control for the industry of a firm with an industry dummy at the 2-digit level, because the stylized facts show that export activities of firms vary strongly across industries. In the intensive margin analysis, I include also dummies for the type of service exported in the regression for the entire sample to take into account that the volume of exports per observation may vary across services. To sum up the described estimation approach, you can formalize the estimation equation for the intensive margin in the following way:

$$ExportSales_{ijkl} = \beta_0 + \beta_1 \ln(ForeignAffiliateSales_{ijl}) + \beta_2 \ln(GoodsTrade_{jl}) + \beta_3 FirmCharacteristics_i + \beta_4 CountryCharacteristics_l + u_{ijkl}$$

The export sales of firm  $i$  in industry  $j$  of service  $k$  in country  $l$  are explained by the foreign affiliate sales of firm  $i$  of industry  $j$  in country  $l$ , the goods trade of products by industry  $j$  with country  $l$ , characteristics of firms  $i$  and country  $l$ . The estimation equation for the probit regression is quite similar. Only the dimension for the types of services exported needs to be dropped and the sales variable on the left-hand side needs to be replaced with the discrete choice variable.

Because the country variables are not available for all countries, I can make use of 172,067 observations in 116 countries in the probit regression. 10,573 observations, or nearly 6% of total observations, show service exports; for these, the discrete choice

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<sup>26</sup>GDP and population data come from the World Development Indicators of the Worldbank (2009). The distance between countries is available in the distance database of the CEPII (2005).

variable is equal to one. The sample for the OLS regression of the intensive margin contains 14,672 observations of export sales of firms. I account for clusters of both countries and firms in the data in the probit regression. Those clusters can lead to a downward bias of standard errors of the estimated coefficients (e.g., Wooldridge, 2003). Standard errors of the coefficients in the OLS regressions are adjusted for clusters of firms. Clusters of countries are less important here.

To account for the presumably large heterogeneity of the firm's activities, I also split up the samples and analyze different types of services for different industries separately. This reduces the number of observations in the respective regressions. To examine potential headquarter services, I run separate regressions for data processing, advertising, management, and R&D services exports. These should show a strong positive relationship with the foreign affiliate activities of firms when they are indeed exported to support an affiliate of a firm. Following the hypotheses in the previous section, R&D services should show in particular a positive relationship with manufacturing affiliates sales whereas advertising services might be particularly affected by distribution affiliates. Data processing services should show a strong positive relationship with both types of affiliates. Furthermore, I explicitly focus on the installation, maintenance, and technical support services provided by the two machinery sectors and run regressions for the construction and engineering services exports of these two industries. For these observations, I expect a particular strong positive relationship of services exports with exported goods.

## 4.2 Regression Results

Tables 7 and 8 show the regression results. For every subsample, I first present the results for the probit regression of the export entry decision of firms and then I show the OLS regression for the intensive margin of service sales. The explanatory variables are listed on the left-hand side of the tables.

Columns one and two of Table 7 present the results for the entire sample of firms and services. The results for the export market entry decision show that many factors have potentially an impact on the service export behavior of firms (column one). Both affiliate sales variables, *Manuf. Affil. Sales* and *Distrib. Affil. Sales*, have a positive and significant coefficient with nearly the same size. In addition, *Goods Exports* and *Goods Imports* show a significant positive coefficient, which is nearly 5 times larger for goods exports. The firm level variables all have a positive and significant coefficient, except for the dummy for foreign-owned firms (*Foreign MNE*). Regarding the country variables, for the *GDP* and the *GDP per capita* of destination countries, I find a significant positive impact.

The results for the intensive margin generally support these results (column two). However, less variables show a significant coefficient, as expected. Again, both the manufacturing and distribution affiliate sales of firms have a positive and significant relationship with service exports. The same can be found for *Goods Exports* of in-

dustries. *Goods Imports* instead show no significant coefficient and even a negative sign. Of the firm variables, the *Service Importer* dummy and the number of manufacturing affiliates of firms (*No. of Manuf. Affil.*) still have a positive and significant coefficient. Furthermore, the dummy for foreign-owned firms has here a significant impact, whereas the dummy for being a manufacturing multinational (*Manufact. MNE*) does not. Altogether, the results are in line with the expectations. Many variables have a significant impact, which underlines that many different drivers for the service export activities of firms might generally exist. In the following, these are more deeply analyzed for different types of services. In particular, I point out how the export of the different types of services is related to the foreign affiliates of firms and goods trade of the industries.

The next results presented in Table 7 are for data processing services exports (columns three and four). The descriptive facts shown above suggest that these services often aim to support both manufacturing and distribution affiliates of firms. This idea is supported by the regression results. The probit regression shows a positive and significant coefficient for both the *Manuf. Affil. Sales* and *Distrib. Affil. Sales* (column three). Furthermore, *Goods Exports* also have a significant positive impact. In the estimation of the intensive margin of exports (column four), I find only the foreign affiliate sales of firms in the destination having a significant coefficient. Most of the other variables show no significant impact. This underlines that data processing services may primarily aim at supporting both the production and distribution of products through foreign affiliates of firms.

Columns five and six show the results for advertising services. In the probit analysis (column five), *Distrib. Affil. Sales* and *Goods Exports* show a positive significant coefficient whereas *Manuf. Affil. Sales* and *Goods Imports* do not have a significant impact. This supports the idea that these services mainly aim at supporting distribution of goods. These could be distributed through foreign affiliates or cross-border exports of goods. However, the intensive margin estimation only gives support for a positive relationship between advertising service sales and distribution affiliates (column six). Here, only the two affiliate sales variables have a significant coefficient.

Columns seven and eight present the results for management services. The observable pattern is, as expected, less clear. The probit regression shows positive and significant coefficients for all affiliate sales and goods trade variables. In the OLS regression, however, only *Manuf. Affil. Sales* show a significant positive relationship with management service export sales. Furthermore, the variable *Foreign MNE* has a significant coefficient. Thus, export sales are significantly larger for foreign-owned firms. Altogether, management services might represent partially headquarter support to production affiliates of firms. However, the general task of these services in the business of firms remains unclear.

Table 8 displays the results for further subsamples. In columns one and two, you can see the results of the probit and OLS regressions for R&D services. R&D

Table 7: Regression Results for Probit Regression of Export Participation and OLS of Intensive Margin of Services Exports by German Manufacturers, 2005

Explanatory Variables	Total Sample		Data Proc. Serv.		Advert. Serv.		Manag. Services	
	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS
<i>ln Manuf. Affil. Sales</i>	0.064** (8.06)	0.044** (4.23)	0.072** (5.05)	0.055* (2.30)	0.014 (1.33)	0.031* (2.05)	0.074** (6.19)	0.057** (3.88)
<i>ln Distrib. Affil. Sales</i>	0.063** (5.73)	0.032** (3.41)	0.044** (3.40)	0.054** (4.30)	0.047** (3.64)	0.053* (2.17)	0.049** (4.24)	0.027 (1.24)
<i>ln Goods Exports</i>	0.177** (5.93)	0.126** (3.82)	0.266** (5.85)	0.053 (0.47)	0.201** (4.80)	0.091 (1.09)	0.191** (5.15)	0.135 (1.78)
<i>ln Goods Imports</i>	0.038** (4.35)	-0.022 (1.28)	0.025 (1.39)	0.047 (0.98)	0.027 (1.57)	0.040 (1.11)	0.050** (3.26)	-0.000 (0.01)
<i>Manufact. MNE</i>	0.208** (3.81)	-0.031 (0.29)	-0.041 (0.32)	-0.205 (0.81)	0.265* (2.21)	0.387 (1.52)	-0.155 (1.92)	-0.225 (1.17)
<i>No. of Manuf. Affil.</i>	0.019** (5.29)	0.015** (4.43)	0.019** (4.26)	0.017** (2.84)	0.010* (2.49)	-0.003 (0.96)	0.008** (2.65)	-0.002 (0.35)
<i>Service Importer</i>	0.548** (11.62)	0.527** (6.45)	0.479** (3.65)	0.409 (1.17)	0.302 (1.64)	0.169 (0.54)	0.534** (4.22)	-0.079 (0.23)
<i>Foreign MNE</i>	0.054 (1.20)	0.256** (2.79)	-0.111 (1.22)	0.208 (0.91)	0.053 (0.48)	0.148 (0.64)	0.276** (3.65)	0.663** (3.31)
<i>ln Distance</i>	-0.048 (1.62)	0.035 (1.55)	0.03 (1.71)	0.057 (0.85)	-0.07 (1.19)	0.091 (1.32)	-0.050 (1.08)	-0.071 (0.99)
<i>ln GDP per Cap</i>	0.048** (3.28)	-0.003 (0.15)	0.117** (3.21)	-0.001 (0.02)	0.126** (3.53)	0.171* (2.41)	0.080** (2.94)	0.079 (1.53)
<i>ln GDP</i>	0.119** (3.18)	0.084** (4.74)	0.093* (4.87)	0.120* (2.16)	0.120** (2.64)	0.117* (2.21)	0.130** (3.03)	0.128* (2.24)
<i>Border</i>	0.147 (1.89)	0.137** (2.68)	0.261* (2.02)	0.292 (1.88)	0.130 (0.92)	0.123 (0.89)	0.156 (1.62)	0.265* (2.09)
Observations	172,067	14,672	27,081	1,094	23,248	1,076	50,147	1,848
$R^2$	0.29	0.15	0.39	0.28	0.36	0.27	0.33	0.12

All regressions include dummies for industry of the firm and service category whenever possible. Z-values in brackets are adjusted for clusters at the firm level and country level in probit and at firm level in OLS. \*\*, \* significantly different from 0 at 1% level and 5%, respectively.

services show in export market entry analysis, as well as management services, a significant positive relationship with *Manuf. Affil. Sales*, *Distrib. Affil. Sales*, *Goods Exports* and *Goods Imports*. Turning to the intensive margin instead in column two, only *Manuf. Affil. Sales* and *Goods Imports* keep their significant coefficient. This result has two major implications. First, it supports the notion that R&D service exports often serve to transfer knowledge from headquarters of firms to their foreign production facilities. This knowledge could concern both production procedures as well as product designs. Second, this shows that there might be a positive relationship between imports of goods and R&D service exports. As already stated above, the applied measurement of goods imports includes, at least partly, the import of intermediate goods. Thus, one possible explanation for a positive relationship of R&D exports and intra-industry goods imports might be that firms provide information to foreign producers of intermediate goods. These could be both foreign affiliates of firms or third-party suppliers.

The results for R&D service exports of automobile firms (columns three and four) support the idea that R&D service exports might be positively related with goods imports. Automobile firms account only for a small number of observations of R&D exports. However, they are responsible for more than 50% of the total volume of foreign cross-border R&D service sales of manufacturing firms. The results of the probit regression are quite similar to the entire sample of R&D service exporting firms. *Manuf. Affil. Sales*, *Goods Exports* and *Goods Imports* have significant and positive coefficients.<sup>27</sup> In the OLS regression, however, only goods imports still have a significant coefficient. This underlines the fact that goods imports might be a driving force for R&D exports, in particular, for automobile firms. Whether this is driven by relationships of firms with foreign suppliers of intermediate product inputs might be an interesting question for future research. However, this is cannot be analyzed precisely here.

Furthermore, Table 8 presents evidence for the construction service exports of machinery firms (columns five and six). These firms are both from the machinery and equipment and electric machinery industries. The results support the notion that these construction services mainly represent installation or assembly services provided as complements to exported machinery. The probit regression shows a significant and positive coefficient of *Distrib. Affil. Sales* and *Goods Exports*. This suggests that these service exports might indeed be closely related to machinery sold abroad through either cross-border or foreign affiliate sales. However, only *Goods Exports* keep a significant coefficient in the estimation of the intensive margin. The coefficient is three times larger than for the entire sample. When machinery exports to a foreign country increase by 10%, construction service exports of machinery firms

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<sup>27</sup>The pattern of the country variables is slightly different. The results show that firms are more likely exporting to countries far away and with a low income level. This might reflect that firms operate in low wage countries that are often very distant from Germany.

Table 8: Regression Results for Probit Regression of Export Participation and OLS of Intensive Margin of Services Exports by German Manufacturers, 2005

Explanatory Variables	R&D Services		R&D Services by Automobile Firms		Constr. Serv. by Machinery Firms		Engr. Serv. by Machinery Firms	
	Probit	OLS	Probit	OLS	Probit	OLS	Probit	OLS
<i>ln Manuf. Affil. Sales</i>	0.081** (8.91)	0.087** (4.98)	0.104** (5.59)	0.098 (1.83)	0.000 (0.03)	0.066* (2.12)	0.028* (2.11)	0.044 (1.78)
<i>ln Distrib. Affil. Sales</i>	0.039* (2.41)	0.034 (1.52)	0.016 (0.87)	-0.054 (1.29)	0.056** (3.05)	0.027 (0.77)	0.004 (0.26)	-0.041 (0.95)
<i>ln Goods Exports</i>	0.163** (3.83)	0.098 (1.76)	0.266** (3.65)	0.289 (1.39)	0.224** (4.51)	0.377** (3.66)	0.235** (6.14)	0.292** (2.60)
<i>ln Goods Imports</i>	0.074** (4.14)	0.100** (3.23)	0.039** (4.00)	0.301** (4.54)	0.016 (1.22)	-0.160** (5.48)	0.013 (0.86)	-0.106* (2.37)
<i>Manufact. MNE</i>	0.019 (0.31)	-0.226 (1.36)	-0.149 (0.57)	-0.920* (1.96)	0.423** (4.66)	0.023 (0.13)	0.235* (2.32)	-0.098 (0.48)
<i>No. of Manuf. Affil.</i>	0.011** (4.29)	0.012** (4.45)	0.022 (1.41)	-0.010 (0.56)	0.015** (3.37)	0.027** (6.63)	0.017** (3.16)	0.031** (10.9)
<i>Service Importer</i>	0.222* (2.40)	0.488** (2.66)	0.551* (2.54)	1.76* (2.44)	0.595** (6.48)	0.726** (5.07)	0.183 (1.71)	0.542** (4.10)
<i>Foreign MNE</i>	0.064 (1.06)	0.248 (1.36)	-0.105 (0.51)	-1.01* (2.41)	0.042 (1.22)	0.062 (0.32)	0.096 (0.94)	0.733** (2.60)
<i>ln Distance</i>	0.048 (1.21)	0.204** (2.87)	0.148** (2.65)	0.351* (2.18)	-0.075* (2.25)	-0.003 (0.08)	-0.07 (1.19)	0.077 (1.15)
<i>ln GDP per Cap</i>	0.029 (1.29)	0.119** (3.05)	-0.111* (1.98)	0.124 (0.76)	0.022 (1.35)	-0.025 (0.67)	-0.038 (1.42)	-0.10 (0.20)
<i>ln GDP</i>	0.164** (3.52)	0.041 (0.91)	0.129** (2.35)	-0.152 (1.08)	0.090* (2.00)	-0.011 (0.20)	0.104** (3.44)	0.049 (0.90)
<i>Border</i>	0.068 (0.84)	0.148 (1.23)	0.004 (0.02)	-0.043 (0.15)	0.164 (1.90)	0.135 (1.50)	0.138 (1.69)	0.082 (0.61)
Observations	62,939	2,160	4,559	284	41,922	3,637	31,633	1,425
R <sup>2</sup>	0.33	0.17	0.40	0.19	0.26	0.19	0.26	0.28

All regressions include dummies for industry of the firm and service category whenever possible. Z-values in brackets are adjusted for clusters at the firm level and country level in probit and at firm level in OLS. \*\*, \* significantly different from 0 at 1% level and 5%, respectively.

are, on average, nearly 4% larger. Thus, machinery exports and installation service activities of firms are obviously closely linked.

The columns seven and eight show the results for engineering service exports of machinery firms. The pattern of determining variables is very similar to the results for construction services. In the probit regression, *Manuf. Affil. Sales* and *Goods Exports* show a significant coefficient whereas again, only *Goods Exports* show a significant positive relationship with the volume of service export sales. This supports the idea that these engineering service exports could be, at least partially, maintenance services or other technical support provided to foreign buyers of machinery. However, as in the case of construction services, to analyze the role of complementary services more deeply, it is necessary to account for both services and goods trade data at the firm level, which is unfortunately thus far not possible for Germany.

Finally, there are some more general facts that appear in the presented results. In most regressions, the firm variables *Service Importer* and *No. of Manuf. Affil.* have a highly significant and positive coefficient. This shows, on the one side, that larger and presumably more productive firms have larger service export activities. Whether there is a causal relationship between firms' service expertise and their performance in international product markets is an interesting question for future research. Furthermore, country variables are found to be important controls for firms' activities. Generally, firms show larger service export activities in countries with a high GDP and GDP per capita. This supports the general notion that service trade is mainly happening between high income countries. Geographical distance seems to be less important, which suggests that the distance costs to provide services are relatively small for manufacturers. One exception is construction services. In Table 8, column five, *Distance* has a significant negative coefficient. This is an intuitive result because these services likely rely primarily on mode four supply of services, which means that the services providers need to travel to the foreign country to supply a service. These travelling costs are likely to increase with geographical distance.

## 5 Conclusions

The present paper analyzed service export activities of German manufacturers at the firm level with data from the Balance of Payments Statistics provided by the *Deutsche Bundesbank*. Service exports of German manufacturers strongly increased in the first decade of this century. Manufacturers accounted for roughly 25% of cross-border producer service exports of German firms in 2005. However, service exports of manufacturing firms have hardly been analyzed thus far in the international trade literature.

For 2005, I have found that the most important services exported are con-

struction, R&D, and engineering services. Service exports are dominated by a few high-tech industries, which include the machinery, automobile, chemistry, and other transport equipment producers. The types of services exported vary strongly across industries. Generally, only a few manufacturers export services. These often serve many countries and various types of services. Altogether, export sales of manufacturers are strongly dominated by a small number of large exporters.

The motives of firms to export services are manifold. Data processing, advertising, and R&D services likely represent, at least partially, headquarter services. Exports of these services show a strong positive relationship with foreign affiliates of firms. Advertising services likely aim at supporting rather the distribution of goods, whereas R&D services may be particularly important for foreign production activities of firms. Providing software to foreign affiliates to support the organization of different activities of affiliates could be important for both production and distribution facilities of firms. However, these headquarter services can explain at most only 20% of the observable service exports of manufacturers. Two further primary functions of services are more important in explaining the observation of service exports of manufacturers.

First, R&D service exports might represent more generally the need of firms to transfer knowledge, not only to foreign affiliates, but also to other trading partner firms. This idea is supported by observing frequently R&D exports when firms have no foreign affiliate in the destination. The recipients of the RD services could be, for instance, suppliers or buyers of intermediate products of firms. In the automobile industry, R&D services show a strong positive relationship with intra-industry imports. This suggests that firms might share informations about product designs with suppliers of intermediate inputs. Second, I find that service exports might also complement exported products. This is particularly important for German machinery firms. Both construction and engineering services exports have a strong positive relationship with machinery exports. This suggests that providing, for instance, installation, maintenance services, or other technical support, are important activities that complement the product supply of machinery producers. Unfortunately, both explanations rely only on presumptions in the present paper. A deeper analysis would require the combination of both services and goods trade data at the firm level, which thus far is not available for Germany.

Generally, there are further reasons, beyond the lack of firm-level goods trade data, as to why the results should be interpreted with caution. The descriptive nature of the analysis generally does not allow for strong causality statements. Furthermore, the BoPS data likely does not account for the entire volume of service exports of firms. On the one side, services that are provided as complements to products are often not billed separately and thus would, in this case, not appear in the data. On the other side, the data also likely neglect headquarter services, because these do only show up when there is a direct payment of the affiliate to the parent firm, which might often not be the case.

Nevertheless, some first lessons for the process of developing advices for future policies can be derived. First, the analysis shows that service trade barriers could, in general, hamper the international business of manufacturers in various ways. This makes reducing these barriers a potential source of future welfare growth. For instance, in the case of German machinery firms, barriers and costs for the temporary stay and working of engineers in foreign countries might hamper the supply of machinery in these markets (Horn and Shy, 1996). Second, it is important to note that industries are likely affected by policy changes in different ways, because industries rely on different types of services. These, in turn, likely use different modes of service exports, which are important for the negotiations in the GATS. R&D exports might mainly represent mode one activities, which are stated to be relatively much liberalized. Installation and maintenance services, in turn, primarily rely on mode four trade, which is found to be most restricted in international services trade (e.g., Francois and Hoekman, 2010). This underlines the fact that a more detailed understanding of service trade activities is necessary to obtain an idea of the benefits and costs of reducing barriers to services trade.

Future research should focus even more on specific industries, such as the machinery or automobile industries, to obtain more precise statements about the role of services in the business of manufacturers and relevant service trade barriers. An analysis that is guided by a more advanced theoretical model may facilitate the interpretation of the results. Country comparisons might help to understand whether my findings are specific for the German economy. For instance, Breinlich and Criscuolo (2011) find in a slightly larger set of services that manufacturers account only for about 10% of services exports and imports in the UK. Beyond this, an international comparison could help to determine in a next step whether the service expertise of German firms might be one partial explanation for the high competitiveness of German manufacturers in international markets.

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## Appendix

Table 9: Service Categories from BoPS and MIDI

Sector	MIDI (Nace rev. 1)	BoP-Statistics (KNZ's)
Construction	4500: Construction	Construction, Installation: 570, 580
Transport	6000: Land Transport, Pipelines 6100: Water Transport 6200: Air Transport	Rail & Road: 013, 215, 226, 233, 234, 240; Maritime and Inland: 081, 210, 216, 220; Air: 014, 020, 225, 244, 270; All Transp.: 015, 016, 080, 260, 271
Auxiliary Transport	6300: Supporting and Auxiliary Transport Activities, Travel Agencies	Logistics & Other Support: 300, 310, 320, 340, 360 Repairing Transport Means: 560
Post & Tele- communications	6400: Post & Telecommuni- cations	518: Communication Services (Satellite, Telephone, Wire) 591: Post & Courier Services
Insurance	6600: Insurance and Pension Funding, except Social Security	Life, Pension and Reinsurance: 400-461
Data Processing	7200: Computer & rel. Activ.	513: Electronic Data Processing
R&D	7300: Research & Development	501: Artistic Copyrights 502: Patents, Licenses, Inventions 511: R&D for products, procedures
Management Services	7411: Legal Advice 7412: Accounting, Book- keeping and Auditing Activities, Tax Consultancy 7413: Market Research, Public Opinion Polling 7414: Business and Management Consultancy	516: Entrepreneurship, Management, Organisation, Administration, Market Research 519: Other Entrepreneurial Activities

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Source: Lipponer (2009), Deutsche Bundesbank (2009)

Table 9: continued

Sector	MIDI (Nace rev. 1)	BoP-Statistics (KNZ's)
Engineering Activities	7420: Architectural and Engineering Activities and related technical Consultancy	512: Engineering, Maintenance, Technical Consultancy, Architect Royalties
Advertising	7440: Advertising	540: Advertising and Fair Costs
Personnel	7450: Labour Recruitment and Provision of Personnel	517: Personal Leasing 521: Non-self-employed Work
Source: Lipponer (2009), Deutsche Bundesbank (2009)		