Financial Constraints and the Margins of FDI

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Abstract

Recent literature on multinational firms has stressed the importance of low productivity as a barrier to the cross-border expansion of firms. But firms may also face financial barriers if they need external finance to shoulder the costs of entering foreign markets. We develop a model of multinational firms facing real and financial barriers to foreign direct investment (FDI), and we analyze their impact on the FDI decision (the extensive margin) and foreign affiliate sales (the intensive margin). We provide empirical evidence based on a detailed dataset of German multinationals which contains information about the location and financial conditions of firms' foreign affiliates. We find that financial factors constrain firms' foreign investment decisions, an effect felt in particular by more productive firms. Financial constraints at the parent level matter for the extensive, but less so for the intensive margin. For the intensive margin, financial constraints at the affiliate level are decisive.

Keywords: multinational firms, heterogeneity, productivity, financial constraints

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Non-technical Summary

Multinational firms are larger than their domestic counterparts. Recent literature stresses differences in firm-level productivity as the main reason for differences in the internationalization of firms. Yet, the two groups of firms also differ in a number of other respects. Multinational firms in Germany, for instance, have lower debt ratios and higher cash flows. This suggests difficulties in obtaining external finance as an additional impediment to foreign expansions.

The purpose of this paper is to assess the importance of real and financial barriers for the cross-border expansion of firms. We distinguish between the decision to enter a foreign market for the first time (the extensive margin) and the decision on the volume of foreign affiliate sales (the intensive margin). We proceed in two steps.

In a first step, we theoretically analyze how productivity and financial constraints affect a firm's choice to become a multinational firm under conditions of limited internal funds and the need to obtain external debt finance. Our model features limited contract enforceability and liquidation costs as two sources of inefficiencies in financial contracting that are particularly relevant for foreign investments. The model provides a set of testable implications concerning the impact of financial constraints, productivity, and host-country characteristics on firms' internationalization choices.

In a second step, we provide empirical evidence using data for German firms. We obtain information on the foreign affiliates of German firms from a detailed firm-level database provided by the Deutsche Bundesbank: the Micro-Database Direct Investment (*MiDi*). Furthermore, we use data on the balance sheets of firms in Germany from the *Dafne* database provided by *Bureau van Dijk* as well as data from *Hoppenstedt.* Our data are unique as they allow measuring financial constraints and productivities at the parent level for domestic firms and for multinationals, as well as financial constraints at the affiliate level. This enables us to analyze the extensive and the intensive margins of FDI. Furthermore, we can evaluate the relative importance of financial constraints at the parent and at the affiliate level, a question that has not been addressed in the literature so far. In contrast to earlier work focusing on manufacturing firms, our sample also contains services firms.

As predicted by our model, we find that productivity and financial constraints have a significant impact on German firms' internationalization decision. Economically, productivity constraints are more important, reflecting that financial constraints matter only to the subset of firms that consider investing abroad. We also investigate the relative importance of financial constraints for the extensive and the intensive margins of foreign expansion. Our model suggests that the extensive margin is more likely to be affected than the intensive margin, unless financial constraints are severe. Our empirical analysis shows that parent financial constraints have indeed a negative impact on the extensive margin of FDI, but less so on the intensive margin. However, we also find that, in contrast to the parent level constraints, the affiliate's financial constraints matter for the intensive margin. This observation points towards a hierarchy of financing the intensive margin, with affiliate financing being preferred over parent financing.

Nicht technische Zusammenfassung

Multinationale Unternehmen sind größer als rein national agierende Firmen. Die aktuelle Forschungsliteratur auf diesem Gebiet betrachtet Unterschiede in der Produktivität auf Firmenebene als wesentlichen Grund für unterschiedliches Expansionsverhalten von Firmen auf internationalen Märkten. Jedoch unterscheiden sich die beiden Gruppen von Unternehmen auch hinsichtlich anderer Merkmale. Beispielsweise haben multinationale deutsche Unternehmen vergleichsweise geringere Fremdkapitalanteile und höhere Cashflows. Dies weist darauf hin, dass Schwierigkeiten bei der Fremdfinanzierung eine zusätzliche Barriere auf dem Weg zur Expansion ins Ausland darstellen können.

Ziel dieses Papiers ist es, die Relevanz von realwirtschaftlichen und finanziellen Barrieren für die Expansion von Unternehmen in das Ausland genauer zu untersuchen. Wir unterscheiden zwischen der Entscheidung, zum ersten Mal in einen ausländischen Markt einzutreten (extensiver Rand) und der Veränderung des Umsatzes bei bereits im Ausland ansässigen Tochterunternehmen (intensiver Rand). Die Analyse erfolgt in zwei Schritten.

Zunächst untersuchen wir theoretisch, inwieweit die Produktivität und etwaige Finanzierungsbeschränkungen die Entscheidung eines Unternehmens, multinational zu werden, beeinflussen. Dies geschieht unter der Annahme, dass unternehmensinterne Finanzmittel für eine Expansion unzureichend sind, und deshalb eine Fremdfinanzierung durch Verschuldung notwendig ist. Unser Modell beinhaltet zwei Ursachen für das Auftreten von Ineffizienzen bei Finanzierungsgeschäften, zum einen auftretende Liquidationskosten und zum anderen beschränkte Möglichkeiten der Vertragsdurchsetzung. Gerade bei Investitionen im Ausland sind diese beiden Hindernisse besonders relevant. Das Modell führt zu einer Reihe von empirisch überprüfbaren Schlussfolgerungen, inwieweit Finanzierungsbeschränkungen, Produktivitätsunterschiede und Ländercharakteristika die Internationalisierungsentscheidungen von Unternehmen beeinflussen.

Im zweiten Schritt liefern wir die dazugehörigen empirischen Ergebnisse. Wir verwenden Daten deutscher Unternehmen. Detaillierte Informationen über Tochterunternehmen deutscher Firmen im Ausland entnehmen wir aus der Mikrodatenbank Direktinvestitionen (*MiDi*) der Deutschen Bundesbank. Außerdem verwenden wir Bilanzdaten deutscher Unternehmen aus *Dafne*, bereitgestellt durch das *Bureau van Dijk* sowie Daten aus der *Hoppenstedt* Bilanzdatenbank. Unsere Daten erlauben die Messung von Finanzierungsbeschränkungen und Produktivität sowohl für rein national tätige Firmen als auch für die Muttergesellschaften multinationaler Unternehmen. Darüber hinaus ermöglichen sie die Untersuchung von Finanzierungsengpässen bei den ausländischen Niederlassungen. Des Weiteren können wir die relative Bedeutung von Finanzierungsbeschränkungen auf Ebene von Mutter- und Tochterunternehmen bestimmen, was unseres Wissens bisher in der Literatur noch nicht durchgeführt wurde. Im Gegensatz zu früheren Arbeiten, die auf sich auf Unternehmen des Verarbeitenden Gewerbes konzentrierten, beinhaltet unser Datensatz auch Dienstleistungsunternehmen.

Wir bestätigen empirisch die von unserem theoretischen Modell entwickelte These, dass sowohl Produktivität als auch Finanzierungsbeschränkungen einen signifikanten Einfluss

auf die Internationalisierungsentscheidungen deutscher Unternehmen haben, wobei die Produktivität für eine Entscheidung eine größere Rolle spielen. Dies spiegelt wider, dass Engpässe bei der Finanzierung überhaupt nur für den Teil der Unternehmen relevant sind, die eine Expansion in das Ausland in Betracht ziehen. Wir untersuchen darüber hinaus die relative Bedeutung von Finanzierungsbeschränkungen am intensiven und am extensiven Rand. Unser Modell lässt darauf schließen, dass der extensive stärker als der intensive Rand von Finanzierungsbeschränkungen betroffen ist, solange diese Beschränkungen nicht zu stark greifen. Unsere empirische Analyse zeigt, dass Finanzierungsengpässe beim Mutterunternehmen einen negativen Einfluss auf die Wahrscheinlichkeit haben, im Ausland Tochterunternehmen zu halten. Der Einfluss auf den Umsatz der Niederlassung ist indessen geringer. Entgegen der geringen Relevanz der Finanzierungsbeschränkungen der Mutter auf den Umsatz der Tochter spielen solche Beschränkungen, wenn sie auf Ebene des Tochterunternehmens vorliegen, jedoch sehr wohl eine Rolle. Diese Beobachtung deutet auf eine Hierarchie bei der Finanzierung der Produktion der ausländischen Niederlassungen hin. Offenbar wird eine Finanzierung durch die im Ausland ansässige Tochter einer Finanzierung durch das Mutterunternehmen vorgezogen.

1 Motivation

Multinational firms are larger than their domestic counterparts. For European firms, Mayer and Ottaviano et al. (2007) show that multinational firms are also more productive, generate higher value added, pay higher wages, employ more capital per worker, and they employ a larger number of skilled workers. In the theoretical literature, the characteristic size patterns of multinational firms are explained mainly by differences in productivity. According to this explanation, observed internationalization patterns reflect real constraints since only the more productive firms can afford to shoulder the fixed costs of market entry.

These stylized facts are confirmed by our data for German companies, where firms owning foreign affiliates are indeed substantially larger than purely domestic firms (Graph 1a). Yet, the two groups of firms also differ in a number of other respects. Multinational firms, for instance, have lower debt ratios and higher cash flows. This suggests difficulties in obtaining external finance as an additional impediment to foreign expansions.[1] However, most of the theoretical literature considers the impact of financial constraints to be of lesser importance, arguing that foreign direct investment (FDI) and the associated financing decisions can largely be treated separately.[2]

The purpose of this paper is to assess the (relative) importance of real and financial barriers for the cross-border expansion of firms. In doing so, we distinguish between the decision to enter a foreign market for the first time (the extensive margin) and the decision on the volume of foreign affiliate sales (the intensive margin). We proceed in two steps. In a first step, we theoretically analyze how productivity and financial constraints affect a firm's choice to become a multinational firm under conditions of limited internal funds and the need to obtain external debt finance. Our model features limited contract enforceability and liquidation costs as two sources of inefficiencies in

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1 In the crisis that started in 2007, for instance, an increasing number of German firms reports credit constraints as an impediment to expansion into foreign countries (DIHK 2009).

2 See, for example, Markusen (2002).

financial contracting that are particularly relevant for foreign investments. The model provides a set of testable implications concerning the impact of financial constraints, productivity, and host-country characteristics on firms' internationalization choices.

In a second step, we provide empirical evidence using data for German firms. We obtain information on the foreign affiliates of German firms from a detailed firm-level database provided by the Deutsche Bundesbank: the Direct Investment (*MiDi*) Micro-Database. Furthermore, we use data on the balance sheets of firms in Germany from the *Dafne* database provided by Bureau van Dijk. Our data are unique as they allow measuring financial constraints and productivities at the parent level for domestic firms *and* for multinationals, as well as financial constraints at the affiliate level. This enables us to analyze the extensive and the intensive margins of FDI. Furthermore, we can evaluate the relative importance of financial constraints at the parent and at the affiliate level, a question that has – to the best of our knowledge – not been addressed in the literature so far. In contrast to earlier work focusing on manufacturing firms, our sample also contains services firms.

Our research is motivated by recent theoretical work stressing the importance of productivity for firms' international expansions (e.g. Melitz 2003, Helpman et al. 2004) The key to these models is that, ex ante, firms do not know the firms' productivity. Upon entry, firms draw their productivity from a commonly known productivity distribution, and the level of productivity becomes common knowledge as well. Depending on the level of productivity, firms exit the market, they produce only for the domestic market, they become exporters, or they set up affiliates abroad.

The implicit assumption of these models is that firms can finance foreign operations internally and/or without incurring an external finance premium. Recent papers introduce financial constraints into the Melitz model. The focus of these models is on firms' decisions to export. Chaney (2005) predicts that financially constrained firms are less likely to be able to cover the fixed costs of exporting. Manova (2006) examines the interaction of productivity and credit constraints and their impact on the export decision as well as the volume of export.

Recent empirical work shows that financial frictions indeed affect export behavior. Using panel data on bilateral exports at the country level, Manova (2006) finds that financially more developed countries are more likely to export, and that the effect is more pronounced in financially vulnerable sectors. Firm-level studies show that financial constraints matter more for the extensive margin than for the intensive margin of exports (Berman and Héricourt 2008), that export starters enjoy better financial conditions (Bellone et al. 2008), and that financially healthy firms are more likely to export (Greenaway et al 2007).[3] Stiebale (2008), in contrast, finds no effect of financial constraints on a firm's export decision once observed and unobserved firm heterogeneity is accounted for.

This paper provides complementary evidence on the role of financial frictions for FDI. As predicted by our model, we find that productivity and financial constraints have a significant impact on German firms' internationalization decision. Economically, productivity constraints are more important, reflecting that financial constraints matter only to the subset of firms that consider investing abroad. Our model also suggests that the extensive margin is more likely to be affected than the intensive margin, unless financial constraints are severe. Our empirical analysis shows that parent financial constraints have indeed a negative impact on the extensive margin of FDI (the probability to hold foreign affiliates), but less so on the intensive margin (affiliate sales). A similar observation has been made by Berman and Héricourt (2008) for exports. However, we also find that, in contrast to the parent-level constraints, the affiliate's financial constraints matter for the intensive margin. This observation points towards a hierarchy of financing the intensive margin, with affiliate financing being preferred over parent financing.

In the following section, we present our model of multinational firms. In section three, we describe our data and provide descriptive statistics. Section four provides empirical evidence, and section five concludes.

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[3] Evidence on the reverse causality from exporting to financial conditions is mixed (Bellone et al. 2008, Greenaway et al. 2007).

2 Finance and the Margins of FDI: Theory

In this section, we analyze a firm's choice to become a multinational firm and the sales of its foreign affiliates in the presence of financial constraints. Firms incur fixed costs of market entry as well as variable costs of production. They finance their foreign expansion using internally generated funds as well as an external bank credit, potentially secured by collateral. Financing decisions are made under uncertainty.

Financial constraints are firm-specific; they do not merely reflect differences across firms with regard to productivity. We do not specify the sources of "financial heterogeneity" but there are several reasons why firms may have different financial constraints. Firms differ, for instance, with regard to their customer structure and, thus, the probability of being hit by an adverse demand shock. Firms also differ with regard to the quality of their management and, thus, the ability of outside lenders to extract information on the profitability of an investment project.

Financial contracting in our model suffers from potential inefficiencies due to limited enforceability of financial contracts, a problem particularly relevant when investing in a foreign country. Enforceability differs across countries and may be linked to the development of the financial market as well as the presence of home country banks abroad. With limited contract enforcement, collateral may be required to obtain credit financing. However, collecting and liquidating collateral generates transaction costs, and the amount of collateral available may be limited. The need for costly and limited collateral confines the use of external finance and thus the foreign expansion of firms.

To see how the model works, consider the decision problem of a multinational firm that can invest abroad to serve the foreign market.[4] The firm's alternative investment option is normalized to zero.[5] To set up a foreign affiliate, the firm has to incur a fixed cost of

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[4] We focus on horizontal FDI. The qualitative implications of our model with regard to the impact of financial constraints would also go through for vertical FDI.

[5] It is straightforward to extend our model and to include an outside option like exports that depends positively on the firm's productivity. As we show in Buch et al. (2009), the firm's productivity level matters relatively more for the investment opportunity abroad than for the outside option of exporting which leaves the qualitative results of our model unchanged.

market entry F. Once the firm has decided to set up a foreign affiliate, it has to choose the level of sales. Thus, we capture both the extensive and the intensive margins of the firm's foreign expansion strategy. To fix ideas, consider the following variable production cost function, $k(x) = \frac{x^2}{2(1+\beta)}$, where x denotes the quantity produced and sold by the foreign affiliate. The productivity of the parent firm, which also spills over onto the foreign affiliate, is captured by β. The larger the fixed cost of entry and the lower a firm's productivity, the larger are the "real barriers" that a firm faces when entering foreign markets.

The firm also faces a "financial barrier" in the form of a cash-in-advance constraint because set up and production costs have to be paid before production starts and before revenues are generated. Revenues that can be generated on the foreign market are uncertain. Serving the foreign market yields positive revenues px with probability q and zero revenues with probability $(1-q)$, where p is the foreign price level.[6]

Benchmark case without liquidity constraints

Before we describe the impact of financial constraints on investment decisions, consider as a benchmark the first-best situation where the firm is not liquidity constrained. The firm can finance both the fixed cost of entry and the variable cost of production from internal funds L. Thus, it maximizes the following profit function:

$$(1) \qquad \pi = qpx - k(x) - F = qpx - \frac{x^2}{2(1+\beta)} - F$$

Taking the first-order condition, solving for the optimal sales of the affiliate $x_{FB} = (1+\beta)qp$ and inserting it back into the profit function (1) yields the following profits under the first-best solution (*FB*):

$$(1') \qquad \pi_{FB} = \frac{1}{2} q^2 p^2 (1+\beta) - F$$

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[6] We abstract from exchange rate changes, i.e. revenues generated on the foreign market can be remitted 1:1 into domestic currency. Russ (2007) has a model in which endogenous adjustment of exchange rates affects firms' entry decisions.

Thus, if liquidity is not an issue, the investment takes place if and only if $\pi_{FB} \geq 0$, i.e. if net profits of the investment are positive. Not surprisingly, profits depend positively on the firm's productivity (β), i.e. less productive firms are less likely to be able to cover the fixed cost of market entry.

Foreign expansion with liquidity constraints

Consider now the situation where the firm is liquidity constrained, i.e. its liquid assets L are not sufficient to cover the costs associated with market entry and production. Thus, the firm needs external finance. We assume that external finance is raised in the form of debt finance and, specifically, credits from banks.[7] This assumption reflects the fact that external equity finance plays a limited role for German firms (Bayraktar et al. 2005). Also, theoretical considerations suggest a "pecking order" of external finance according to which external equity finance and portfolio capital are dominated by bank lending.

Let D denote the credit necessary to finance the fixed and variable costs of entry for a production level x, given the available liquid funds L, i.e. $D = k(x) + F - L$. Furthermore, let $(1+r)D$ denote the repayment of principal plus interest payment that the firm is supposed to pay. Like Chaney (2005) and others, we assume that credit repayment is possible only if the affiliate's revenues are positive. In particular, we rule out the possibility that the parent firm steps in and repays the affiliate's credit if the affiliate is not able to do so. This implies also that the credit repayment $(1+r)D$ cannot exceed the revenues px, i.e. $(1+r)D \leq px$. Banks are assumed to operate competitively and to determine the interest rate such as to just break even in expected terms.

To capture enforcement problems in financial contracts, we assume that credit repayment cannot be enforced with certainty, even if revenues are positive, but only with probability μ, with $0 \leq \mu < 1$. The enforcement parameter μ has two interpretations. On the one hand, it can reflect different institutional quality across countries. Legal systems may, for

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[7] Firms can obtain credits from domestic or foreign banks. We do not model this choice explicitly and hence do not impose restrictions with regard to the degree of integration of financial markets. However, domestic and foreign banks may differ with regard to their ability to enforce contracts. For instance, if domestic banks maintain affiliates in the foreign country, too, they are in a better position than banks operating abroad solely to monitor the affiliates and collect collateral.

instance, differ with regard to the degree of creditor friendliness and the enforceability of contracts.[8] On the other hand, it could reflect a greater presence of home-country multinational banks in the host country. These banks may be able to acquire useful information on the host-country environment and be able to monitor firms more closely through their affiliates abroad. This reduces informational asymmetries and makes it more likely that credit enforcement is successful.

The firm can collateralize (part) of its credit with assets from two potential sources. First, the firm can pledge its fixed cost investment in the foreign affiliate, *F*, as collateral. Second, the firm can use an exogenously given collateral, $\overline{C}$, provided by the parent company, to secure the credit. Let $C \leq \overline{C} + F$ denote the collateral actually chosen to secure the credit, the exact value of which is determined endogenously below. If the credit is not repaid, the creditor can seize the collateral to cover her losses. However, she can realize only a fraction θ of the collateral when liquidating it.[9] Thus, liquidating the collateral involves a dead weight loss of $(1-\theta)C$.

There are two situations where liquidation of a collateral (potentially) becomes an issue. Suppose the affiliate has positive revenues but the creditor fails to be able to enforce the repayment. Then, the bank has the option to liquidate the collateral. However, it would be inefficient to do so, due to the dead weight loss of liquidation. In this case, we assume that efficient renegotiation will make the firm pay θC, i.e. the amount that the bank can realize from liquidating the collateral, to avoid inefficient liquidation, and the bank will accept this offer.[10] If revenues are not positive, however, liquidation of the collateral cannot be avoided.

Now, consider the zero profit condition for banks which determines the interest rate for a given choice of *C*:

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[8] Harrison et al. (2004) report that financial development lowers financial constraints.

[9] Without loss of generality, we assume that the efficiency loss is the same for both kinds of collateral goods.

[10] This assumes that the creditor can hold the bank down to its outside option of liquidating the collateral. It would be straightforward to modify this assumption and let the two parties split the gains from not liquidating the collateral. However, given our assumption of a perfectly competitive banking market, the first assumption seems to be the most convincing one.

$$(2) \qquad \mu q(1+r)D + (1-\mu q)\theta C = D$$

Banks obtain the promised credit repayment $(1+r)D$ only if credit repayment can be enforced. In all other cases, they obtain the liquidation value of the collateral, θC , either because this is what the firm pays voluntarily, after renegotiation, or this is what they receive from actually liquidating the collateral. Solving for *(1+r)D*, we find that banks charge a risk premium over and above the risk-free rate which is declining in the probability of success of the project (*q*) and in the efficiency of the liquidation procedure, (θC):

$$(3) \qquad (1+r)D = \frac{D-(1-\mu q)\theta C}{\mu q}.$$

Recall from above that the maximum repayment cannot exceed revenues, requiring:

$$(4) \qquad (1+r)D = \frac{D-(1-\mu q)\theta C}{\mu q} \leq px.$$

Note that the smaller μ , the more important it is to pledge a collateral for this condition to be satisfied. However, due to the dead weight loss in case the collateral is actually liquidated, which happens with positive probability, the firm limits the collateral pledged to the minimum required to obtain the desired credit. Inserting $D = k(x) + F - L$ and solving for *C* yields the minimum collateral needed to finance the fixed cost of market entry and a given level of affiliate sales *x*, taking into account that the collateral has to be non-negative:

$$(5) \qquad C^*(x) = \max\left\{0, \frac{[k(x)+F-L]-\mu qpx}{(1-\mu q)\theta}\right\}$$

The larger the required credit, the larger is the minimum collateral needed. Note, however, that the collateral cannot exceed the upper bound specified above, $\overline{C} + F$. We consider, in turn, the cases where this upper bound of collateral constrains the firm's optimal sales choice and where it does not, starting with the case of a non-binding collateral constraint.

2.1 Non-Binding Collateral Constraint

Suppose for a moment that the collateral constraint is not binding. Then, for a given level of affiliate sales *x* and collateral *C*, the firm expects the following profits:

$$(6) \qquad \pi = qpx - \mu q(1+r)D - (1-\mu)q\theta C - (1-q)C - [k(x)+F] + D\,.$$

The first term reflects the expected revenues, the second term the debt repayment that can be enforced with probability μ if revenues are positive, which happens with probability *q*. If credit repayment cannot be enforced, the firm voluntarily pays what the bank would be able to collect in the event of liquidation, θC, to avoid costly liquidation, as discussed above. If revenues are not positive, however, the collateral will be liquidated, as captured by the fourth term. The last terms capture the cost of market entry and production and the credit obtained by the firm to finance these costs.

The firm maximizes its profits by choosing the optimal sales of the affiliate *x*, taking into account the collateral needed to finance market entry and production, $C^*(x)$:

Using $D = k(x) + F - L$ and the equations (3) and (5) for (1 + *r*)*D* and $C^*(x)$, we obtain:

$$(6') \qquad \pi = qpx - k(x) - F - (1-q)(1-\theta)\max\left\{0; \frac{[k(x)+F-L-\mu qpx]}{(1-\mu q)\theta}\right\}$$

Note that if $C^*(x) = 0$, i.e. if no collateral is needed to secure the credit, financing costs do not bias the investment decision. If collateral is needed, however, profits are lowered by the expected liquidation cost, $(1-q)(1-\theta)C^*(x)$.

The following proposition characterizes the solutions of the firm's maximization problem.

Proposition 1**: **Non-Binding Collateral Constraint

The profit-maximizing sales level *x** is characterized by the following solution:

$$(7) \qquad x^* = \begin{cases} \dfrac{1+\mu z}{1+z}(1+\beta)qp & < x_{FB} \quad for \quad C^*(x^*) > 0 \\ (1+\beta)qp & = x_{FB} \quad for \quad C^*(x^*) = 0 \end{cases} \quad \text{with } z = \frac{(1-q)(1-\theta)}{(1-\mu q)\theta}$$

The maximum profit the firm can attain is given by

$$(8) \qquad \pi^* = \begin{cases} \dfrac{(1+\mu z)^2}{(1+z)}\dfrac{1}{2}(1+\beta)q^2p^2 - z(F-L) - F \le \pi_{FB} & \text{for} \quad C^*(x^*) > 0 \\ \dfrac{1}{2}(1+\beta)q^2p^2 - F = \pi_{FB} & \textit{for} \quad C^*(x^*) = 0 \end{cases}$$

provided that the maximum exogenous collateral is not binding, i.e.

$$\overline{C} \quad \ge \quad C^*(x^*) - F$$

Proof: See Appendix

Note that for $\mu = 1$, the optimum level of sales is the same as the first-best level. Also, if $\theta = 1$, then $z = 0$, and again the optimum level of sales is the same as in the first-best case. Thus, the optimum level of sales differs from the first-best choice only if *both* $\mu < 1$ *and* $\theta < 1$. The intuition for this is straightforward. Only if contract enforcement is less than perfect, may a collateral be required to obtain a credit, and only if the use of a collateral is costly does it affect the marginal cost of production. Thus, only if a costly collateral is required do profits fall short of first-best profits.

Of course, the firm will engage in investment only if the maximum profits from investment are non-negative. The following proposition characterizes the comparative statics for the firm's extensive and intensive margins of investment.

Proposition 2**: **Non-Binding Collateral Constraint

Changes in the following parameters affect the probability of non-negative profits and thus the probability of engaging in FDI:

$$\frac{d\pi^*}{d\beta} > 0, \quad \frac{d\pi^*}{dp} > 0, \quad \frac{d\pi^*}{d\theta} > 0, \quad \frac{d\pi^*}{d\mu} > 0, \quad \frac{d\pi^*}{dF} < 0, \quad \frac{d\pi^*}{dL} > 0, \quad \frac{d\pi^*}{d\overline{C}} = 0$$

Furthermore, the intensive margin is described by the following comparative static results for the optimal volume of foreign affiliate sales:

$$\frac{dx^*}{d\beta} > 0, \quad \frac{dx^*}{dp} > 0, \quad \frac{dx^*}{d\theta} > 0, \quad \frac{dx^*}{d\mu} > 0, \quad \frac{dx^*}{dF} = \quad \frac{dx^*}{dL} = \quad \frac{dx^*}{d\overline{C}} = 0$$

Proof: See Appendix

The optimal volume of sales and the firm's profits increase in the firm's productivity and in the lucrativeness of foreign markets. Furthermore, better contract enforcement in the host country has a positive effect on sales and profits because it lowers the requirement to use costly collateral, and improving the efficiency of liquidating collateral reduces costs. Higher fixed cost lower expected profits not only directly but also indirectly. The larger the fixed cost, the fewer liquid funds are left for financing the investment. Less liquid funds, in turn, mean greater need for using costly collateral. Hence, there is an indirect negative effect of fixed cost over and above the direct effect. However, fixed cost and internal funds do not affect the optimal production choice because the marginal cost of using collateral does not depend on how much collateral is actually needed. The maximum collateral, in turn, has no effect on profits and on the firm's choice of sales as long as it does not impose a binding constraint.

This scenario describes the situation of a mildly financially constrained investor. The need for credit financing and the requirement of providing collateral increase the marginal cost of investment and hence limit the volume of sales and profits. However, as long as the collateral requirement does not impose a binding constraint, the constraints are not as severe, as fixed cost and internal funds affect the extensive margin only, not the intensive margin.

2.2 Binding Collateral Constraint

Consider now the case where the collateral constraint is binding for the optimal sales level determined above, $x = x^*$, i.e.

$$(9) \qquad \overline{C} + F < C^*(x^*) \equiv \left\{0; \frac{[k(x^*) + F - L] - \mu q p x^*}{(1-\mu q)\theta}\right\}.$$

In this case, x^* cannot be implemented because the credit constraint becomes binding. Instead, production settles at a smaller level $\bar{x}$ that is determined by the maximum available exogenous collateral:

$$(10) \qquad \overline{C} + F = \frac{[k(\bar{x}) + F - L] - \mu q p \bar{x}}{(1 - \mu q)\theta}.$$

Solving this equation for $\bar{x}$ and inserting it into the firm's profit function, yields the constrained optimal production choices and profits as characterized by the following Proposition.

Proposition 3**: **Binding collateral constraint

Suppose the maximum exogenous collateral imposes a binding constraint on the firm's optimal choice of the level of sales, i.e.

$$(11) \qquad \overline{C} \;<\; C^*(x^*) - F$$

Then, the investor can attain a maximum profit of

$$(12) \qquad \bar{\pi} = qp\bar{x} - [k(\bar{x}) + F] - (1-q)(1-\theta)[\overline{C} + F] \leq \pi^*$$

Where the level of sales $\bar{x} < x^*$ is determined by equation (10)

Proof: See Appendix

Not surprisingly, profits fall short of the second-best profits that can be attained if the collateral constraint is non-binding. The following proposition characterizes the comparative static results for the extensive and intensive margins.

Proposition 4**: **Binding collateral constraint

The following comparative static results characterize the extensive margins of FDI, summarizing which parameters are more or less likely to ensure non-negative profits:

$$\frac{d\bar{\pi}}{d\beta} > 0, \quad \frac{d\bar{\pi}}{dp} > 0, \quad \frac{d\bar{\pi}}{d\theta} > 0, \quad \frac{d\bar{\pi}}{d\mu} > 0, \quad \frac{d\bar{\pi}}{dF} < 0, \quad \frac{d\bar{\pi}}{dL} > 0, \quad \frac{d\bar{\pi}}{d\overline{C}} > 0$$

and

$$\frac{d^2\bar{\pi}}{d\bar{C}d\beta} > 0, \quad \frac{d^2\bar{\pi}}{dLd\beta} > 0 .$$

Furthermore, the intensive margin is described by the following comparative statics for the optimal volume of foreign affiliate sales:

$$\frac{d\bar{x}}{d\beta} > 0, \quad \frac{d\bar{x}}{dp} > 0, \quad \frac{d\bar{x}}{d\theta} > 0, \quad \frac{d\bar{x}}{d\mu} > 0, \quad \frac{d\bar{x}}{dF} < 0, \quad \frac{d\bar{x}}{dL} > 0, \quad \frac{d\bar{x}}{d\bar{C}} > 0$$

and

$$\frac{d^2\bar{x}}{d\bar{C}d\beta} > 0, \quad \frac{d^2\bar{x}}{dLd\beta} > 0 .$$

Proof: See Appendix

Like above, productivity, lucrativeness of foreign markets, contract enforcement, and the efficiency of collateral liquidation positively affect both the extensive and the intensive margin of foreign direct investment. Unlike before, however, fixed costs and internal funds now affect the level of sales as well, because higher fixed cost (or fewer internal funds) leave fewer funds for the financing of the production, which cannot be compensated by increasing credit financing if the collateral constraint becomes binding. And of course both margins are positively affected if the collateral constraint becomes less binding.

We also find that the financial status of the firm as captured by the liquid funds and the collateral available plays a more important role for more productive firms, since they are the ones more likely to invest.

This scenario captures the case of a more severely financially constrained firm that is not only exposed to higher marginal cost of credit financing, but that is also constrained in its access to collateral. The firm is constrained not only at the extensive, but also at the intensive margin of expansion. Of course, in reality, the two cases may be considered as representing the two limits of a continuous distribution, with marginal cost of using a

collateral increasing in the size of the collateral. It would be straightforward to generalize our set up and to allow for a more continuous distribution of financial constraints.

2.3 Financial Constraints at the Affiliate Level

So far, we have assumed the liquid funds, *L*, and the exogenous collateral, $\overline{C}$, to be provided by the parent firm. For the market entry decision, this is the natural assumption. Over time, however, the foreign affiliate may in turn accumulate earnings and collateral goods that may affect the financing constraints for the volume of sales. A natural extension of the model would thus be to take into account liquid funds and collateral goods provided by the affiliate itself. It seems plausible to conjecture that funds provided by the affiliate incur lower opportunity cost and/or dead weight losses than funds provided by the parent firm.[11] If this is the case, we would expect funds provided by the affiliate to be used first, and only if they are not sufficient would we expect them to be supplemented by funds provided by the parent.

2.4 Summing Up

The model has rich implications for the determinants of firms' intensive and extensive margins of foreign activities. Higher productivity, more efficient liquidation of collateral, better contract enforcement, and more lucrative foreign markets always increase the volume of affiliate sales. Higher fixed costs decrease and higher internal funds increase activities. The impact of these variables on the intensive margin depends on whether the collateral constraint is binding. They have no effect on the intensive margin if the available collateral is sufficiently large. Likewise, the impact of the size of the collateral depends on the scenario considered. It should matter most when the collateral available is low. Finally, our model predicts that financial constraints matter more for more productive firms, since they are more likely to be interested in foreign expansion. Table 1 gives an overview of the results of the comparative static analyses.

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[11] See the literature on internal capital markets.

3 Data and Stylized Facts

3.1 Data Sources[12]

To investigate the importance of real and financial constraints for the foreign investment choices of firms, we use data from three sources. *Dafne* and *Hoppenstedt* are commercial databases providing financial information on a large panel of firms that are active in Germany.[13] We use these datasets to obtain information on parent-level financial constraints and productivity. Information on the number of German firms' foreign affiliates, their sales, the host countries, and affiliate-level financial constraints from the firm-level database on multinational firms *MiDi* (Microdatabase Direct Investment), provided by the Deutsche Bundesbank (Lipponer 2008).

To eliminate outliers, we start from the full *Dafne* dataset and drop firms with negative values for key variables such as sales and total assets. Also, as we need information on cash flow and sales, we eliminate observations for firms which do not report an income statement. We additionally truncate the data at the 1st and 99th percentile. Finally, we drop observations showing large changes from one year to another, i.e. increasing by a factor of 10 or dropping to 1/10 or less in order to control for possible merger-induced outliers.

Table 4 compares the structure of the sample after the outlier correction and the full sample used for the regressions. The two samples are fairly similar in terms of the percentage allocation of the number of firms across sectors. We can also compare the structure of our sample to the sectoral structure of the German economy as a whole. Although the sample is not randomly chosen from the population of German firms, the rank correlation in terms of sectoral structure of sales is quite high.[14]

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[12] See Table 2 in the Appendix for details.

[13] *Dafne* is the German equivalent to the European firm-level database *Amadeus*. Bayraktar et al. (2005), for instance, use the German data from *Amadeus* for an analysis of firm-level investment behaviour.

[14] Data on the sectoral structure of output of German firms has been taken from the EUKLEMS database (www.euklems.net) and refers to the average for the years 2001-2005.

3.2 Dependent and Explanatory Variables

Extensive and Intensive Margin

By merging the firm-level databases *Dafne* and *Hoppenstedt* with information on the foreign affiliates of German firms provided in *MiDi*, we obtain a dataset which includes two groups of firms. The first group contains purely domestic German firms, i.e. firms which do not hold affiliates abroad ('Domestic Firms') (91.25% of the firm-year observations). The second group consists of German firms with foreign affiliates ('German MNEs') (8.75%). From *MiDi*, we also obtain a count variable on the number of affiliates that a given parent operates abroad. This measure serves as an additional proxy for the extensive margin of foreign activities, which measures complex FDI strategies involving many affiliates. We also have information on the volume of a firm's foreign affiliates' sales as a measure of the intensive margin.

Productivity

In line with the theoretical model, we use cost efficiency as a firm-level measure of productivity. Cost efficiency is given by sales over total costs, i.e. labor costs plus the costs of other inputs. A higher value reflects higher cost efficiency, hence we expect a positive sign.[15] We also control for the size of the parent as a measure for its productivity, and the expected sign is positive.

Fixed costs

The firm's fixed costs of investment are proxied by its ratio of fixed over total assets. We use the ratio rather than the level of this variable as we additionally account for size effects in our regressions. We expect a negative impact of the fixed asset share on the extensive margin. The impact of this variable on the intensive margin could be insignificant, according to our model, if the collateral available is sufficiently large.

Internal funds

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[15] Higher sales relative to total costs might also reflect higher mark-ups. The expected sign of the coefficient would be the same.

In our model, we distinguish liquid funds from less liquid collateral as two determinants of financial constraints. Log cash flow of the parent is used to measure the internal funds available for financing a particular investment project. This variable should have a positive impact on the extensive margin of foreign activities. As in the case of fixed cost, its impact could be insignificant on the intensive margin if the collateral available is sufficiently large. In addition, we look at retained earnings of the affiliate as a measure for the liquid funds available to the affiliate to finance the intensive margin. Again, the expected sign is positive or insignificant.

Collateral

The debt ratio measures leverage at the parent and at the affiliate levels *ex ante*. We can interpret the debt ratio as a measure of the firms' collateral – firms which are more highly leveraged have, *ceteris paribus*, fewer assets available that can serve as collateral for new credits. Hence, the expected sign for the parent debt ratio is negative for both the extensive and the intensive margins if the collateral constraint is binding, and similarly the expected sign for the affiliate debt ratio is negative for the intensive margin. Firms may also report a high leverage ratio precisely because they have taken out a credit in order to finance FDI. If this were the correct interpretation, we should expect a positive sign of the coefficient.

Foreign market size

In our theoretical model, we have described the attractiveness of the foreign market in terms of the price that firms can fetch abroad for their product. In our empirical model, we distinguish two aspects of foreign market size. The first is the size of the market measured through its GDP. The second is the state of development of a foreign market measured through GDP per capita. We expect a positive sign for both variables.

Contract enforcement

The probability of contract enforcement depends on two parameters – an index measuring difficulties of contract enforcement as well as the presence of home-country banks abroad. Contract enforcement measures the number of procedures required to enforce contracts, and the expected impact is negative. This variable can be expected to influence

both, the entry decision as well as the volume of activities, and we include it for both margins. Home-country banks should be at an advantage over other lenders with regard to monitoring foreign affiliates and enforcing contracts. We use *MiDi* to obtain information on the volume of FDI of German banks by country, and we expect a positive impact on the intensive margin.

3.3 Stylized Facts

In Graphs 1a-1e, we visualize the differences between German MNEs and Domestic Firms by plotting the Kernel densities of size (Graph 1a), cost efficiency (Graph 1b), cash flow (Graph 1c), the debt ratio (Graph 1d), and the share of fixed assets (Graph 1e) for domestic and multinational firms.

Graph 1a confirms stylized facts reported in earlier papers using firm-level data (e.g. Mayer and Ottaviano et al. 2008): MNEs are larger than purely domestic firms. Unreported one-sided *t*-tests on the equality of the means between the two sub-samples show that this difference is statistically significant. Measuring size through the volume of sales gives a very similar result. MNEs also exhibit a somewhat lower share of fixed assets (Graph 1e). Graph 1b shows that differences between the two types of firms in terms of cost efficiency are small and are, in fact, not significant.

Hence, while the dividing line between multinationals and non-multinationals is not as clear-cut as might have been expected on the basis of the cost efficiency of these firms, the dividing line is clear for measures of financial status. Multinationals have significantly higher cash flow (Graph 1c) and lower debt ratios (Graph 1d). Prima facie, these graphs suggest that heterogeneity with regard to the openness and international orientation of firms could be driven by financial factors just as by real factors.

4 Productivity versus Financial Constraints: Regression Results

Our main empirical equation relates financial constraints and productivity to the pattern of internationalization at the firm level. We are interested in two main questions. First, do

financial constraints and productivity affect the probability of investing abroad? Second, do these factors affect the volume of foreign affiliates' sales? We answer these questions in two steps. In a first step, we analyze the determinants of firms' extensive margin of FDI using the probability of investing abroad and the number of affiliates as proxies. In a second step, we analyze the sales of affiliates across countries, i.e. the intensive margin. We also estimate the extensive and intensive margins jointly using a Heckman selection model.

4.1 Extensive Margin

Our baseline regression for the extensive margin – the decision to enter a foreign market – is given by the following probit model:

$$(12) \qquad \Pr(FDI)_{i,k,t} = \alpha_0 + \alpha_1 \mathbf{Z}_{i,t-1} + \alpha_2 \mathbf{Z}_{k,t} + \alpha_3 I + \alpha_4 S + \alpha_5 T + \varepsilon_{i,t}$$

where $\Pr(FDI)_{i,k,t}$ indicates whether a firm *i* has invested abroad in year *t* in country *k*. $\mathbf{Z}_{i,t-1}$ ($\mathbf{Z}_{k,t}$) are vectors of firm-level (country-level) control variables.[16] We include the ratio of sales over total costs as a measure of cost efficiency. Our main proxies for financial barriers are cash flow and the debt ratio. The country-level control variables are GDP, GDP per capita, and the severity of contract enforcement. We additionally include firm size, an exporter dummy, and a full set of industry (*I*), German states (*S*), and time (*T*) dummies. These dummies capture systematic differences across industries and states as well as common macroeconomic effects. We also include an exporter dummy to account for the fact that exporting is typically a stepping stone into international markets (see Helpman et al. 2004). This variable is insignificant.

Table 5 shows the results. Column (1) has the baseline specification for the full regression sample. In columns (2)-(7), we split the sample by size, by sector (manufacturing versus services), and by legal status (listed versus unlisted). While the sub-sample of listed firms is small (4,268 versus 43,213 firm-country-year observations),

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[16] Firm-level regressors are lagged by one period to account for the simultaneity of the explanatory variables.

it nevertheless serves as a useful test of the impact of financial frictions. A priori, we expect financial frictions to be less important for the listed firms with access to a larger range of financial sources.

Larger and more efficient firms are more likely to be multinationals. *Size* has a positive and significant impact on the probability of being a multinational, and this effect is robust across specifications. Contrary to expectations, *cost efficiency* is negative and significant in some specifications. This effect is driven by sub-samples such as the large and services firms. It shows that size is a better proxy for productivity than cost efficiency.

Our measure for fixed cost of market entry, the *fixed asset share* has a strong and significantly negative impact on the probability of investing abroad for all specifications, as expected.[17] Berman and Héricourt (2008) as well as Manova (2006) interpret this ratio as capturing the tangibility of assets, and hence as a measure of easier access to external finance secured by collateral. Following their interpretation, the expected effect is positive. The negative coefficient we find suggests that, for FDI, our interpretation is the more appropriate one.

Financial constraints have a significant and robust impact on the extensive margin. *Cash flow* is positive and significant. The *debt ratio* has a negative impact on the probability of engaging in FDI. This is consistent with the interpretation of high debt ratios as indicators of low collateral at the parent level which is available to back up new lending. Sample splits into listed versus unlisted firms confirm our expectation that financial constraints do not matter for the (small group of) listed firms.

Table 5 gives the marginal effects, which show a similar importance of measures of productivity and financial frictions. Generally, however, fixed costs of entry (the fixed asset share) and the country-level variables are more important than variables such as size or the debt ratio. Calculating elasticities also shows the strongest response to changes in log GDP (elasticity of +0.66), followed by cost efficiency (-0.43), firm size (+0.33), and the fixed asset share (+0.27).

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[17] An alternative interpretation of this finding is that firms with a large share of intangibles and thus firm-specific know-how are more likely to venture abroad. These firms would also have a lower fixed asset share.

To study the interaction of productivity and financial constraints and the importance of financial constraints for different types of firms, we split the sample. We take firm size as an indicator for firm productivity. One expectation could be that smaller firms are more affected by financial constraints since they are more opaque. This is not the case though. Both financial variables, cash flow and debt ratio, matter for large firms, but are insignificant for small firms. This is consistent with the prediction of our model that financial constraints should matter more, the more productive the firm and hence the more interested it is in expanding abroad. Financial constraints, in other words, do not impede the foreign expansion of small firms because these firms are not productive enough to invest abroad in the first place.

The country-level variables are significant and have the expected sign. GDP and GDP per capita are positive and significant, thus confirming the expectation that market size matters. Consistent with our model, greater difficulties with contract enforcement lower the probability that a given German firms enters a particular country.

In sum, our results show that parent-level financial constraints and productivity affect the extensive margin of foreign entry: larger, more efficient, less indebted firms, and firms with a lower share of fixed assets are more likely to become multinationals. In addition, country-level variables play an important role for the entry decision.

4.2 Extensive Margin: Number of Affiliates

An alternative way of looking at the extensive margin of firms' foreign activities is to count the number of foreign affiliates that a given parent holds. Adding an affiliate implies new set-up costs, hence the count data models presented in Table 6 provide information on the determinants of complex FDI strategies. The count data models differ in their assumptions regarding the moments of the distribution and the presence of unobserved individual heterogeneity. These models, therefore, allow controlling for the large share of zeros in our data to a differing degree.[18] The basic count data model is the Poisson model which is quite restrictive in assuming that the conditional mean of the

[18] For a detailed description of count data models, see, for example, Jones et al. (2007).

dependent variable equals the conditional variance. The Negative Binomial model allows for unobserved individual heterogeneity and for overdispersion. It seems to be the preferable model, as the equidispersion assumption is strongly rejected for our data. Finally, zero-inflated models assign an even higher weight to the probability of observing a zero in the dependent variable.

Results from count data models support our finding that larger, less indebted parents, firms with a lower share of fixed assets, and firms with higher cash flow are more active internationally. Cost efficiency is negative or insignificant. Naturally, we omit the country-level variables from this regression.

4.3 Intensive Margin: Sales of Affiliates

We now focus on the sales of the foreign affiliate, while taking the decision to *become* a multinational as well as its location as given. The dependent variable $\log(Sales)_{ijk,t}$ are the sales of affiliate *j* of parent *i* in country *k*, and the regression equation includes control variables at the parent level ($\mathbf{Z}_{i,t}$), at the affiliate level ($\mathbf{Z}_{j,t}$), and at the country level ($\mathbf{Z}_{k,t}$):

$$(13) \qquad \log(Sales)_{ijk,t} = \alpha_0 + \alpha_1 \mathbf{Z}_{i,t} + \alpha_2 \mathbf{Z}_{j,t} + \alpha_3 \mathbf{Z}_{k,t} + \alpha_4 S + \alpha_5 T + \varepsilon_{ijk,t}$$

We estimate this equation as a parent-level fixed effects model; results are given in Table 7. The volume of affiliate sales in the full sample (column 1) is positively related to the size of the parent. Cost efficiency is insignificant, as is the share of fixed assets. In contrast to the results for the extensive margin, all our parent-level measures for financial constraints –debt ratio and cash flow – are insignificant for the intensive margin. Once we control for parent characteristics which also capture their financial constraints, financial constraints do not have an additional impact on the sales of their affiliates.

What does matter are the retained earnings of the affiliate, which enter with a positive and significant sign in all specifications. Hence, the availability of liquid funds at the affiliate level does matter for the volume of activities. The affiliate's debt ratio is negative for some sub-samples.

Our host-country regressors yield the expected signs. German firms have larger foreign affiliates in larger countries and in countries hosting many German banks. While the impact of market size per se is not surprising and would, in fact, be borne out by many theoretical models, the positive impact of bank FDI is in support of our theoretical model. A greater presence of home country banks and thus familiarity of domestic lenders with the foreign market should improve the collection of information on the foreign affiliate. This increases the probability that collateral can be collected abroad, thus lowering the costs of financing and increasing the volume of lending.

In columns (2)-(5), we perform similar sample splits as before. Once we restrict the analysis to the large firms which have affiliates in foreign markets, we find that financial constraints are more binding for the smaller multinationals.

Overall, results for the intensive margin confirm the importance of firm size for the volume of activities. Whereas parent-level frictions do not matter for the volume of activities, financial frictions at the affiliate level have the expected negative impact. These results suggest a hierarchy of financing foreign expansion, where preference is given to local funds and only if they are not sufficient, parent funds are used, albeit at potentially higher opportunity cost.

4.4 Heckman Selection Model

So far, we have treated the decision whether to enter a foreign country and the decision how much to produce and sell separately. To check whether this assumption is justified, we estimate a Heckman selection model, which explicitly accounts for the selection into the FDI mode (Table 8). We use state dummies as exclusion restrictions, thus accounting for the fact that – historically – different regions in Germany have different degrees of international openness. Variables measured at the affiliate level and German bank FDI abroad are included in the outcome but not in the selection equation. The Mills ratio in the outcome equation – affiliate sales – is insignificant, which justifies our earlier assumption to model the extensive and the intensive margin separately.

Qualitative results by and large confirm earlier findings. It is interesting to see that some variables affect the probability of setting up an affiliate but not the volume of its sales.

Larger parents and those with lower debt ratios, for instance, are more likely to invest abroad. But these variables have no significant impact on the volume of sales. Also, country-level variables such as GDP, GDP per capita, and contract enforcement have a stronger impact on the extensive than on the intensive margin. Bank FDI has the expected positive impact on the intensive margin.

Some parent-level variables such as cost efficiency (negative) and cash flow (positive) have a consistent impact on both margins.[19] Affiliate-level variables retained earnings (positive) and the debt ratio (positive) have a strong and significant impact on the intensive margin, thus confirming the previous finding that distinguishing parent- and affiliate level financial frictions is important.

Finally, splitting the sample into small and large firms confirms that selection into foreign status is affected by financial constraints for the large firms. Market size has a positive and significant impact on the volume of foreign sales of large firms only. This reflects scale economies and the sorting of smaller firms into smaller markets.

5 Conclusions

Multinationals are large. Earlier literature focuses on differences in productivity across firms as an explanation for this stylized fact. More productive firms find it easier to shoulder the fixed costs of foreign entry, thus being more likely to enter new markets. This paper adds financial constraints as a complementary explanation for the characteristic size patterns of multinationals.

We provide a theoretical model and empirical evidence using data on firms' extensive margin of foreign activities (the probability to be a multinational firm) as well as their intensive margin (the volume of affiliate sales across countries). Considering real barriers to entry as captured by size/productivity and entry cost, we find that larger firms and firms with a smaller share of fixed assets are consistently more likely to become

[19] Note that results in Table 8 are not fully comparable to those in Table 7 since we do not include parent fixed effects in Table 8 but only sector and state fixed effects.

multinationals, and these firms also have larger foreign activities. Cost efficiency, in contrast, does not have the expected positive impact.

Considering financial constraints, our empirical results confirm that these constraints matter for foreign expansions. Less indebted parents (i.e. those with greater available collateral) and parents with larger cash flow are more likely to become multinationals and have more affiliates. For the intensive margin, we find a weaker impact of parent-level financial constraints, but a strong positive impact of affiliate's retained earnings. This suggests a financing hierarchy for the intensive margin, with affiliate financing to be the first and parent financing to be the second choice. Furthermore, considering the interaction of real and financial barriers, financial constraints matter most for large firms because these firms are most likely to expand abroad.

The findings of our paper have a number of implications for different literatures. To the literature of multinational firms, we add a mechanism through which productivity and financial constraints interact. Models ignoring financial constraints would predict that enhancement of firm productivity could improve firms' access to foreign markets. Our results imply that lowering financial constraints might be just as important, in particular for larger firms.

To the banking literature, we add a mechanism explaining why banks and non-financial firms typically expand into foreign markets in tandem. One reason for the "follow their customer" patterns in the data could be that home-country banks that are active abroad could have comparative advantages over local banks in enforcing credit repayment and in assessing the creditworthiness of FDI projects. This does not ultimately resolve the "follow their customer" question, but the specific interaction between financial and real barriers to entry that we stress may provide the possibility of testing this link more structurally.

Finally, our findings can have implications for the international macroeconomic literature. Essentially, the financial constraints imbedded in our model are similar to the financial accelerator mechanism. In this sense, extensions of our model might provide useful insights into credit channel mechanisms in open economies and the persistence of shocks triggering entry into foreign markets.

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6 Mathematical Appendix

Proof of Proposition 1

We obtain x^* by taking the first-order condition, setting it equal to zero and solving for the optimal x^*. To see that $x^* \le x_{FB}$, note that $\frac{1+\mu z}{1+z} < 1$ if $\mu < 1$, which is required for a positive collateral to be needed.

$\pi^* \le \pi_{FB}$ follows directly from $x^* \le x_{FB}$ and can be shown analytically by checking that $\pi_{FB} > \pi^*$ whenever $C > 0$.

Q.E.D.

Proof of Proposition 2

Consider first x^*. It is straightforward to see that

$$\frac{dx^*}{d\beta} > 0, \quad \frac{dx^*}{dp} > 0, \quad \frac{dx^*}{dF} = \quad \frac{dx^*}{dL} = \quad \frac{dx^*}{d\overline{C}} = 0$$

To obtain the remaining comparative statics, we evaluate first

$$\frac{dz}{d\theta} = \frac{-(1-q)(1-\mu q)\theta - (1-q)(1-\theta)(1-\mu q)}{(1-\mu q)^2\theta^2} = -\frac{(1-q)}{(1-\mu q)\theta^2} = -\frac{z}{\theta(1-\theta)} < 0$$

and

$$\frac{dz}{d\mu} = \frac{(1-q)(1-\theta)q}{(1-\mu q)^2\theta} = \frac{zq}{(1-\mu q)} > 0$$

Using these derivatives we obtain

$$\frac{dx^*}{d\theta} = (1+\beta)qp\frac{(1+z)\mu\frac{dz}{d\theta} - (1+\mu z)\frac{dz}{d\theta}}{(1+z)^2} = -(1+\beta)qp\frac{(1-\mu)\overbrace{\frac{dz}{d\theta}}^{(-)}}{(1+z)^2} > 0$$

and

$$\frac{dx^*}{d\mu} = (1+\beta)qp\frac{(1+z)\left[\mu\frac{dz}{d\mu}+z\right]-(1+\mu z)\frac{dz}{d\mu}}{(1+z)^2}$$

$$= (1+\beta)qp\frac{(1+z)z-(1-\mu)\frac{dz}{d\mu}}{(1+z)^2} = (1+\beta)qp\frac{z}{(1+z)^2}\left[1+z-\underbrace{\frac{(1-\mu)q}{(1-\mu q)}}_{<1}\right] > 0$$

Consider next the comparative statics for π^*.

$\frac{d\pi^*}{d\beta} > 0$, $\frac{d\pi^*}{dp} > 0$, $\frac{d\pi^*}{dF} < 0$, $\frac{d\pi^*}{dL} > 0$, $\frac{d\pi^*}{d\bar{C}} = 0$ are straightforward to see. To see that $\frac{d\pi^*}{d\theta} > 0$ and $\frac{d\pi^*}{d\mu} > 0$, note that $\frac{dx^*}{d\theta} > 0$ and $\frac{dx^*}{d\mu} > 0$. Using a revealed preference argument, it follows that the profit has to be increasing in these parameters as well.

Q.E.D.

Proof of Proposition 3

We find the constrained optimal choice of $\bar{x}$ by solving the collateral constraint

$$\bar{C} + F = \frac{[k(\bar{x}) + F - L] - \mu qp\bar{x}}{(1-\mu q)\theta}$$

for $\bar{x}$. This gives us a quadratic function of $\bar{x}$ which has the following solutions

$$\bar{x}_{1/2} = (1+\beta)\mu qp \pm \sqrt{(1+\beta)^2\mu^2q^2p^2 - 2(1+\beta)\left[F - L - (1-\mu q)\theta(\bar{C}+F)\right]}$$

Since we are looking at constrained level of sales that fall short of the second-best level of sales x^*, the solution for the investor is to choose the larger of the two levels of sales.

Q.E.D.

Proof of Proposition 4

Consider first $\bar{x}$. It is straightforward to see that

$$\frac{d\bar{x}}{d\beta} > 0, \quad \frac{d\bar{x}}{dp} > 0, \quad \frac{d\bar{x}}{dF} < 0, \quad \frac{d\bar{x}}{dL} > 0 \quad \frac{d\bar{x}}{d\bar{C}} > 0 \quad \frac{d\bar{x}}{d\theta} > 0$$

Finally, note that $\frac{d\bar{x}}{d\mu} > 0$, because increasing μ relaxes the collateral constraint. To see this, note that the right-hand side of

$$\bar{C} + F \geq \frac{[k(\bar{x}) + F - L] - \mu q p \bar{x}}{(1 - \mu q)\theta}$$

decreases in μ, for a given $\bar{x}$. To see this, note that

$$\frac{d\left[\frac{[k(\bar{x}) + F - L] - \mu q p \bar{x}}{(1 - \mu q)\theta}\right]}{d\mu} =$$

$$\frac{(1 - \mu q)\theta(-q p \bar{x}) - (F + k(\bar{x}) - L - \mu q p \bar{x})(-q\theta)}{(1 - \mu q)^2 \theta^2} =$$

$$-q\theta \frac{p\bar{x} - (F + k(\bar{x}) - L)}{(1 - \mu q)^2 \theta^2} < 0$$

To see the comparative statics for $\bar{\pi}$ note that they have the same signs as the comparative statics for $\bar{x}$ because they follow from relaxing (or tightening) the constraints on the constrained choice of $\bar{x}$.

Q.E.D.

Table 1: Summary of the Theoretical Model and Empirical Measurement

This Table summarizes the comparative static results of the model presented in Section 2. See Table 2 for the definitions of the empirical variables.

Parameter	Measurement	Proposition II: Non-binding collateral constraint		Proposition IV: Binding collateral constraint	
		Extensive margin	Intensive margin	Extensive margin	Intensive margin
Productivity (β)	Cost efficiency Sales / Total assets	+	+	+	+
Foreign prices (p)	GDP GDP per capita	+	+	+	+
Liquidation value (θ)		+	+	+	+
Probability of contract enforcement (μ)	Bank FDI	+	+	+	+
Fixed costs (F)	Fixed / Total assets	–	0	–	–
Internal funds (L)	Cash flow of the parent Retained earnings of the parent Retained earnings of the affiliate	+	0	+	+
Collateral (C)	Debt ratio of the parent	0	0	+	+

Table 2: Data

Unless otherwise indicated, parent-level information comes from *Dafne* (Bureau van Dijk) and *Hoppenstedt*, affiliate level information comes from *MiDi* (Microdatabase Direct Investment, Deutsche Bundesbank). Country-level information comes from the World Bank's World Development Indicators. All values in €1,000 (unless otherwise indicated). Cash flow and cost efficiency are corrected for outliers by truncating the data at the 1st and 99th percentile. Fixed asset share, the debt ratio, and sales are orrected for outliers by truncating the data at the 99th percentile

Variable	Definition
	Parent-level data
Cash flow	Cash flow from operations
Cost efficiency	Sales / total cost (cost of materials + labor cost)
Debt ratio	Total debt / total assets
Firms with foreign affiliate	0/1 dummy for firms with foreign affiliates from *Dafne-MiDi*-merge
Fixed asset share	Fixed assets / total assets
Number of foreign affiliates	Count of total number of affiliates worldwide obtained from *MiDi*
Sector definitions	We use two definition of sectors: (i) A broad definition of 28 sectoral groups is used for sample splits (see also Table 5), (ii) a narrow definition of about 64 sectors at the 2-digit-level, used to generate sector-level dummy variables
Sales	Turnover
	Affiliate-level data
Debt ratio	Total debt / total assets
Sales	Aggregate turnover of parent *i* in country *j* in year *t*, i.e. data are aggregated across all affiliates in a given country for a given parent and weighted by the parent's ownership share
Retained earnings / total assets	Revenue reserves / total assets
	Country-level data
Bank FDI	Aggregate volume of FDI of German banks in country *j* in year *t*, calculated from *MiDi* in €1,000
Contract enforcement	From the World Bank's "Doing business" database (http://www.doingbusiness.org/), we use the variable "Enforcing contracts / Procedures (number)"
GDP	Host country GDP per capita in constant USD, converted into €bn, World Bank (2008)
GDP per capita	Host country GDP per capita per capita in constant USD, converted into €1,000, World Bank (2008)

Table 3: Descriptive Statistics

This Table provides summary statistics for the regressions reported below. GDP per capita is in €1,000. Negative values in ln(GDP per capita) hence come from countries with a GDP per capita of less than €1,000. Minimum and maximum values for affiliate-level variables are not reported due to confidentiality reasons.

a) Extensive margin

Variable	Obs	Mean	Std. Dev.	Min	Max
Cash flow (log)	162,576	5.359	2.251	0.000	10.669
Cost efficiency	121,944	1.351	0.434	0.430	4.664
Debt ratio	186,280	0.560	0.291	0.000	1.000
Exporter dummy	193,979	0.073	0.260	0.000	1.000
FDI dummy	193,979	0.047	0.212	0.000	1.000
Fixed / total assets	168,833	0.272	0.271	0.000	0.971
Size (log)	193,918	7.807	2.408	0.000	18.922

b) Intensive margin

	Obs	Mean	Std. Dev.	Min	Max
Affiliate-level					
Debt ratio	12,211	0.516	0.272	…	…
Retained earnings / total assets	12,211	0.063	0.151	…	…
Sales (log)	11,303	9.832	1.331	…	…
Parent-level					
Cash flow (log)	2,892	8.696	2.092	0.000	18.604
Cost efficiency	2,947	1.303	0.313	0.438	4.622
Debt ratio	3,870	0.426	0.231	0.000	0.996
Fixed assets / total assets	3,586	0.180	0.174	0.000	0.963
Number of foreign affiliates	3,767	5.315	11.968	1.000	213.0
Size (log)	3,885	11.901	2.053	3.296	20.718
Country-level					
Bank FDI (log)	11,664	13.478	1.882	6.267	16.812
Contract enforcement (number of procedures)	7,738	33.112	5.649	21.0	51.0
GDP (log)	11,363	6.519	1.544	-0.664	9.762
GDP per capita (log)	11,358	2.705	1.073	-1.853	4.001

Table 4: Full versus Reduced Sample

This table compares the sample corrected for outliers ("corrected sample") and the sample used for the regressions ("Regression sample"). The two samples differ because of missing observations for the explanatory variables.

	Regression sample				Corrected sample			
	Number	%	Sales (million €)	%	Number	%	Sales (million €)	%
Agriculture & Fishing	818	1.54	4,230	0.18	2,450	1.49	14,098	0.17
Chemicals	849	1.60	71,785	3.09	1,928	1.17	262,077	3.15
Construction	5,158	9.70	55,997	2.41	17,330	10.53	225,080	2.70
Education	191	0.36	2,352	0.10	803	0.49	17,118	0.21
Energy	2,063	3.88	161,085	6.94	4,300	2.61	599,130	7.19
Financial services	206	0.39	15,129	0.65	1,925	1.17	111,767	1.34
Food & Tobacco	1,267	2.38	134,305	5.79	2,880	1.75	390,397	4.69
Furniture	746	1.40	22,467	0.97	1,810	1.10	49,113	0.59
Glass	577	1.09	22,545	0.97	1,519	0.92	52,564	0.63
Health	2,100	3.95	71,826	3.10	4,618	2.81	161,503	1.94
Hotels & Restaurants	526	0.99	6,542	0.28	1,553	0.94	17,715	0.21
Coking	62	0.12	12,405	0.53	167	0.10	65,987	0.79
Leather	35	0.07	1,265	0.05	99	0.06	3,052	0.04
Machinery	2,394	4.50	109,282	4.71	5,974	3.63	323,250	3.88
Metals	3,132	5.89	105,345	4.54	7,650	4.65	283,941	3.41
Mining	178	0.33	8,298	0.36	577	0.35	128,768	1.55
Office equipment	1,802	3.39	84,709	3.65	4,756	2.89	262,423	3.15
Other services	1,832	3.45	63,913	2.76	6,543	3.98	221,432	2.66
Paper	1,242	2.34	46,603	2.01	3,066	1.86	146,526	1.76
Real estate & Business services	9,866	18.56	377,030	16.25	44,801	27.22	1,686,567	20.24
Rubber & Plastics	925	1.74	46,633	2.01	2,160	1.31	89,402	1.07
Textiles	513	0.96	16,839	0.73	1,348	0.82	63,173	0.76
Trade & repair	12,793	24.06	705,005	30.39	34,859	21.18	2,186,342	26.24
Transport & Communication	2,844	5.35	112,761	4.86	8,393	5.10	632,186	7.59
Vehicles	559	1.05	47,385	2.04	1,446	0.88	298,832	3.59
Wood	349	0.66	10,252	0.44	924	0.56	20,962	0.25
n.e.c	134	0.25	3,869	0.17	692	0.42	18,121	0.22
Total	53,161	100.00	2,319,853	100.00	164,571	100.00	8,331,527	100.00

Table 5: Probability of Owning Affiliates Abroad

This table reports results of probit regressions using a 0/1 dummy variable of owning foreign affiliates as the dependent variable. All explanatory variables are at the parent level (P). Sample splits are at the sample median. Sector, state, and year fixed effects included. Standard errors in parentheses. Marginal effects are reported. ***, **, * = significant at the 1%, 5%, 10%-level.

	Full sample	Large	Small	Manufacturing	Services	Listed	Unlisted
Log size t-1 (P)	0.010***	0.014***	0.009***	0.017***	0.006***	0.034***	0.009***
	(0.002)	(0.004)	(0.002)	(0.002)	(0.002)	(0.006)	(0.001)
Cost efficiency t-1 (P)	-0.010**	-0.012*	-0.006	-0.008	-0.009**	0.015	-0.010**
	(0.004)	(0.007)	(0.005)	(0.008)	(0.004)	(0.019)	(0.004)
Debt ratio t-1 (P)	-0.012*	-0.039***	0.009**	-0.016*	-0.001	-0.018	-0.011*
	(0.006)	(0.014)	(0.004)	(0.008)	(0.009)	(0.038)	(0.006)
Log cash flow t-1 (P)	0.005***	0.011***	0.000	0.003*	0.005**	0.004	0.004**
	(0.001)	(0.003)	(0.001)	(0.002)	(0.002)	(0.005)	(0.001)
Fixed asset share t-1 (P)	-0.043***	-0.067***	-0.019***	-0.027**	-0.045***	-0.169***	-0.032***
	(0.009)	(0.018)	(0.007)	(0.013)	(0.012)	(0.036)	(0.009)
Log GDP	0.021***	0.028***	0.015***	0.022***	0.019***	0.034***	0.020***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
Log GDP per capita	0.004***	0.005**	0.002*	0.003**	0.004*	0.017***	0.002*
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.005)	(0.001)
Contract enforcement	-0.001***	-0.002***	-0.001***	-0.001***	-0.001***	-0.001	-0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)
Exporter (0/1)	0.001	-0.002	0.001	-0.003	0.005	0.005	-0.000
	(0.003)	(0.006)	(0.002)	(0.003)	(0.005)	(0.009)	(0.003)
Observations	47,486	23,702	23,784	27,932	17,420	4,268	43,218
Pseudo R^2	0.143	0.143	0.122	0.164	0.132	0.234	0.130
log likelihood	-8,229	-5,103	-3,068	-4,918	-2,912	-1,015	-7,141

Table 6: Determinants of the Number of Affiliates

This table reports the estimated coefficients of the Poisson (Negative Binomial, Zero-Inflated Poisson ZIP) regression using the total number of affiliates of each German firm as the dependent variable. Year fixed effects included. Standard errors in parentheses. ***, **, * = significant at the 1%, 5%, 10%-level.

	(1) Poisson	(2) NegBin	(3) ZIP
Log size t-1 (P)	0.012***	0.007***	0.019***
	(0.002)	(0.001)	(0.003)
Cost efficiency t-1 (P)	-0.009***	-0.000	-0.010
	(0.003)	(0.001)	(0.007)
Debt ratio t-1 (P)	-0.029***	-0.002	-0.044***
	(0.007)	(0.002)	(0.012)
Log cash flow t-1 (P)	0.012***	0.002***	0.015***
	(0.002)	(0.001)	(0.003)
Fixed asset share t-1 (P)	-0.086***	-0.029***	-0.118***
	(0.014)	(0.003)	(0.019)
Exporter (0/1)	0.013***	0.007***	0.010**
	(0.004)	(0.001)	(0.004)
Observations	56,740	56,740	56,740
Pseudo R^2	0.692	0.296	
log likelihood	-29,907	-17,439	-20,882

Table 7: Determinants of the Volume of Affiliate Sales

This table reports results of parent fixed effects panel regressions using the log sales of affiliates of domestic multinational *i* in host country *j* as the dependent variable. (P) = parent-level variables, (A) = affiliate-level variables. In Panel (b), sample splits are at the sample median. Standard errors in parentheses. ***, **, * = significant at the 1%, 5%, 10%-level.

	Full sample	Large	Small	Manufacturing	Services
Log size t-1 (P)	0.541**	0.713*	0.296	0.265	0.890**
	(0.241)	(0.407)	(0.291)	(0.355)	(0.373)
Cost efficiency t-1 (P)	-0.098	-0.159	-0.181	0.223	-0.425
	(0.467)	(0.698)	(0.579)	(0.801)	(0.627)
Debt ratio t-1 (P)	-0.276	-0.221	-0.499	0.207	-1.073
	(0.529)	(0.859)	(0.602)	(0.717)	(0.882)
Log cash flow t-1 (P)	-0.017	0.027	-0.045	0.002	-0.013
	(0.070)	(0.130)	(0.071)	(0.090)	(0.117)
Fixed asset share t-1 (P)	-0.403	0.990	-0.437	-0.649	-1.147
	(1.096)	(3.066)	(0.983)	(1.451)	(1.908)
Retained earnings / total assets t-1(A)	0.310*	0.258	0.398*	0.299	0.575
	(0.172)	(0.255)	(0.217)	(0.201)	(0.360)
Debt ratio t-1 (A)	-0.122	-0.050	-0.252**	-0.132	0.023
	(0.097)	(0.139)	(0.126)	(0.119)	(0.180)
Log GDP	0.111***	0.116***	0.098***	0.142***	0.044
	(0.022)	(0.032)	(0.029)	(0.027)	(0.042)
Log GDP per capita	0.112***	0.135***	0.053	0.077**	0.209***
	(0.030)	(0.042)	(0.041)	(0.036)	(0.056)
Log bank FDI	0.058***	0.086***	0.014	0.048**	0.075***
	(0.016)	(0.023)	(0.020)	(0.020)	(0.027)
Contract enforcement	-0.011**	-0.002	-0.025***	-0.012**	-0.010
	(0.005)	(0.007)	(0.006)	(0.006)	(0.008)
Constant	2.278	-1.637	7.055**	4.824	-1.008
	(2.609)	(4.929)	(3.057)	(3.970)	(3.815)
Observations	2,290	1,101	1,189	1,431	785
R^2	0.117	0.146	0.092	0.115	0.143
Cross-sections	614	178	436	365	223

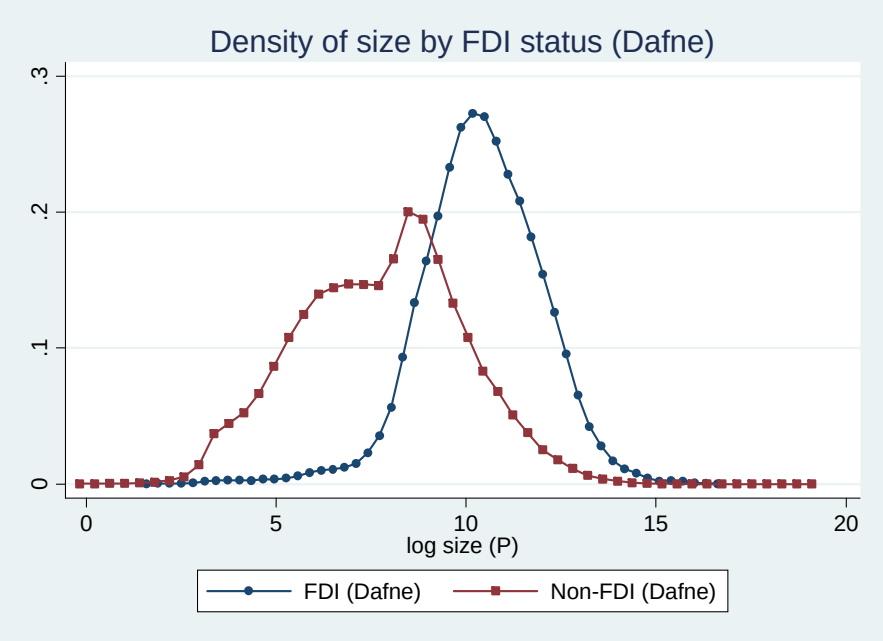
Table 8: Heckman Selection Model

This table reports results of a Heckman selection model using the log sales of affiliates of domestic multinational *i* in host country *j* as the dependent variable. (P) = parent- level variables, (A) = affiliate-level variables. Sector and year fixed effects included. Sector fixed effects included in the selection equation. Standard errors in parentheses. ***, **, * = significant at the 1%, 5%, 10%-level.

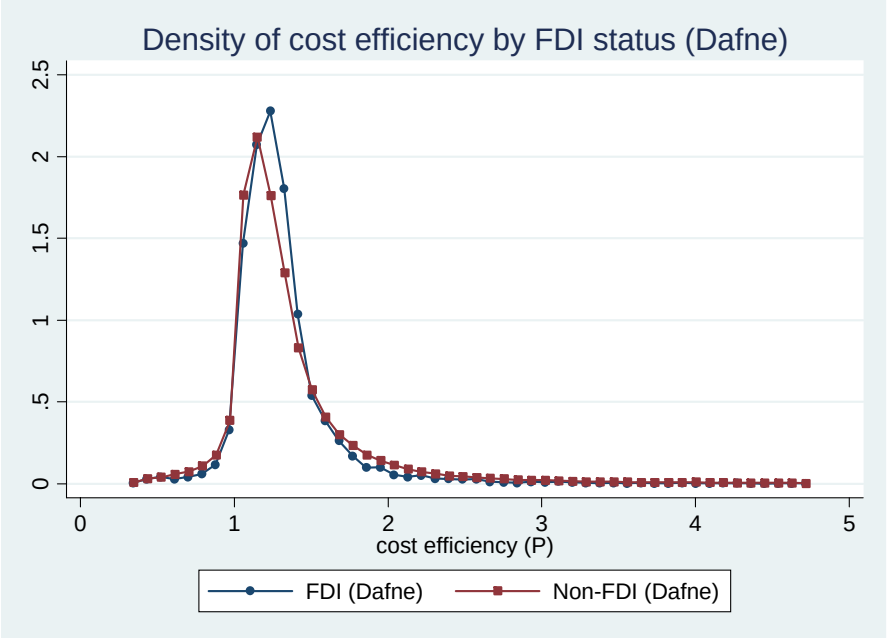
	Full sample		Small		Large	
	Outcome	Selection	Outcome	Selection	Outcome	Selection
Log size t-1 (P)	0.152	0.148***	0.010	0.147***	-0.100	0.115***
	(0.103)	(0.015)	(0.173)	(0.035)	(0.123)	(0.025)
Cost efficiency t-1 (P)	-0.880***	-0.146***	-1.377***	-0.109	-0.617**	-0.145**
	(0.203)	(0.047)	(0.307)	(0.100)	(0.263)	(0.060)
Debt ratio t-1 (P)	0.401	-0.175***	0.194	0.121	0.608	-0.418***
	(0.261)	(0.060)	(0.294)	(0.087)	(0.482)	(0.090)
Log cash flow t-1 (P)	0.227***	0.067***	0.154**	-0.000	0.238**	0.112***
	(0.065)	(0.014)	(0.065)	(0.021)	(0.108)	(0.020)
Fixed asset share t-1 (P)	-1.394***	-0.598***	0.045	-0.352**	-2.054***	-0.802***
	(0.522)	(0.095)	(0.521)	(0.138)	(0.769)	(0.141)
Log GDP	0.249	0.293***	-0.398	0.298***	0.416**	0.292***
	(0.169)	(0.009)	(0.268)	(0.014)	(0.185)	(0.013)
Log GDP per capita	-0.027	0.051***	0.156	0.051**	-0.173	0.052***
	(0.081)	(0.015)	(0.115)	(0.022)	(0.105)	(0.019)
Contract enforcement	-0.018	-0.016***	0.015	-0.015***	-0.033*	-0.016***
	(0.013)	(0.003)	(0.019)	(0.004)	(0.017)	(0.003)
Retained earnings /	0.989***		0.584*		1.721***	
total assets t-1 (A)	(0.313)		(0.344)		(0.491)	
Debt ratio t-1 (A)	1.052***		1.138***		1.004***	
	(0.137)		(0.169)		(0.196)	
Log bank FDI	0.113***		0.088**		0.122***	
	(0.030)		(0.040)		(0.040)	
Constant	3.857	-4.700***	13.154**	-5.051***	-5.197	-5.351***
	(4.051)	(0.466)	(5.524)	(0.777)	(4.502)	(0.612)
Observations	47,481	47,481	27,289	27,289	20,192	20,192
Censored observations	45,052	45,052	26,367	26,367	18,685	18,685
Mill's ratio	0.892	0.892	-0.885	-0.885	0.963	0.963
Standard error	0.688	0.688	1.036	1.036	0.760	0.760
ρ	0.424	0.424	-0.526	-0.526	0.419	0.419

Graph 1: Firm Characteristics by Multinational Status

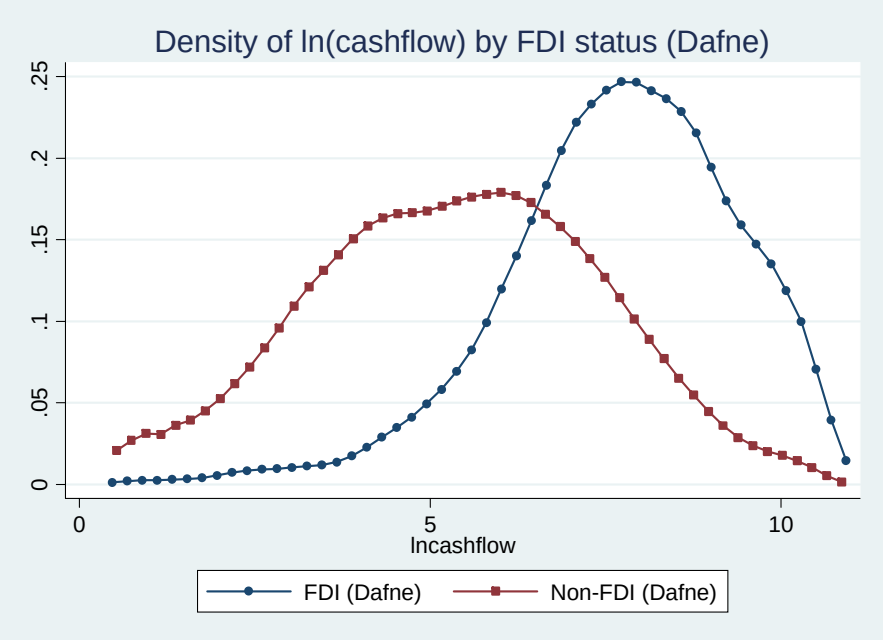
(a) Firm size



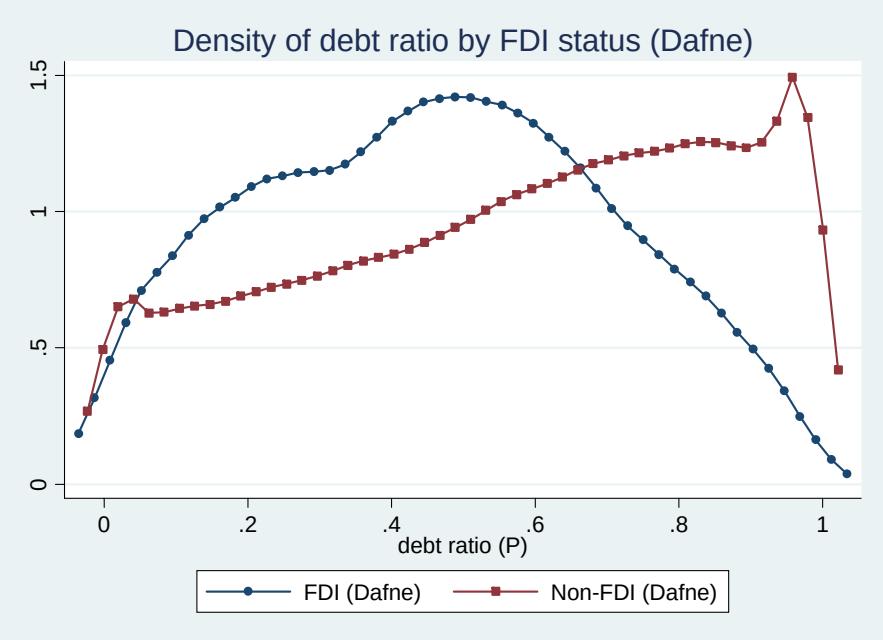
(b) Cost efficiency



(c) Cash flow



(d) Debt ratio



(e) Fixed asset share