Dissecting FDI ⋆

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Abstract

This paper investigates the importance of firm heterogeneity for the understanding of the aggregate volume of cross-country multinational sales. Recent theoretical literature points out a sorting of firms with respect to their internalization strategies according to their productivity. Using firm-level data on German firms' activities, we find a strong effect of firm's size on internationalization pattern. Moreover, we show that most of variation of the aggregate volume of multinational sales is due to variation in the number of firms participating in the market.

Keywords: Gravity equation, multinational firms, heterogeneity.

JEL classification: F23, F12, C21

⋆ This paper has substantially benefited from the comments of Jens Arnold, Claudia Buch, Gabriel Felbermayr, Jonathan Eaton, Peter Egger, and Horst Raff. We are also indebt to the seminar participant at the Budapest Economics Seminar Series, the ETSG as well as from participants at the Göttingen Workshop in International Economics and the annual meeting of the Econometric Society 2008 in New Orleans. We are of course solely responsible for any remaining errors.

1 Introduction

Recent empirical research has documented huge heterogeneity among firms within industries. Firms that differ in size and productivity show also pronounced differences in their engagement in international trade. Bernard and Jensen (1995, 1999a, 1999b), Bernard *et al.* (2005), Clerides *et al.* (1998), and Eaton *et al.* (2004) demonstrated that the bulk of international trade tends to be conducted by a small number of exporters. Research on firm heterogeneity and firms' international activities has mainly focused on international trade, although a few contributions have also considered activities of multinational firms. Extending the trade literature, Helpman *et al.* (2004), Girma *et al.* (2004), and Head and Ries (2003) analyzed multinational firms. They show that the probability that a firm serves a foreign market through affiliates' production abroad increases with its productivity. Theoretical and empirical results point to a sorting of firms with respect to their internationalization strategy. The most productive firms engage in production abroad while the least productive firms operate only in the domestic market. Firms with intermediate levels of productivity produce at home and serve the foreign market through exports.

There are however almost no systematic studies on the characteristics of multinational firms' activities. Yeaple (2005) reports evidence from US multinational firms in the manufacturing sector. He uses a confidential survey on multinational manufacturing firms from the US in 1994. His empirical findings are in line with the theoretical predictions of Helpman *et al.* (2004). The theoretical model of Helpman *et al.*incorporates heterogenous firms into a general equilibrium framework. The model allows to examine the huge heterogeneity found in firm-level data. We therefore use a slightly simplified version of this framework in our theoretical analysis.

We derive four propositions from this theoretical model. They are particularly concerned with the sorting of multinational firms with respect to their productivity. In addition, we explore the effect of changes in market size and/or trade costs on the activities of multinational firms. Firms might react to exogenous changes through entry and exit (extensive margin) or through the adjustment of sales of existing firms (intensive margin). We then test the predictions using firm-level data on German multinational activities in 2002. The database includes information on all German parent and their foreign affiliates in more than 200 countries. We find strong support for all four propositions.

The rest of the paper is organized as follow. In section 2, we present descriptive firm-level statistics of German firms' foreign affiliates. In section 3, we derive the propositions from a model with heterogenous firms. We test these propositions in section 4. We conclude in section 5.

2 Descriptive Statistics

2.1 Data

This paper exploits a confidential firm-level database which provide information on German multinational activities. The *MIDI (MIcro data base Direct Investment)* dataset of the *Deutsche Bundesbank* provides a detailed breakdown of the foreign assets and liabilities of German multinational firms abroad (Lipponer, 2006). German foreign direct investment is defined as the direct or indirect ownership or control by a single German entity of at least ten percent of the voting securities of an incorporated foreign firm or the equivalent interest in an unincorporated foreign firm. The database comprise information on all foreign affiliates of German multinational firms.

The comprehensive database holds the balance sheets data of German foreign affiliates, including their sales, employment and total assets in each of over 200 country destinations. It also includes information on the sector of activity of parent firm and affiliate at NACE rev-1 two-digit level. The data covers foreign affiliates activities between 1989 and 2002. However, information for the parent company is only available for 2002.

The database covers the whole population of German firms foreign affiliates which have a balance sheet total that exceeds the reporting limit of 3 million euro. The database covers all sectors and classifies the sector of parent firms and foreign affiliates separately. Figure 1 gives an break down of the number of affiliates with respect to these sector classifications. We want to highlight three things. First, parent firms from manufacturing (row 3 to 15) hold 58.5% of all foreign affiliates of German firms. In spite of the dominance of service sectors in GDP, activities of multinational firms are dominated by firms from manufacturing. Second, parent firms from the manufacturing sector set up affiliates mainly in their own sector (43.2%) or in the wholesale sector (column 18)(33.9%). Business services and financing rank third (13.9%) and activities in other manufacturing industries forth (5.4%). Third, while manufacturing firms set up affiliates in wholesales and services, service and wholesale firms do *not* establish affiliates in manufacturing to a similar degree. 89.1% of foreign affiliates in manufacturing are hold by parent firms from manufacturing.

Some multinational firms own more than one affiliate in a particular sector of a particular country. To come closer to theory which models single-affiliate firms and make activities of many-affiliates parents more comparable to single-affiliates parents, we aggregate the affiliate level data sales and employment for each (*i*) parent company, (*ii*) sector, (*iii*) country and (*iv*) year but keep the information about the number of affiliates of each parent firm.

Table 1. Number of foreign affiliates by sector of the German Parent and sector of the affiliate, 2002

Parent / Affiliate	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	Total
1 Agriculture	43							x										7				x		7	x
2 Mining		71						x	16	26							x	31		x		6		13	168
3 Food	4		**252**			x		x			x							**173**	6	x	6	15	x	46	512
4 Textiles				**187**							x		x	x	x			**224**		x	4	10		28	460
5 Wood					**22**					x					x		9	**9**			x	31		x	78
6 Paper			x		x	**287**			x			x				x		**152**		9	8	41	x	105	613
7 Petroleum		x					**35**	4				x						**30**		x	x	x		5	81
8 Chemicals	x	x						**1078**	15	x	x	4	20	x	x			**828**		x	33	111	23	231	2356
9 Plastics				7	x	x		13	**410**		8	x	x	35	x		x	**190**		x	5	16		68	763
10 Non-metallic minerals		14				x			5	**402**			x		x	x	17	**68**	x	x	24	24	x	120	683
11 Metal				x		x			25	x	**576**	80	5	49	x		9	**444**		x	9	35	x	99	1340
12 Machinery		4	x		4	x		63	14		49	**812**	31	26	x	x	x	**1081**		x	18	73		151	2336
13 Electrical Equipment			x	x				5	4	x	11	50	**823**	37		9		**790**		9	36	108	46	144	2075
14 Transport Equipment		x				x			12	x	6	8	34	**666**	8			**378**	x	61	130	138	11	130	1586
15 other manuf.								5			x		x	x	**90**		x	**56**			x	x		8	172
16 Utilities		4									x	x	x			205		9		x	16	14	x	72	327
17 Construction	x	5			x				x	5	x		19	x			141	13			4	20	x	29	244
18 Wholesales	5	x	33	15	6	9	x	24	18	4	42	28	45	10	11	x	4	1565	x	23	22	167	9	168	2217
19 Hotels																		x	51		x	x		11	68
20 Transport & Communication		x				x					10			4	x			8	26	731	17	69	x	109	979
21 Finance	x		x	x	x	x		6	x		4	x	6	x		6		14	x	6	1727	350	13	404	2554
22 Business serv.	6	x	10	12	x	x		23	4	5	24	38	32	22	11	19	7	203	17	11	62	1039	10	170	1733
23 other services	32	4	18	21	6	12		10	23	7	31	33	31	10	7	8	5	134	20	24	12	283	94	90	915
Total	96	113	320	247	46	326	x	1237	551	458	771	1062	1053	865	137	254	198	x	124	892	2140	2558	216	x	22320

x denote numbers < 4 that are suppressed for disclosure rules.

Source: MIDI (2002), authors' computation.

2.2 Size and International Activities

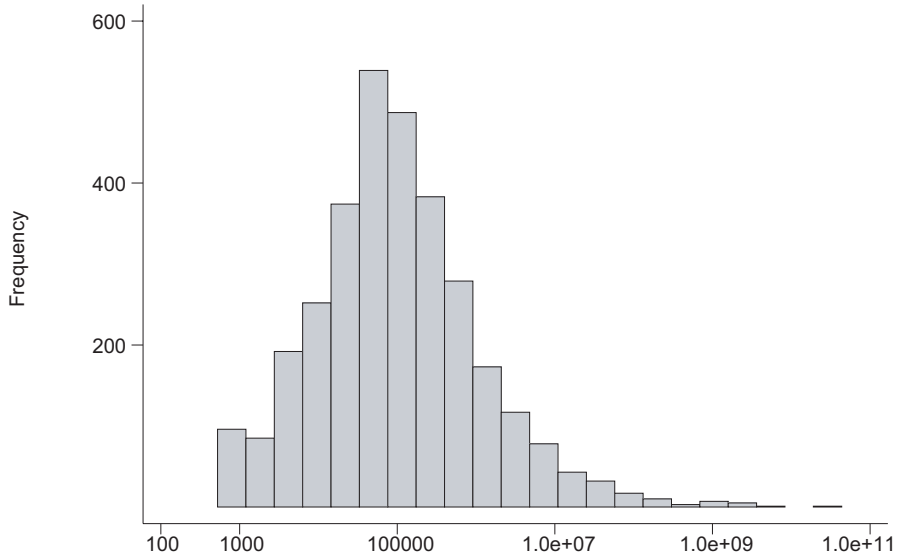
The database includes 6,178 German parent firms with total sales in Germany of 1,150 Billion Euro in 2002. The sample counts 1,748 parent firms in manufacturing with sales in Germany of 954 Billion Euro. While only 0.21% of all German firms are multinational firms, they account for about 27% of total sales in Germany. Multinational firms are large firms, at least on average.

One might expect a priori little heterogeneity within the group of multinational firms because multinational firms are not randomly drawn from a distribution of all firms. Instead, firms select themselves into this group. Thus the within group heterogeneity might be expected to be small. However, as shown in Figure 1, we find huge heterogeneity within the group of multinational firms. German multinational firms' distribution is right skewed. While it is often argued in the literature that large firm are Pareto distributed, the shape shown in Figure 1 shows that the distribution is not too far from log-normal. From this very crude inspection, the distribution of German multinational firms does not differ from other firm size distributions (Sutton 1997, Cabral and Mata 2003).

Table 2 contains information about German parent firms. We report information on the number of German parent firms, the number of foreign affiliates, the volume of German multinational sales and their employees abroad according to the size distribution of German parent firms. We measure this size by their total assets in 2002. Table 2 shows a high concentration of foreign affiliates' activities on few parent firms. Large German multinationals own on average relatively more and larger affiliates. They employ more labor and have higher sales.

In 2002, the largest German multinational parent firms, which represent 1%

Fig. 1. German Multinational Firms' Turnover, (2002, in Thousand Euro)



Source: MIDI, authors' computation.

of the total number of German parents, owns 10% of the number of foreign affiliates. They account for 29.3% of total German multinationals' foreign sales abroad, and make up for 17.8% of German multinationals' foreign employment. Table 2 shows moreover that most of German multinational firms are of smaller size. The three first deciles comprise almost 2/3 of the total number of parent firms. These firms account for only 10% of total German multinational sales abroad and 17.3% of German multinationals' foreign employment. The 62 largest German parent firms own on average 36 affiliates. This is much more than the average 1.4 affiliates which are hold by parent firms in the first decile. Table 2 shows that the larger the German firms, the more foreign affiliates they own.

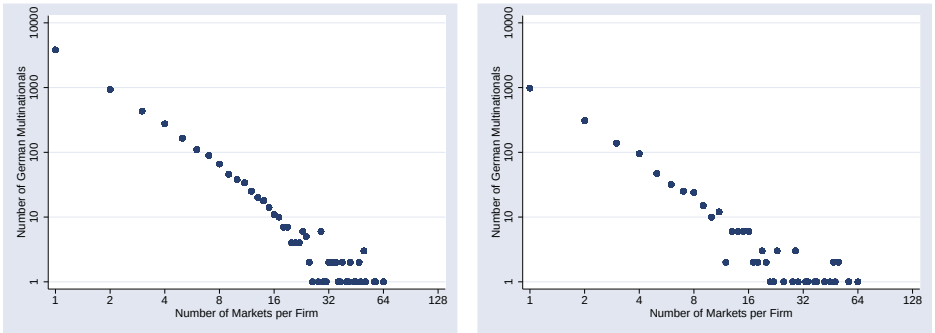
In 2002, about 62% of the total number of German multinational parent firms own affiliates in exactly one market. The share of the parent firms that own affiliates in two to nine countries amounts about 34%. About 4% for the parents firms that invest in more than 10 markets. Thus, German multinational

Table 2
Quantile of German Parent Companies' Total Assets (2002, percent of the total into parentheses)

Decile	Parent companies	Foreign affiliates	Foreign Sales (1000 Euro)	Foreign Employment
1	1454	1980	6.75E+07	334151
	(23.5)	(8.8)	(4.6)	(7.0)
2	1352	2282	4.10E+07	267023
	(21.9)	(10.1)	(2.8)	(5.6)
3	981	2188	4.15E+07	220928
	(15.9)	(9.7)	(2.8)	(4.7)
4	739	2313	5.19E+07	282535
	(12.0)	(10.2)	(3.5)	(6.0)
5	605	2307	6.59E+07	373929
	(9.8)	(10.2)	(4.5)	(7.9)
6	382	2335	8.20E+07	348786
	(6.2)	(10.3)	(5.6)	(7.3)
7	315	2302	1.41E+08	501531
	(5.1)	(10.2)	(9.6)	(10.7)
8	201	2337	2.51E+08	770814
	(3.3)	(10.3)	(17.1)	(16.2)
9	87	2290	2.99E+08	805698
	(1.4)	(10.1)	(20.3)	(17.0)
10	62	2262	4.31E+08	845493
	(1.0)	(10.0)	(29.3)	(17.8)
Total	6178	22596	1.47E+09	4750888

Source: MIDI (2002), authors' computation.

firms are also heterogenous with respect to their degree of internationalization as shown in Figure 2. We illustrate the degree of internationalization of all German multinationals and those from the manufacturing sectors.



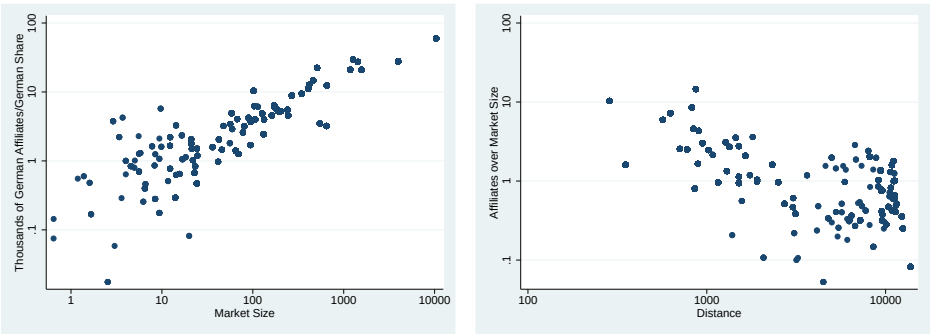
(a) Total (b) Manufacturing

Fig. 2. Market per Firms, 2002

Each panel of Figure 2 represents the frequency with which firms are active in different markets. This frequency decreases. Most firms concentrate their foreign activities in one market while only a few are global players.

About 20% of the total number of German multinational own affiliates in France, which is a large and close-by market. Only very few German firms, in contrast, own an affiliate in Kiribati. The literature using gravity equation states that the number of affiliates in a foreign market increases in the size of this market and decreases in bilateral distance. We show this relationships in Figure 3. We present in panel (a) the correlation between the number of firms weighted by their market share in a particular market and the size of this market. We illustrate in panel (b) the correlation between the number of affiliates weighted by the market size against distance from Germany.

Fig. 3. Number of German firms' foreign affiliates in 2002 and the effect of



(a) Market Size (b) Distance

We show in panel (a) a positive correlation between the number of firms weighted by their market share in a particular market and the size of this market. The picture looks very similar to Eaton *et al.* (2004) results in their study on French exporters. Their results can thus be generalized to (German) multinational firms. The number of (German) multinational firms normalized by (German) market share increases systematically with market size, but with an elasticity less than one. Panel (b) shows a negative correlation between the

number of affiliates weighted by the market size and distance from Germany.

3 Firm Heterogeneity in a Proximity-Concentration Model

Productivity differences are the most likely candidate to cause the huge heterogeneity in size within the group of multinational firms. Helpman *et al.* (2004) were first to incorporate productivity differences in a model of multinational firms. In their model, each firm has a specific level of productivity that the firm draws at entry from a common distribution. Firms can choose between exporting or producing abroad to serve the foreign market. Firms' choice depends on their productivity level. The most productive firms produce abroad, less productive firms export, while the least productive firms do not serve the foreign market at all. A firm that produce abroad can transfer its productivity without deduction to its foreign affiliate(s).

We follow Helpman *et al.* in the general set up. Yet, our focus is different. We want to explain the pattern of multinational firms activities. These activities are to a third activities in wholesales. Thus, we incorporate wholesale activities in the model by allowing for the establishment of a wholesale affiliate in the foreign market. This strategy ranges between exports and production abroad with respect to engagement in the foreign market, i.e. the requirement of fixed costs abroad. The advantage of selling through a wholesale affiliate over exporting through an independent importer is the lower price at which the foreign market is served. This lower price emerges because there is no additional mark-up from the importer on every unit sold abroad. The disadvantage of the wholesale strategy relative to exporting through an independent firm is that it involves additional fixed costs abroad.

We define the productivity level as $1/a_k$ where a_k denotes the marginal cost

of production of a firm k. Market structure is monopolistic competitive, thus profit maximization leads to a price that is a fixed markup over marginal cost. Thus firm k sets its firm-specific producer price to $p_k = a_k/\rho$, where ρ is the degree of differentiation between products, which is assumed to be equal for all firms. Equation (1) described the optimal quantity x_{kij} sold in the sector i of the foreign country j by firm k.

$$x_{kij} = (p_{kj}^h)^{-\sigma} Y_{ij} P_{ij}^{\sigma-1} \tag{1}$$

where $\sigma = 1/(1-\rho)$. P_{ij} denotes the price index in sector i of country j. Y_{ij} denotes total demand in sector i of country j. For the ease of notation we suppress the sector index i in the remainder of the theoretical part. p_{kj}^h is the price of firm k selling in market j. The superscript h, $h = Ex, WS, MNE$, indicates respectively whether a firm is an exporter, establishes a wholesale affiliate or produces abroad.

Each firm can choose between the three channels. Consumer prices of good k that is exported from a firm in another country l, p_{kj}^{Ex} include bilateral iceberg trade costs, τ_{lj}, between the home country l and sales market j. Goods that are sold through a wholesale unit of a multinational firms have a lower price p_{kj}^{WS}. The price includes bilateral iceberg transport costs, t_{lj}, between the home country l and the host country j with $1 < t_{lj} < \tau_{lj}$. We assume that transport costs paid to an independent export firm or a foreign importer τ_{lj} are higher than transport costs between parent firm and wholesale affiliate t_{lj} because internalization of transport services in this case allows gains from specialization and avoids double marginalization. For both reasons, t_{lj} is smaller than τ_{lj}. As argued above, lower unit transport costs t_{lj} of selling through a wholesale affiliate comes at the cost of higher fixed costs for establishing the wholesale network. Hence, $f_{lj}^{WS} > f_{lj}^{Ex}$. We assume however that the fixed costs f_{lj}^{WS} of establishing a wholesale affiliate are lower than fixed costs f_{lj}^{MNE}

of establishing a production unit.

We assume symmetric countries and therefore equal wages in all countries. Firms produce abroad at the same marginal costs as at home, since labor is the only factor of production. Hence, the prices of good k produced abroad are the same as in the home country.

Thus, firm k's good's price in country j is highest if the firms exports it goods produced in l through an independent firm and lowest if firm k produces in country j. The good's price is in between if firm k sells its goods through a foreign wholesale affiliate. The decision between exporting, selling through a wholesale affiliate and producing abroad depends therefore on the absolute and relative levels of trade and transport costs between j and l and on the absolute and relative levels of fixed costs, f_{lj}^{Ex}, f_{lj}^{WS} and f_{lj}^{MNE} respectively, required for each strategy.

Each firm compares the profit related to each mode of entry in market j. Profits in the home market are unaffected by the choice of the strategy. Hence, the choice depends on the comparison of profits in the foreign market, $\{0, \pi_{lj}^{Ex} = \frac{1}{\sigma} p_{lj}^{Ex} x_{lj}^{Ex} - f_{lj}^{Ex}, \pi_{lj}^{WS} = \frac{1}{\sigma} p_{lj}^{WS} x_{lj}^{WS} - f_{lj}^{WS}, \pi_{lj}^{MNE} = \frac{1}{\sigma} p_{lj}^{MNE} x_{lj}^{MNE} - f_{lj}^{MNE}\}$. The choice proves to be productivity dependent. A sorting of firms emerges where the least productive firms serve only their home market, productive firms export, even more productive firms set up a wholesale affiliate, and the most productive firms produce abroad.

Using firms that are indifferent between two strategies we can calculate the critical levels of productivity for each strategy. They are given in equation (2). We use the indifference conditions to derive the critical productivity level (a) for an exporting firm, (b) for a firm selling through a wholesale unit, and (c) for a firm that produces abroad. Firms that have a higher productivity level than $1/a_{lj}^{Ex}$ are active in the foreign market l and earn positive profit there. Firms

that have a productivity level exactly equal to $1/a_{lj}^{WS}$ are indifferent between exporting and selling through a wholesale affiliate because both strategies yield the same profit. Firms with a productivity level higher than $1/a_{lj}^{WS}$ sell through a wholesale affiliate in country j. They have higher profits than firms with a lower productivity level that export to j. The most productive firms (productivity level at least $1/a_{lj}^{MNE}$) produce in the foreign country. They earn the higher profits.

$$1/a_{lj}^{Ex} = \tau_{lj} \left(\frac{1}{\sigma} f_{lj}^{Ex} Y_j \right)^{\frac{1}{\sigma-1}} P_j^{-1} \frac{\sigma}{\sigma - 1} \tag{2a}$$

$$1/a_{lj}^{WS} = \left(\frac{f_{lj}^{WS} - f_{lj}^{Ex}}{t_{lj}^{1-\sigma} - \tau_{lj}^{1-\sigma}} \frac{1}{\sigma} Y_j \right)^{\frac{1}{\sigma-1}} P_j^{-1} \frac{\sigma}{\sigma - 1} \tag{2b}$$

$$1/a_{lj}^{MNE} = \left(\frac{f_{lj}^{MNE} - f_{lj}^{WS}}{1 - t_{lj}^{1-\sigma}} \frac{1}{\sigma} Y_j \right)^{\frac{1}{\sigma-1}} P_j^{-1} \frac{\sigma}{\sigma - 1} \tag{2c}$$

We define $A = \frac{Y_j \sigma^{-\sigma}}{P_j^{1-\sigma}(\sigma-1)^{1-\sigma}}$, solve (2a) for f_{lj}^{Ex} and insert it in (2b). Rearranging terms yields equation 3, which shows that the wholesale firms are more productive than exporting firms.

$$\left(a_{lj}^{WS} t_{lj}\right)^{1-\sigma} A - f_{lj}^{WS} = \left(\left(a_{lj}^{WS} \tau_{lj}\right)^{1-\sigma} - \left(a_{lj}^{Ex} \tau_{lj}\right)^{1-\sigma} \right) A \tag{3}$$

To see this, note that the left hand side must be non-negative, because it expresses the profits of a firm serving the foreign market through a wholesale affiliate. Profits cannot be negative because we assume free exit. Thus, the right-hand side must be non-negative as well what requires that $a_{lj}^{WS} \leq a_{lj}^{Ex}$. The same can be done for a multinational firm producing abroad.

To see whether the minimum productivity level of a firm using a wholesale affiliate is lower than the minimum productivity level of a firm producing abroad, we differentiate the profit difference $\pi^{diff} = \pi^{MNE} - \pi^{WS}$ with respect to the marginal costs a. Since $\frac{\partial \pi^{diff}}{\partial a} = (1-\sigma)(1 - t_{lj}^{1-\sigma}) a^{-\sigma} A < 0$, the profit difference falls in marginal costs and, hence, increases in productivity $1/a$. For

low productivity level, profit difference π^{diff} is negative, because the fixed cost of producing aborad f^{MNE} exceed the fixed costs of the wholesale unit f^{WS}. For high productivity fixed costs differences are of minor importance, relative to the large variable profits. Thus, the profit function of producing abroad cut at $1/a_l j^{MNE}$ through the profit function of using a wholesale affiliate from below. Hence, there exist only wholesale affiliates in equilibrium if $1/a_{lj}^{WS} < 1/a_{lj}^{MNE}$.

Head and Ries (2003) provide empirical evidence for such a sorting from Japanese firms. They show from a sample of large Japanese firms that the more productive of these firms export and hold affiliates abroad while the less productive just export. Using German micro data, Wagner (2006) reports a sorting with respect to productivity where the least productive firms produce only for the home market, while more productive firms serve also foreign markets. The most productive among them have established affiliates abroad.

Since we have data only on the foreign affiliates of German multinational firms, we focus in the following on the characteristics of the groups of multinational firms, i.e. those with wholesale and those with production units. First, note that *within* each group, sales depend on productivity. That is easy to see by multiplying (1) by the price of the good and partially differentiating with respect to the productivity level $1/a_k$. Partially differentiating yields $\frac{\partial p_k x_k}{\partial(1/a_k)} = (\sigma - 1)(1/a_k)^{\sigma-2} Y_j P_j^{\sigma-1} > 0$ and leads to Proposition 1.

Proposition 1: *A more productive firm owns a foreign affiliate that has larger sales.*

Proposition 1 holds for every host market. It is important to stress, that it does not allow size comparison between different host countries. Sales of a foreign affiliate does not only dependent on productivity of the parent firms but is also affected by host country's market size and competition, and by the

distance between the two markets.

Second, there are differences *between* the two groups of multinational firms from the same home country which are active in the same host country.

Proposition 2: *(a) a firm from country l that serves country j through a wholesale unit is less productive than a firm from country l that produces in country j, (b) country j sales of a wholesale unit of a firm from country l are smaller than country j sales of an affiliate from a l-based multinational firm that produces in country j.*

Third, we turn to the decision of *one* particular firm concerning its optimal strategy for *different host countries*. If fixed costs f_{lj}^{MNE} and f_{lj}^{WS} in (2) differ between countries, the decision of firm k differs between countries. Yet, more productive firms are more likely to establish a foreign affiliate in any country. Thus, adding up the foreign affiliates of firm k over all countries, we have that more productive firms are likely to be active in more foreign countries.

Proposition 3: *A more productive firm owns a larger number of foreign affiliates.*

From the critical productivity levels given in equations (2), we can also derive the effect of country characteristics on the internalization decision of firms. All else equal, a larger foreign market Y_{lj} decreases the minimum productivity levels of firms using wholesale affiliates and firms producing abroad. Thus, there are more firms active in a larger foreign country. Trade costs increase the productivity level of firms using wholesale affiliates. Thus, less firms are active in countries further away. If fixed costs are independent of trade costs, trade costs decrease the minimum productivity level of a firm producing abroad. Among the firms from country l active in a foreign country j, the share of firms producing abroad increase with trade costs. Proposition 4 summarizes

the effects of market size and distance on affiliate activities.

Proposition 4: *The number of firms that are active in a foreign country j increases in the foreign country market size and decreases with bilateral trade costs between l and j.*

4 Empirical Results

4.1 Size

In this section, we test each of the proposition using information on manufacturing German parent firms. The sample includes information on 1,748 parent firms classified in manufacturing and their 6,930 foreign affiliates in 2002.

Our test strategy is based on the theoretical model which establishes a direct link between productivity and the size of the parent firm. We therefore use the size of the parent as measure of productivity. We know that productivity is not the only determinant of size. Yet, we are confident that the size of a firm is a good proxy for productivity even in a world where firms are not symmetric with respect to consumer preferences and vertical differentiation also exists. We rely on size because we can not estimate firm-level productivity since we lack data on value added.

Proposition 1 states that more productive, i.e. larger, firms own foreign affiliates that have larger sales in a foreign country. The empirical test of proposition 1 is thus straight forward. We regress the logarithm of the size of the foreign affiliate on the logarithm of the size of the parent firm. We add country fixed effects and two set of sector dummy variables related to the sector of the affiliate, D_i^a, and to the sector of the parent firm, D_i^p. We control for the fact that a parent firm can own several affiliates by clustering the standard errors

around the parent firm identity. Given country and sector fixed effects, we expect a positive impact of the size of the parent firm on the affiliate size.

$$\ln(\text{size affiliate}_{kij}) = \underset{(7.18)}{4.873} + \underset{(12.66)}{0.184} \ln(\text{parent size}_k) + D_i^a + D_i^p + D_j + u_{kij}$$

The R^2 is 0.28. The variation of the parent firm size and the fixed effects explain thus 28% of the variation of the foreign affiliate size. The parent firm size has a positive and significant impact on the size of the foreign affiliate.

Turning to proposition 2, it states that a firm that serves the foreign market through a wholesale affiliate is less productive (i.e. smaller at home) and has smaller sales in country j than a firm that produce in country j. To test this proposition we must first distinguish between firms selling through a wholesale unit and firms producing aborad. We do this by using the sector classification of firms and affiliates. In the data, affiliates and parent firms are classified according to the sector they are engaged in. For our analysis, we define a parent firm classified in manufacturing that has affiliates active *only* in the wholesale sector of a particular country as a firm selling through a wholesale unit. We define a manufacturing parent firm which holds affiliates that are active in manufacturing as firm producing abroad. Not surprisingly, many firms own both wholesale affiliates and affiliates in manufacturing, although not often in the same country. In fact, only 8% of all multinational firms-host country pairs in 2002 involve firms that hold a wholesale affiliate *and* a affiliate classified in manufacturing. Hence, the postulated choice between the two strategies matches the data well.

Because of the multi-unit structure of many firms, a test of Proposition 2a relies on a inter-group comparison of *parent* firms size from parent firms with wholesale or manufacturing affiliates in a particular country. Relying only on information of firms with affiliates in just one country reduces the number of

observations drastically. We are therefore restricted to evidence from the US when testing proposition 2a. Subtracting affiliates from firms that hold both, affiliates in wholesale and in manufacturing, German firms have established 220 affiliates in manufacturing and 202 affiliates in wholesale in the US. That allows to compare the two distributions.

We analyze systematic differences between both distribution using the non-parametric Kolmogorov-Smirnov test (KS-test). The two-sided KS-test has the advantage of making no assumption about the distribution of data. It determines whether two distributions differ significantly. Therefore it calculate the largest difference between the observed and expected cumulative frequencies, which is called *D-statistics*. These statistics are compared against the critical D-statistics for that sample size. The results of the two-sided KS-test is shown in Table 3. The second line of Table 3 test the hypothesis that *parents* of affiliates in manufacturing have smaller sales than those with affiliates in wholesales. The largest difference between the distributions functions is 0.4166 which is statistically significant at 1%. Thus, the null hypothesis that parents with affiliates in manufacturing are smaller is rejected. The third line test the hypothesis that manufacturing contains larger values than wholesales. The largest difference between the distributions functions is -0.0384 which is not significant.

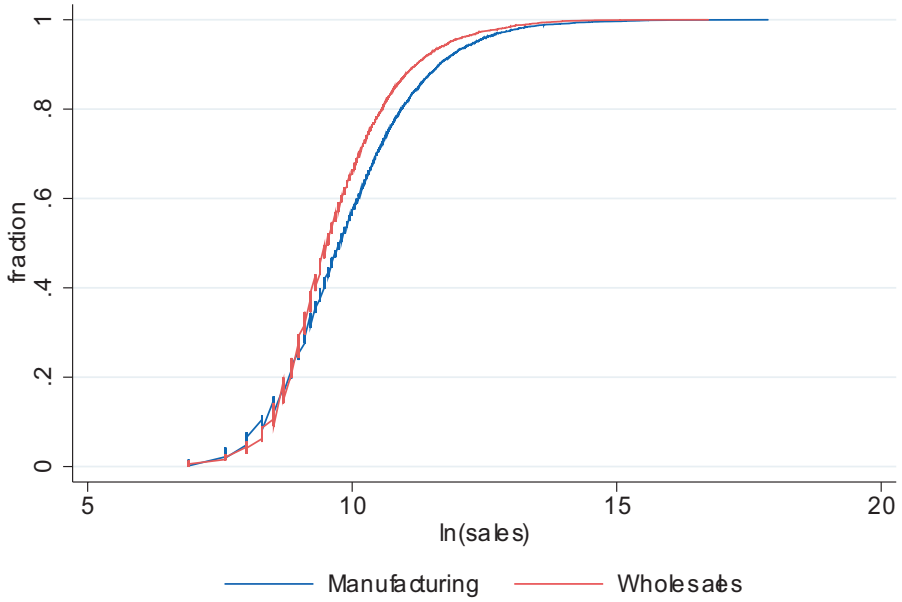
Table 3
KS Test of Differences between parents holding manufacturing affiliates and wholesale affiliates in the US

Group	Largest Difference	*P-value*	Corrected
Ho: $M - W \leq 0$	0.4166	0.000	
Ho: $W - M \leq 0$	-0.0384	0.692	
Combined K-S-Test	0.4166	0.000	0.000

Source: MIDI (2002), authors' computation.

Proposition 2b, in contrast, states that *affiliates* in wholesale have smaller sales than affiliates in manufacturing. Having grouped the firms in those which hold

Fig. 4. Cumulative Distribution of Foreign Affiliates' Sales (2002)



Source: MIDI, authors' computation.

a wholesale unit and those which produce abroad, we first look at the cumulative distribution of the foreign *affiliates* in wholesale, W, and in manufacturing, M. They are shown in Figure (4). The graph points to a first-order stochastic dominance of manufacturing affiliates with respect to sales. Manufacturing affiliates are larger than wholesale affiliates over the whole distribution.

The results of the two-sided KS-test is shown in Table 4. The second line of Table 4 test the hypothesis that affiliates in manufacturing have smaller sales than those in wholesales. The largest difference between the distributions functions is 0.069 which is statistically significant at 1%. Thus, the null hypothesis that affiliates in manufacturing are smaller is rejected. The third line test the hypothesis that manufacturing contains larger values than wholesales. The largest difference between the distributions functions is -0.0275 which is not significant.

From the two-sided test of Table 4, we clearly reject the hypothesis that manufacturing and wholesale affiliates have equal size distribution. We cannot reject

Table 4
KS Test of Differences between manufacturing affiliates and wholesale affiliates

Group	Largest Difference	*P-value*	Corrected
Ho: $M - W \leq 0$	0.0696	0.000	
Ho: $W - M \leq 0$	-0.0275	0.157	
Combined K-S-Test	0.0696	0.000	0.000

Source: MIDI (2002), authors' computation.

the stochastic dominance of manufacturing size distribution over wholesale size distribution. However, we can reject the stochastic dominance of wholesale size distribution over manufacturing size distribution.

4.2 Intensive and Extensive Margins

A new feature of the proximity-concentration model with heterogenous firms is that not only the number of foreign affiliates (extensive margin) but also their average sales (intensive margin) adjust to changes in market size or trade costs. In our multi-unit firm framework, there exist two extensive margins. First, a new firm might enter a foreign market and become a multinational. Second, a multinational firm might set up a new affiliate in a country which it has served through exports before.

Proposition 3 refers to the second extensive margin. It states that a more productive firm owns a larger number of foreign affiliates. In order to test this proposition, we regress the number of foreign affiliates on the size of the parent firm from a manufacturing sector and add a set of parent firm's sector specific effects. We estimate a negative binomial regression model since we find overdispersion in the data. When there is overdispersion the poisson estimates are inefficient with standard errors biased downward yielding spuriously large z-values. We control for the fact that a parent firm can own several affiliates by clustering the standard errors around the parent firm identity. We also include sector fixed effects. We expect a positive impact of the size of the parent firm

on the number of foreign affiliates.

$$\begin{array}{lccc} (\text{number of affiliates})_k = & 1.381 & + & 0.139 \\ & (6.05) & & (2.58) \end{array} \ln(\text{parent size}_k) + D_i^p + u_k$$

The Cragg and Uhlher R^2 is 0.17 meaning that the variation of the parent firm size and the fixed effects explain about 17% of the variation of the number of foreign affiliates. Computing the marginal effects of the parent size on the number of foreign affiliates, we find that a one percent increase in the size of the parent firm, increases the number of foreign affiliate by 0.54%. The size of the parent firm has a positive and significant impact on the number of foreign affiliates. We interpret this as positive effect of productivity of the parent firm on the number of its foreign affiliates.

In order to analyze more precisely the respective importance of the extensive and intensive margins, we conduct a simple regression analysis similar to Eaton *et al.* (2005) and Yeaple (2005). We use a gravity equation to decompose changes in market size and trade costs into the extensive and intensive margins. The gravity equation states that host country's market size has a positive effect on the volume of affiliates' sales while geographic, regulatory and cultural transaction costs between countries have a negative effect (Kleinert and Toubal, 2009). The different transaction costs can be summarized by the market share of foreign affiliates of German multinational firms in country j, λ_{lj}. This share is calculated as the share of German affiliates' sales S_{lj} in total sales in country j X_j. Yet, total sales of German firms' foreign affiliates in country j S_{lj} can also be decomposed in the number of German firms' foreign affiliates N_{jl} and the average size of a German foreign affiliate in country j $\bar{s_{lj}}$. Thus, sales of all German multinational affiliates in market j, S_{jl} can be expressed as:

$$S_{lj} = N_{lj}\bar{s_{lj}} = \lambda_{lj}X_j \tag{4}$$

Total sales in country j X_j equals country's j absorption defined as gross

Table 5
Intensive and Extensive Margin, (2002)

	Label	Manufacturing Affiliates	Wholesale Affiliates
German Market Share	λ_{jl}	0.64***	0.63***
		(0.04)	(0.04)
Absorption	X_j	0.66***	0.63***
		(0.04)	(0.03)
Constant		-11.02***	-10.85***
		(1.01)	(0.84)
Nb. Obs.		721	685
R^2		90.62	86.50

Robust standard errors into parentheses. Standard errors have been adjusted for clustering around the country's identity.
*** denotes statistical significance at one percent level.

production plus import minus export. We regress the logarithm of $N_{lj} \equiv S_{lj}/\bar{s}_{lj}$ on the logarithm of German firms' market share in country j and the logarithm of absorption X_j in country j to show how much of the variation in German multinationals' sales is due to variation in the market share of German affiliates and how much to variation in market size of country j. To explore the possibility that aggregate sample masks effects of sectoral variation of multinational sales across countries, we conduct this decomposition using a full set of country specific dummy variables.

Table (5) shows two different specifications corresponding to activities of foreign affiliates. We interpret the coefficient estimates in the manufacturing sectors as follow: given country's market size, a higher German multinational market share is due to a 64% increase in the number of affiliates and a 36% increase in the average sales per affiliate. Further, given the market share of German multinational firms, a larger market reflects 66% more affiliate and 34% more sale per firms. These results are in line with the results found by Yeaple (2005) for foreign affiliates of US manufacturing firms. Much of the variation of German multinational sales across countries is due to variation in the number of firms participating in the market.

The estimated parameters for affiliate in manufacturing are lower as the parameters in Eaton *et al.* (2004) who analyze international trade of French firms. That should be expected if fixed costs of production abroad are higher than fixed costs of exporting. We also estimated the adjustment of wholesale affiliate of German multinational firms. We expected their coefficients in-between those of our manufacturing units and those of Eaton *et al.*'s exporter. Surprisingly, wholesale affiliates' adjustment to changes in market size and the German market share does not differ significantly from those of manufacturing affiliates of German multinational firms. Given country's market size, a higher German multinational market share is due to a 63% increase in the number of affiliates and a 37% increase in the average sales per affiliate. Further, given the market share of German multinational firms, a larger market reflects 63% more affiliate and 37% more sale per firms. The adjustment through the extensive margin is lower as Eaton *at al.* (2004)'s estimates for France. We believe that the difference in the results stems from our smaller sample of wholesale affiliates which is biased towards larger firms. In sum, the results show that adjustment through the extensive margin in our sample is almost twice as large as adjustment through the intensive margin.

5 Conclusion

We examine firm heterogeneity using information from a comprehensive dataset on multinational activities. Therefore, we derive four propositions from a proximity-concentration model with heterogenous firms and test them. The empirical analysis strongly supports all four theoretical predictions.

First, we show that larger firms have larger affiliates. Second, firms selling through wholesale units in a particular country are less productive than firms

that produce in this country. The sales of an wholesale units in a particular country are smaller than the sales of a multinational firm's affiliate that produces there. Third, more productive firms own a larger number of foreign affiliates. The probability of producing in a particular foreign country increases with productivity. Hence, the adjustment to changes of market size and/or trade costs through the extensive margin is largely driven by an increasing number of affiliates of existing multinational firms. Fourth, we conduct a deeper analysis of the respective importance of the extensive and intensive margins. We show that the extensive margin is twice as important as the intensive margin.

References

Bernard, Andrew B. and Jensen, J. Bradford (1995). Exporters, Jobs, and Wages in U.S. Manufacturing: 1976-1987. Brookings Papers on Economic Activity: Microeconomics: 67-119.

Bernard, Andrew B. and Jensen, J. Bradford (1999a). Exceptional Exporter Performance: Cause, Effect, or Both? Journal of International Economics 47: 1-25.

Bernard, Andrew B. and Jensen, J. Bradford (1999b). Exporting and Productivity. NBER Working Paper No. 7135.

Bernard, Andrew B., Jensen, J. Bradford and Peter, K., Schott (2005). Importers, Exporters and Multinationals: A Portrait of Firms in the US that Trade Goods. NBER Working Paper No. 11404.

Clerides, Sofronis, Lach, Saul, and Tybout, James R. (1998), Is Learning by Exporting Important? Micro-Dynamic Evidence from Colombia, Mexico, and Morocco. Quarterly Journal of Economics 113 : 903-947.

Eaton, Jonathan, Kortum, Samuel, and Francis Kramarz (2004). Dissecting

Trade: Firms, Industries and Export Destinations. American Economic Review 94(2): 150–154.

Girma, Sourafel, Görg, Holger and Erik Strobl (2004). Exports, international investment, and plant performance: Evidence from a non-parametric test. Economics Letters, 83 (3): 317-324.

Head, Keath and Ries, John (2003). Heterogeneity and the FDI versus Export Decision of Japanese Manufacturers. Journal of the Japanese and International Economies, 83 (3): 317-324.

Helpman, Elhanan, Melitz, Marc J., and Yeaple, Stephen R. (2004). Export Versus FDI with Heterogeneous Firms. *American Economic Review* 94 (1), 300–316.

Kleinert, Jörn and Farid Toubal (2009). Gravity for FDI. *Review of International Economics*. forthcoming.

Melitz, Marc J. (2003). The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity. *Econometrica* 71 (6), 1695–1725.

Wagner, Joachim (2006). Exports, Foreign Direct Investment, and Productivity: Evidence from German Firm Level Data. *Applied Economic Letters* 13(6): 347–349.

Yeaple, Stephen R. (2005). Firm Heterogeneity and the Structure of US Multinational Activity: An Empirical analysis. University of Pennsylvania, Mimeo, march 2005.