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# Export Market Risk and the Role of Public Credit Guarantees

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## Abstract

In this paper we analyze the impact of public export credit guarantees on firms' exports. Earlier studies show that export credit guarantees stimulate exports, employment, and value added. Furthermore, there is evidence at the aggregate level that financial market imperfections are key to understanding the beneficial effects of this policy instrument. We use monthly firm-level survey data combined with official transaction-level data on covered exports of German firms to analyze in detail the hypothesis that the positive effects are due to mitigated financial constraints. Considering exporter and importer characteristics, as well as transaction-specific characteristics, we shed light on the particular sources of financing constraints that can be alleviated by the policy instrument. We find that positive effects are stronger at times when refinancing conditions for the private sector are tight. Furthermore, our results indicate that small firms and firms with little liquid means benefit more, and that the public guarantees matter especially for contracts involving large values at risk. Our analysis contributes to a better understanding of the interplay between export credit guarantees and financial market imperfections, which is crucial for an efficient policy design.

JEL codes: F12, F36, G28, H81.

Keywords: Public Export Credit Guarantees; Credit Constraints.

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# 1 Introduction

In light of the “great trade collapse” following the financial crisis 2007/2008, there has been increased interest in the role of finance for export business and there is now ample evidence that exports are more vulnerable to financing conditions than domestic sales. Accordingly, financing constraints inhibit firms’ exports both on the intensive margin as well as on the extensive margin.<sup>1</sup> Most countries have public credit guarantee programs to improve access to finance for exporting firms. Recent literature analyzes the effectiveness of such schemes as a means of stimulating exports, value added and employment. Felbermayr et al. (2012) estimate that public export credit guarantees in Germany, the so-called “Hermes coverage”, increase firms’ sales growth by about 4.5% percentage points in the year of the grant, supporting previous evidence of a positive relationship at the aggregate level.<sup>2</sup> However, evidence on the working mechanism of the instrument is scarce. This is somewhat surprising, given that how the mechanism works is fundamentally related to the question of whether it does indeed what it is intended to do, namely, correct a market failure. This paper aims to fill that void. We use a unique transaction level data set to shed light on the channels through which Hermes guarantees manifest their effects. Our empirical analysis is guided by a small theoretical model of heterogeneous exporters that face uncertainty about export revenues and differ with respect to their needs for and access to external finance. We analyze whether and, if so, what kind of financial market frictions can be mitigated by public export credit guarantees.

Our work is motivated by the finding of positive effects of the public insurance scheme on exports and employment that raises the question of whether the scheme actually results in positive value added effects at the national level. Obviously, the answer would be no if the government provided the means of finance at below social opportunity cost. Social costs are hard to assess, but we can look at the profit and loss account of the program to get an idea about whether the government is just redistributing national funds by insuring projects with negative expected values. In a world with multiple distortions this would not necessarily imply a net welfare loss. Yet, rejecting this presumption makes a strong case for value added effects being net gains. A look at the cumulative 50-year results of the program run by the German government reveals that, on average, returns to the credit insurance are non-negative.<sup>3</sup> The realized cumulative net gains for the period 1950 to 2010 amount to 2 billion Euro.<sup>4</sup>

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<sup>1</sup> For studies at the firm-level see e.g. Greenaway et al. (2007) (United Kingdom), Muûls (2008) (Belgium), Manova et al. (2011) (China), Amiti and Weinstein (2011) (Japan) and Minetti and Zhu (2011) (Italy). Chor and Manova (2012) look at sectoral US imports during the financial crisis.

<sup>2</sup> Felbermayr and Yalcin (2011) find a positive relationship between sectoral exports and Hermes guarantees that is particularly strong for sectors that depend more on external finance. Moser et al. (2008) also find a positive effect in a country-level study. For the case of Austria, Egger and Url (2006) report positive effects, as do Janda et al. (2012) for the Czech Republic. Auboin and Engemann (2012) find a strong positive effect of export credit insurance on bilateral trade, based on an extensive dataset covering more than 70 countries and public as well as private insurers.

<sup>3</sup> German public export credit guarantees are administered by a private consortium made up of *Euler Hermes Deutschland AG* and *PriceWaterhousecoopers AG*, acting on behalf of the federal government.

<sup>4</sup> Numbers stem from the Annual Report 2010 of Euler Hermes. The report is available at

But if, as this number suggests, the government does not provide insurance at below opportunity cost, why does not the private capital market offer the insurance at a competitive price? Clearly, frictions on financial markets could serve as an answer. We argue that there are three sources of market imperfection that might give the government a cost advantage. First, if there are costs to diversifying risk for private agents, the government's "deep pocket" will give it a comparative advantage in financing or insuring projects with large values at risk.<sup>5</sup> Second, if coordination of creditors in case of payment default comes at a cost, then the government as a single actor will also have a cost advantage when it comes to asserting claims.<sup>6</sup> And third, we argue that the government has greater bargaining power when it comes to debt renegotiations with entities in foreign countries, which, as we discuss below, often involve other foreign governments. Under any of these conditions, the government can offer insurance at a lower premium than private capital markets without incurring losses in the long run.

In our theoretical model with heterogeneous exporters, external finance, and an optional credit guarantee scheme, we show how financial market conditions determine exporters' cost of finance, optimal sales and the decision to enter into foreign markets. We borrow the basic set-up from Manova (2013), but consider default risk on the side of the importer rather than imperfect contract enforcement in the exporting country. In Manova (2013), as well as in Matsuyama (2008), Muûls (2008), and Feenstra et al. (2011), credit constraints - defined as a firm not being able obtain finance for projects with positive expected values - are due to moral hazard. In our model, credit constraints arise from the transaction cost of risk diversification in the financial sector. In line with existing literature, we consider banks to be exposed to a constant risk of illiquidity that is due to the maturity mismatch of their assets and liabilities (Diamond and Dybvig, 1983) or market-based valuation of assets (Allen and Gale, 1998) and makes them prone to runs. Bank runs entail costly early liquidation of long-term assets and, potentially, insolvency. Regulatory standards are enacted to reduce the probability of those events by forcing banks to engage in (costly) measures of risk diversification and contribute to deposit insurance schemes.<sup>7</sup> Risk neutralization in banks can be accomplished by various means, including portfolio management, hedging, holding cash, and issuing subordinate debt or equity.<sup>8</sup> The cost of holding risk might be considered as a measure of financial market effectiveness. In an Arrow-Debreu world with complete contingent markets and costless transactions, the costs would be zero. If, at the other extreme, the risk was not at all diversifiable,

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<http://www.agaportal.de/en/aga/downloads/jahresberichte.html>

<sup>5</sup> As is often argued, this lender-of-last-resort property provides a rationale for the government playing an active role of as loan guarantor or deposit insurer; see e.g. Merton (1977), Diamond and Dybvig (1983).

<sup>6</sup> Transaction costs of this sort have been proposed as one reason for the existence of banks; see Mayer (1988), Sharpe (1990).

<sup>7</sup> Current regulation requires banks to hold regulatory capital in an amount such as to achieve a constant solvency probability. Gordy and Howells (2006) show that for the Internal Ratings Based Approach of Basel II, the targeted one-year solvency probability was 99.9 percent.

<sup>8</sup> See Kashyap et al. (2002) for a quantitative assessment of the cost associated with such buffer stocks for U.S. banks.

banks obliged to maintain a solvency probability of almost 1 would need to hold the full amount at risk in liquid assets, with cost then reflecting foregone interest.

In our model, perfectly competitive banks pass on those costs to firms by way of charging interest on loans for more risky projects that is higher than the actuarially fair compensation for the risk involved. Credit constraints thus derive from the threat of illiquidity with its detrimental consequences and the limited ability of private financial markets to diversify risk. These constraints can be mitigated by export credit guarantees to the extent that the guarantor is more efficient at dealing with risk. Based on the model, we show how the cost of credit and credit guarantees determine the financing cost of firms and, interacting with further firm characteristics, impact their export performance. The government's cost advantages in providing credit guarantees will be reflected in higher exports by firms with specific characteristics.

We apply the detailed predictions of our model to the data. Our empirical analysis draws on an exceptional dataset, that is a combination of all project-specific guarantees issued by Euler Hermes between 2000 and 2010 with monthly survey data on 7,000 manufacturing firms from the business cycle survey of the Ifo Institute. The dataset brings together information on contract size, duration, and riskiness of the publicly insured transactions with firms' individual assessment of their export situation and their demand and financing conditions, as well as employment and balance sheet information. Given the ordinal nature of our variable of interest – firms' qualitative assessment of the stock of foreign orders – and the structure of our econometric model, we use a binary choice model to estimate the effect of Hermes guarantees and analyze how it varies with characteristics specific to the contract, the importer, the exporter, or the time of the grant.

To preview our results, we confirm the findings in the extant literature that participation in the public export credit guarantee scheme is positively associated with higher exports. Furthermore, consistent with our model's predictions, we find that there is systematic heterogeneity of the effect. We can single out characteristics of the exporting firm, the importing firm, and the contract for which the effect is particularly strong. Hermes guarantees particularly benefit small firms, and the effect is stronger for projects with large values at risk or during periods when financing conditions on the private capital market are tight. Our results lend support to the hypothesis that the public credit guarantee scheme does mitigate frictions on private capital markets by exploiting the government's cost advantages.

In the following section we present the model and derive testable predictions. In Section 3 we discuss our data sources, explain our empirical strategy, and present the results. Section 4 concludes.

## 2 Theory

In this section we develop a partial equilibrium model of international trade with heterogeneous firms that are confronted with uncertain export transactions. Our model builds on Manova (2013), who analyzes heterogeneity in firms' need for and access to external finance in a Melitz (2003) framework. We introduce importer default risk into the model, allow the refinancing conditions of the banking sector to vary, and show under what conditions the use of credit guarantees affects the extensive and intensive margin of firms' exports.

### 2.1 Demand

Demand for variety  $a$  of a differentiated good that is imported by firm  $j$  is derived from a symmetric CES utility function over a set of differentiated varieties and results as

$$q_j[a] = p_j[a]^{-\varepsilon} A_j, \quad (1)$$

where  $p_j[a]$  is the price of variety  $a$  that importer  $j$  faces and  $A_j$  is a demand shifter.  $\varepsilon > 1$  is the elasticity of substitution between any two varieties. Due to fixed costs of production, any variety is produced by only one firm, hence  $a$  subsumes the exporter index. In the following, we always look at a specific transaction characterized by the pair  $(a, i)$ . For ease of notation we drop the importer index  $j$ .

### 2.2 Firm Behavior

Firms pay a sunk entry cost to set up production and draw a productivity level  $1/a$  from a cumulative distribution function  $G[a]$  with bounded support  $[a_L, a_H]$ ,  $a_H > a_L > 0$ . To produce, ship, and sell  $q$  to the foreign country, firms have to pay a fixed cost  $f$  and variable cost  $a$  per unit of  $q$ , where  $a$  is the unit cost corresponding to the firm's productivity draw.<sup>9</sup> Fixed and variable costs must be paid upfront before payment from the importer is received. We assume that firms have an amount  $k$  of liquid funds available to cover these upfront costs. Furthermore, they can borrow from a competitive banking sector. Payment for exported goods is uncertain due to the possibility of importer default, which occurs with probability  $1 - \lambda$ . We assume that the firm has no other sources of revenue; hence, if the importer defaults, the firm will be forced to default on its debt.<sup>10</sup> The importer's default risk will thus be reflected in the cost of external finance. Firms can lower the interest rate on the loan by purchasing credit insurance. Before we discuss the financial sector in detail, we first derive firms' optimal export behavior for exogenously given costs of external finance.

<sup>9</sup> Costs are expressed in terms of the price of a fixed input bundle. We scale units such that this price is normalized to 1. Without loss of generality we set variable trade cost to 0.

<sup>10</sup> We make this assumption for the sake of simplicity. The qualitative results of our model will be the same as long as the exporter's default risk is positively associated with the importer's default risk.

In this monopolistic competition framework, firms set prices, choose how much to borrow, and how much to cover with a guarantee. Whenever the costs of external finance exceed the firm's opportunity costs of its own liquid funds, the firm will use external finance only after its own available funds have been exhausted. Furthermore, if the firm's liquid means are small relative to the size of the project, in particular if it has to rely on external finance no matter how much it is going to sell because  $k$  is smaller than the *fixed* set-up costs, then the choice of the optimal price is independent of  $k$ . To keep the model as simple as possible, we proceed under the assumptions that external finance is more costly than internal finance and that the amount of liquid funds is small, so that  $k < f$ . Appendix B shows that our results are qualitatively the same in the general case.

Let  $R^o$  denote the cost of external finance for a given project, with  $o \in [B, G]$  indicating whether the firm finances the export project only through a bank ( $B$ ) or with the help of a credit guarantee ( $G$ ) to eliminate default risk. Furthermore, let  $\bar{R}$  denote the gross return to the firm's alternative investment. For a given financing mode  $o$ , the firm then only chooses its price to maximize expected profits given by

$$\max_p \lambda pq - \bar{R}k - \lambda R^o(aq + f - k) \quad o \in [B, G], \quad (2)$$

subject to demand as in (1). Expected profits consist of the uncertain payment  $\lambda pq$ , the cost of investing the liquid means  $\bar{R}k$ , and the costs of borrowing the remaining part of the investment  $aq + f - k$  at  $R^o$ , which are, however, only incurred if the project is successful. Optimal prices and quantities result as

$$p^*[a] = \frac{R^o a}{\theta} \quad \text{with} \quad \frac{1}{\theta} = \frac{\varepsilon}{\varepsilon - 1}, \quad (3)$$

$$q^*[a] = \left( \frac{R^o a}{\theta} \right)^{-\varepsilon} A. \quad (4)$$

Let  $r[a] = p[a]^* q[a]^* = \left( \frac{R^o a}{\theta} \right)^{1-\varepsilon} A$  denote the optimum revenue of the firm. Maximum expected profits are then given by

$$\pi^*[a] = \frac{\lambda}{\varepsilon} r[a] + (\lambda R^o - \bar{R})k - \lambda R^o f. \quad (5)$$

The first term on the right-hand side of (5) denotes operating profits, which are proportional to revenue, as in Melitz (2003). The remaining terms summarize the effective set-up costs, on which the firm spends all its liquid funds  $k$ , and the amount  $f - k$  that is borrowed at the gross interest rate  $R^o$  and repaid only with probability  $\lambda$ . Higher costs of external finance  $R^o$  lead to lower expected profits by increasing both the marginal costs as well as the fixed set-up costs. Optimal expected revenue increases in productivity  $1/a$ ; hence, conditional on the demand and financing conditions, a firm needs to be sufficiently productive in order to break even. The break-even productivity level  $1/a^*$  results implicitly from the zero-profit condition  $\pi^*[a] = 0$ , which is derived from equation (5)

as

$$\frac{\lambda}{\varepsilon} r[a^o] = \lambda R^o(f - k) + \bar{R}k. \quad (6)$$

The cost of external finance thus affect both the intensive and the extensive margin of firm's exports. We summarize the relationship between  $R^o$  and the firm's export decisions in Result 1.

**Result 1.** *An increase in the cost of external finance  $R^o \in [R, G]$  (weakly) increases the profitability threshold and (weakly) decreases the firm's optimal level of sales for a given export transaction. The effect on the profitability threshold is stronger for firms with little liquid means.*

**Proof:** The result follows from differentiating and cross-differentiating  $r[a]$  and the right-hand-side of (6) with respect to  $R^{o'}$  and  $a^{o'}$ , for  $o' \in (R, G)$ . The weakness of the relationship is due to the fact that the firm may be operating under the alternative financing mode  $o \neq o'$  and is thus not affected. Details are found in Appendix A. ■

In the next section we describe the properties of the banking sector and derive the financing cost  $R^B$  and  $R^G$  under the two modes of financing available to the firm: pure bank finance ( $B$ ) and bank finance with a credit guarantee ( $G$ ).

### 2.3 The Banking Sector

We assume that the banking sector is perfectly competitive and banks can refinance themselves at an exogenous (gross) interest rate  $\bar{R} \geq 1$ .<sup>11</sup> Banks are risk-neutral, but obliged to hedge the risk in their balance sheet to prevent runs.<sup>12</sup> We take a parsimonious approach to modeling the hedging; we assume banks to bear a constant cost  $c^B \in \left[0, \frac{\bar{R}-1}{\bar{R}}\right]$  per unit of the value at risk in their balance sheet to ensure liquidity at any point in time. We assume that  $c^B$  reflects the bank's cost-minimizing choice among the possible means of doing so, including portfolio management, hedging, insurance, or holding buffer stocks in the form of equity, securities, or cash.  $c^B = \frac{\bar{R}-1}{\bar{R}}$  corresponds to the most expensive case where banks must hoard cash. Furthermore, suppose that in the event of borrower default a fraction  $b^B \in [0, 1]$  of the claim can be recovered from the trade partner in the destination country as part of insolvency proceedings.<sup>13</sup> We summarize the parameters characterizing the financing environment in the set  $\mathcal{B} = \{\bar{R}, b^B, c^B\}$ . Then, the gross interest rate

<sup>11</sup> We have normalized to unity the opportunity cost of money in the second period where profits are realized and banks are repaid (or not).

<sup>12</sup> Assuming that all banks comply with this obligation, a bank run, which we could think of as a case of prohibitively high refinancing cost, is ruled out. This justifies our normalization assumption (see previous footnote).

<sup>13</sup> We can consider  $b^B$  as the outcome of the bank's cost-minimization problem with respect to the effort expended on recovering claims or corporate rescues, thus capturing both the cost of coordination of creditors and the bargaining power in debt renegotiations.

that a bank facing financing conditions  $\mathcal{B}$  and perfect competition can offer on a loan of amount  $\ell$  with default risk  $1 - \lambda$  is given by the following no-arbitrage condition:

$$\lambda R^B \ell + (1 - \lambda) b^B R^B \ell = \bar{R} \ell + \bar{R} c^B (1 - \lambda) (1 - b^B) R^B \ell. \quad (7)$$

It requires that the expected return – consisting of the borrower’s payment  $R^B \ell$  that arrives with probability  $\lambda$  and the amount  $b^B R^B \ell$  that is recovered in case of default – equal the refinancing cost of the bank  $\bar{R} \ell$  plus the cost of hedging the value at risk  $(1 - \lambda)(1 - b^B) R^B \ell$  that remains in the bank’s balance sheet. Solving for  $R^B$  then yields

$$R^B := R^B[\lambda, \mathcal{B}] = \frac{\bar{R}}{\rho^B} \quad \text{with} \quad \rho^B = \lambda + (1 - \lambda)b^B - \bar{R}c^B(1 - \lambda)(1 - b^B) \quad (8)$$

Hence, the interest rate is given by the bank’s refinancing cost and a project specific risk adjustment factor. In a world without payment uncertainty (either  $\lambda$  or  $b^B$  equal one), banks would simply pass through their refinancing cost  $\bar{R}$  to firms. Suppose for expositional purposes but without loss of generality that  $b^B = 0$ . Then, in an Arrow-Debreu world with costless risk diversification ( $c^B = 0$ ), firms would face an interest rate  $\frac{\bar{R}}{\lambda}$  reflecting banks refinancing cost augmented by an actuarially fair risk premium.<sup>14</sup> If in this case  $\bar{R}$  reflects the true opportunity cost of finance in the economy, then from the firms’ profit-maximization problem it can be seen that firms’ private marginal costs are well aligned with the social marginal cost.<sup>15</sup>

In general, it holds that in a competitive financial market transaction costs are passed on to the borrowing firms. To what extent these costs matter depends on characteristics of the project and the banks’ refinancing conditions. We summarize the relationship between financial market conditions and the project-specific interest rate in Result 2.

**Result 2.** *The project-specific costs of external finance under bank financing,  $R^B$ , are high if refinancing costs  $\bar{R}$ , the cost of risk diversification  $c^B$ , or the probability of default  $\lambda$  is high, or if the recovery rate  $b^B$  is low. The effect of higher costs of diversification or a lower recovery rate is stronger if refinancing costs or the probability of default are high.*

**Proof:** See Appendix A. ■

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<sup>14</sup>An actuarially fair premium is the benchmark premium as determined on a perfectly competitive market, that is, a premium chosen such that the deterministic price of the insurance is equal to the expected loss.

<sup>15</sup>Note that in contrast to the work by Matsuyama (2008), Manova (2013), and Feenstra et al. (2011), moral hazard is absent from our model. Furthermore, even when there are frictions on the financial market in terms of  $c > 0$ , the incentives of banks and firms are well aligned, and the bank’s participation constraint that is key in the aforementioned models (sometimes referred to as “cash-flow constraint” or “financing constraint”) is never more restrictive than the firm’s participation constraint (break-even condition) (6).

## 2.4 The Credit Guarantee Scheme

Suppose that firms can insure themselves against default risk by means of a guarantee or an insurance that pays out in the event of importer default. There are two main differences between these two instruments. First, the guarantor takes over the claim against the contract partner in case of default, which the insurer does not. Second and relatedly, the guarantee cannot cover more than the value of the contract, whereas, potentially, the insured amount can exceed the loss associated with the actual default. From the firm's point of view, both schemes are effectively identical in their effect since we set its own recovery rate equal to zero.<sup>16</sup> Under plausible economic conditions, namely, whenever the insurance premium or the guarantee premium are not actuarially favorable, the firm will never insure more than the part of the cost that it finances through the bank. As we show in Appendix B, this is an implication of our simplifying assumption that external finance is more expensive than internal finance. Under these conditions, we can nest the insurance case as a special case of a guarantee, namely, the single case where the recovery rate of the guarantor  $b^G$  is zero.<sup>17</sup>

We assume that the guarantor (potentially the government, but not necessarily so) offers the following financing terms: it guarantees to pay the amount  $g \leq pq$  in the event of default, in exchange for a premium payment of  $\gamma g$ . In the event of default, the guarantor assumes the part  $g$  of the claim against the importer and is able to recover a share  $b^G \in [0, 1]$ . Furthermore, just like for banks, the guarantor has to hedge risk in its balance sheet, for which it incurs  $c^G \in [0, \frac{\bar{R}-1}{\bar{R}}]$  per unit of value at risk.

The financing conditions of the guarantor are summarized in  $\mathcal{G} = \{\bar{R}, b^G, c^G\}$ . Except for  $\bar{R}$ , we allow them the potential to be different from the bank's parameters  $\mathcal{B}$ , reflecting differences in the guarantor's ability to diversify risk or recover claims. In a competitive insurance market, the premium  $\gamma$  is then determined by the following condition

$$\gamma g \bar{R} + (1 - \lambda) b^G g = (1 - \lambda) g + c^G \bar{R} (1 - \lambda) (1 - b^G) g, \quad (9)$$

which states that the return from the premium  $\gamma g$ , that can be invested immediately at a rate  $\bar{R}$ , and the return from acquiring the claim in the event of default  $(1 - \lambda) b^G g$  equal the expected payment  $(1 - \lambda) g$  plus the cost of hedging the value at risk in the balance sheet. Solving for  $\gamma$  then yields

$$\gamma := \gamma[\lambda, \mathcal{G}] = \frac{1 - \lambda - (1 - \lambda) b^G + c^G \bar{R} (1 - \lambda) (1 - b^G)}{\bar{R}} \quad (10)$$

With the guarantee in hand, firms can obtain credit from the bank at the "risk free" rate  $\bar{R}$ . To show how the firm's cost of external finance under bank financing with a credit guarantee are

<sup>16</sup>Note that we can do this without loss of generality as long as the recovery rate of the firm is smaller than that of the bank or guarantor, as we can think of  $\lambda$  as reflecting two factors: the repayment probability and the firm's recovery rate.

<sup>17</sup>As will become clear below, the assumption is not restrictive. Arbitrarily small transaction costs are sufficient to render the insurance premium non-favorable.

determined, we consider again the firm's profit-maximization problem. Clearly, any coverage is profitable only if it decreases the cost of external finance; hence, a guarantee will not be purchased if  $R^G > R^B$ . It is straightforward to show that firms will cover exactly the share of exports that they finance externally when  $R^G < R^B$ ; see Appendix B. Given the firm's liquid funds  $k$ , the amount covered by a guarantee  $g$  is then implicitly given by  $g = \bar{R}(aq + f - k + \gamma g)$ , since the firm has to take into account that it must spend  $\gamma g$  of its liquid funds on the premium and thus has to borrow more compared to the case of pure bank financing. With such a guarantee, the bank's credit risk is eliminated and hence the competitive interest rate for the covered loan is equal to  $\bar{R}$ . The firm's expected profit-maximization problem is then

$$\begin{aligned} \max_p \quad & \lambda pq + (1 - \lambda)g - \bar{R}k - g \\ &= \lambda pq - \bar{R}k - \frac{\bar{R}}{1 - \bar{R}\gamma}(aq + f - k) + (1 - \lambda)\frac{\bar{R}}{1 - \gamma\bar{R}}(aq + f - k) \end{aligned} \quad (11)$$

where we have solved and inserted the above expression for  $g$ . The firm's profit-maximization problem is simple: with probability  $\lambda$  it receives the payment  $pq$  from the importer, with probability  $1 - \lambda$  the guarantee pays off in the amount  $g$ . With certainty, all liquid funds  $k$  are invested and the loan plus interest  $g$  is repaid. Rearranging (23) shows, that expected profits are given by (2) with

$$R^G = \frac{\bar{R}}{\rho^G} \quad \text{and} \quad \rho^G = 1 - \bar{R}\gamma = \lambda + (1 - \lambda)b^G - c\bar{R}(1 - \lambda)(1 - b^G). \quad (12)$$

In analogy to Result 2 we can establish how financial market conditions affect the export performance of firms using credit guarantees. These relationships are summarized in Result 3.

**Result 3.** *The project-specific costs of external finance under bank financing with a credit guarantee  $R^G$  are high if refinancing costs  $\bar{R}$ , the cost of risk diversification  $c^G$ , or the probability of default  $\lambda$  are high, or if the recovery rate  $b^G$  is low. The effect of higher costs of diversification or a lower recovery rate is stronger if refinancing costs or the probability of default are high.*

**Proof:** See Appendix A. ■

Comparing the cost of external finance under both financing schemes ((8) and (12)), observing (10)) shows that they are similar if risk diversification costs and the recovery rates of the bank and the guarantor do not differ for a given export transaction, that is, if  $c^B = c^G$  and  $b^B = b^G$  so that  $\rho^B = \rho^G$ . This is a direct implication of the risk-neutrality assumption. From (2) it is straightforward that expected profits with and without a guarantee are equivalent if the financing cost with a guarantee  $R^G$  equals the cost of pure bank financing  $R^B$ .

## 2.5 Testable Hypotheses about the Effects of Public Export Credit Guarantees

Now suppose firms have chosen the financing mode which, given financing conditions  $\mathcal{B}$  and  $\mathcal{G}$ , minimizes their costs of external finance. Then, credit guarantees provided by a public agency that makes non-negative profits, or in other words, is observing a similar pricing condition as private agents on competitive markets (cp. (7) and (9)) will be used only if the government has a cost advantage. Suppose this is true, for example, due to stronger bargaining power or because it faces lower (no) cost of risk diversification. Then firms using public credit guarantees will face lower cost of external finance, have higher optimal sales for a given export transaction and are more likely have crossed the profitability threshold. The same effects, of course, would arise if the government was subsidizing the guarantees. Yet, the empirical fact that we observe non-negative cumulative profits of the public agency over a period of more than 50 years strongly suggests that the prices of public credit guarantees adhere to a profitability constraint.

As discussed in the introduction to this paper, the government might have a cost advantage in providing guarantees for projects with large values at risk because, thanks to its “deep pockets,” it does not have to engage in costly risk diversification. Looking at yearly profit and loss accounts of *Euler Hermes* shows that the cumulative gain masks substantial variation in annual results. For example, between 1982 and 1998, repeated annual losses were incurred, involving amounts up to 2.5 billion. In 1999, annual results turned positive and have remained so to date.<sup>18</sup> With its potential for unlimited refinancing, the state can withstand repeated periodic losses associated with large risky projects, for which the positive expected value materializes only in the very long run. Of course, a perfectly functioning capital market should be able to diversify those types of risks equally well. However, in the presence of diversification or coordination costs, the above reasoning could explain a government cost advantage that is pronounced for very large and very risky projects.

Furthermore, the government is likely to have an advantage in asserting claims in foreign countries thanks to more bargaining power and because, in contrast to a dispersed set of agents that jointly finance projects through the capital market, it does not have to incur coordination costs when it comes to debt renegotiation. Since a substantial number defaults can be attributed to political events, bargaining power seems to be very important. In 2006, about 50 percent of the total amount of claims (292.9 million Euro) were political risk claims.<sup>19</sup> Many outstanding claims, particularly those from developing countries, are handled by the Paris Club as part of multilateral negotiations on

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<sup>18</sup> Interestingly, as Dewit (2001) points out, in 1995 the WTO Agreement on Subsidies and Countervailing Measures came into force, which significantly strengthened the rules for provision of public export credit guarantees, in particular outlawing premia policies that yield long-term losses as well as allowing countries suffering from those policies access to the Dispute Settlement System.

<sup>19</sup> For a detailed description of events that are classified as political risks see [http://www.agaportal.de/en/aga/grundzuege/gedeckte\\_risiken.html](http://www.agaportal.de/en/aga/grundzuege/gedeckte_risiken.html). All numbers in this section are from the Euler Hermes Annual Report 2010, unless stated otherwise. The report is available at <http://www.agaportal.de/en/aga/downloads/jahresberichte.html>.

debt restructuring.<sup>20</sup> In 2010, the federal government held claims of 4.25 billion Euro, of which 1.67 billion were regulated under official rescheduling agreements. Also, the largest part of the cumulative losses before 2006 can be attributed to the Russian economic crisis that occurred in the aftermath of the Soviet Union's collapse. In 2005 and 2006, Russia paid back about 13.6 million Euro,<sup>21</sup> resulting in large positive annual gains and rendering the cumulative result positive. Negotiations with Russia were also conducted by the Paris Club. Based on those facts, we hypothesize that the government has a higher recovery rate in default cases where bargaining power matters.

Presupposing that the government has lower diversification costs and higher recovery rates in case of default, we can derive the following testable hypotheses based on Results 1 and 3.

*With financial markets characterized by conditions  $\mathcal{B}$ ,  $\mathcal{G}$  and firms having chosen profit-maximizing financing modes according to (2), the presence of a public credit guarantee scheme possessed of cost advantages has the following effects:*

- (i) *It reduces firms' financing costs and thus leads firms to conduct more export transactions and increase the volume of sales for a given transaction.*
- (ii) *The effects are stronger when refinancing conditions in private markets are tight*
- (iii) *Small firms and firms with high demand for external finance or little liquid means benefit more from the presence of such a scheme.*

Furthermore, we look for evidence of the presupposed cost advantages by testing the following hypothesis.

- (iv) *The government's cost advantage is more pronounced for export transactions involving large values at risk and/or a foreign public agency as guarantor of the importer.*

In the following section we test these hypotheses.

### 3 Empirics

#### 3.1 Data

We obtained data on the universe of insured transactions between 2000-2010 from Euler Hermes, of which we use all transaction-specific guarantees as only for those the type of good, the importer,

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<sup>20</sup>The Paris Club is a non-institutionalized association of creditor countries that was formed to facilitate multilateral debt renegotiation, restructuring, and cancellation agreements with indebted countries. The Paris Club regularly agrees to reschedule debt in favor of developing countries. In 2010, for example, Germany agreed to a total debt forgiveness of 643 million Euro under the HIPC (Heavily Indebted Poor Countries)- Initiative of the Paris Club. This, of course, strengthens the case for the program being operated at non-negative returns.

<sup>21</sup>See the Annual Report of Euler-Hermes 2006.

the value of the transaction, and the duration of the relationship are specified.<sup>22</sup> The merge with the Ifo Business Survey leaves us with 2,659 covered transactions among 684 firms in a total pool of 5,530 firms that we observe over the period from January 2000 to December 2010. The use of lags in our preferred estimation specification somewhat reduces our estimation sample. For each Hermes transaction we know the dates of the first and the last shipment. We consider a firm as treated during the period spanned by those two observations. Furthermore, we have information on the importer's risk category, which comprises the class of the importer's guarantor (state, bank, no guarantor) and a risk rating on a scale 1-2 for firms with a state guarantor and 1-5 for the other classes, ratings that are assigned by Euler Hermes. Since the number of observations in each of these classes is very small, we collapse them into four categories: 1 “no guarantor/unknown”, 2 “private guarantor”, 3 “foreign bank” and 4 “foreign state/foreign central bank.” When firms have multiple insured transactions at the same time, we pool the covered volumes together, assigning all respective types of guarantors to this one observation.

The Ifo Business Survey covers about 7,000 firms which are surveyed on a monthly basis. The sample is representative of the population of German firms in the manufacturing sector. In the questionnaire, firms are asked to appraise their own business conditions and the economic environment in general, choosing between three or four possible answers usually coded as 1 “better than usual”, 2 “as usual”, 3 “worse than usual,” and occasionally, 4 “does not apply”.<sup>23</sup> For some variables, such as *employment*, the survey asks for the actual numbers.<sup>24</sup> Most relevant for our analysis is the variable *stock of foreign orders*, which captures the assessment of the current stock of settled deals and takes on the four values described above. Since we primarily estimate a binary choice model, we collapse the categories “as usual”, “worse than usual,” and “no exports” for this dependent variable into one. Moreover, we use the variables *expected exports* (1 “decrease” 2 “stay the same” 3 “increase”) and *demand* (1 “worsened” 2 “unchanged” 3 “improved”), capturing the firms’ assessment of expected future exports and the general demand situation, as well as the indicator variable *unconstrained* reflecting firms’ assessment of production constraint (1 “yes” 2 “no”). Table C.2 in the Appendix contains the relevant survey questions.<sup>25</sup>

We merge yearly balance sheet data from the Amadeus Database using information on firms’

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<sup>22</sup>The original label of this type of guarantees is “Einzeldeckungen.” They make up the largest part of the total volume of exports covered. Other types are “Ausfuhrpauschalgewährleistungen” which are provided for a specific product and one (or sometimes more than one) destination market in a given period of time without specifying the importer. “Revolverende Deckungen,” which can be used for repeated similar transactions, are quantitatively only of marginal importance.

<sup>23</sup>For ease of interpretation, we recoded the variables so that 3 “higher”, 2 “as usual”, 1 “lower”.

<sup>24</sup>The survey is actually conducted at the product level, although only some questions are product specific. The number of products per firm is small and equals 1 in the majority of cases. Furthermore, survey answers within firms across products are very strongly correlated; hence, we feel relatively safe in dropping multiple products randomly.

<sup>25</sup>We translated the question from the original language as accurately as possible. The original questions and answers can be found at <http://www.cesifo-group.de/ifoHome/facts/EBDC/Ifo-DataPool/EBDC-Ifo-Business-Survey-Industry/ebdc-ibs-ind-2012b/main/02/variablesDocBinary/ebdc-ibs-ind-2012b-de.pdf>.

**Table 1:** Summary Statistics of Estimation Sample

<b>Estimation sample</b>		Obs	Mean	Std. Dev.	Min	Max
<i>Stock of for. orders</i>	binary	210371	0.1020055	0.3026563	0	1
<i>Demand</i>	ordinal	210371	1.985502	0.6435709	1	3
<i>Employment</i>		210371	2705.909	16844.8	1	200000
<i>ExpectExp</i>	ordinal	210371	2.06055	0.5308772	1	3
<i>Unconstrained</i>	binary	210371	1.60942	.2930711	1	2
<i>Ibrate</i>	in %	210371	2.964665	1.317412	0.6438182	5.113087
<i>WorkingCap</i>	in 1000 EUR	60695	4.22E+07	1.41E+08	-1.29E+09	2.55E+09
<i>CashFlow</i>	in 1000 EUR	53379	3.42E+07	1.83E+08	-1.08E+09	4.67E+09
<i>Tangibles</i>	in 1000 EUR	65382	4.98E+07	2.46E+08	0	6.26E+09
<i>ContractSize</i>	in EUR	2659	3.25E+06	1.62E+07	0	4.45E+08
# Firms		3964				
<b>Estimation sample - Hermes firms</b>						
<i>Stock of for. orders</i>	binary	36375	0.1421581	0.349217	0	1
<i>Demand</i>	ordinal	36375	2.00712	0.6327066	1	3
<i>Employment</i>		36375	2162.424	10599.71	3	191200
<i>ExpectExp</i>	ordinal	36375	2.107491	0.5420085	1	3
<i>Unconstrained</i>	binary	36354	1.631769	.2751239	1	2
<i>Ibrate</i>	in %	36375	2.969295	1.299862	0.6438182	5.113087
<i>WorkingCap</i>	in 1000 EUR	13133	5.38E+07	9.87E+07	-5.86E+07	7.19E+08
<i>CashFlow</i>	in 1000 EUR	12538	2.43E+07	1.09E+08	-1.08E+09	1.24E+09
<i>Tangibles</i>	in 1000 EUR	13384	5.08E+07	1.30E+08	0.00	1.81E+09
<i>ContractSize</i>	in EUR	2659	3.25E+06	1.62E+07	0	4.45E+08
# Firms		521				

stock of *tangible assets*, the amount of *working capital*, and their *cash flow*. This information is available only for a subsample of firms. Furthermore, from the Thompson/Reuters Datastream we obtain monthly averages of the *interbanking rate* (Euribor) for loans with a duration of three months. Table 1 summarizes our data and the estimation sample used in our preferred specification.<sup>26</sup> Since we use six lags, the first observation for each firm is July 2000.

### 3.2 From Theory to Empirics

Ideally, we would perform the empirical analysis at the transaction level. However, linking the guarantee data to the survey is possible only at the firm level. We still expect to see the effects in the firm's assessment of its overall business conditions, albeit perhaps less pronounced.

Let  $\ln y_{it}^* := \ln(\lambda r_{it}) = (1 - \varepsilon) \ln R_{it} - (1 - \varepsilon) \ln(\frac{a}{\theta}) + \ln A_{it}$  be the expected export sales of firm  $i$  at time  $t$  as derived in Subsection 2.2. Then, denoting with  $\Delta x_{it} := \ln x_{it} - \ln \underline{x}_i$  a deviation from

<sup>26</sup>Table C.1 in the Appendix sets out summary statistics for the full sample: they do not reveal any remarkable differences.

the firm's normal conditions  $\underline{x}_i$  and assuming that the firm's productivity and demand elasticity are constant, deviations in expected export sales result as

$$\Delta y_{it}^* = (1 - \varepsilon)\Delta \bar{R}_t - (1 - \varepsilon)\Delta \rho_{it} + \Delta A_{it}. \quad (13)$$

Hence, changes in expected export sales arise from changes in financing conditions induced by changes in the banking sectors's refinancing cost  $\bar{R}$  and changes in the contract- specific risk premium  $\rho$ , as well as changes in demand conditions  $A$ .

Furthermore, let, in accordance with (6),  $\ln \bar{y}_{it} = \ln \varepsilon + \ln \kappa_{it}$  denote the threshold level of expected sales required to break even, with  $\kappa_{it} = \lambda R_{it}(f_i - k_i) + \bar{R}_t k_i$  summarizing the firm's fixed set-up costs. Positive changes in expected exports are observed only if the new level of expected sales is at least as high as the break-even level, i.e.,  $\ln y_{it}^* \geq \ln \bar{y}_{it}$ . Using the definitions of  $\Delta y_{it}^*$  and  $\Delta \kappa_{it}^*$  we can rewrite this as

$$\Delta y_{it}^* \geq \ln \varepsilon + \Delta \kappa_{it} + \ln \underline{\kappa}_i - \ln \underline{y}_i. \quad (14)$$

Since our data are qualitative in nature, meaning that we observe the direction of the deviation in a firm's export sales but not the magnitude, the structure of the model lends itself to estimation by a categorical choice model. Our observed variable is the firm's assessment of its *stock of foreign orders* relative to usual conditions:

$$\Delta y_{it} = \begin{cases} 1 & \text{"larger than usual"} \\ 0 & \text{"as usual" / "worse than usual" / "no exports"} \end{cases} \quad \text{if } \Delta y_{it}^* \geq \ln \varepsilon + \Delta \kappa_{it} + \ln \underline{\kappa}_i - \ln \underline{y}_i \\ \text{else}$$

The latter three answering possibilities have been collapsed into one since, for reasons outlined below, the binary choice model is our preferred estimation strategy. The probability that firm  $i$  reports a larger than usual stock of foreign orders at time  $t$  is then given by

$$P[\Delta y_{it} = 1] = P[\Delta y_{it}^* \geq \ln \varepsilon + \Delta \kappa_{it} + \ln \underline{\kappa}_i - \ln \underline{y}_i]. \quad (15)$$

Our empirical counterpart to (13) is

$$\begin{aligned} \Delta y_{it}^* = & \alpha_t + \beta_1 Hermes_{it} + \beta_{11} Hermes_{it} \times Ibrate_t + \\ & + \beta_{12} Hermes_{it} \times (\ln ContractSize)^2 + \beta_{13} Hermes_{it} \times Guarantor_{it} + \\ & + \beta_{20} Demand_{it} + \beta_{21} Demand_{i,t-1} + \dots + \beta_{2l} Demand_{i,t-l} + \\ & + \beta_{30} ExpectExp_{it} + \beta_{31} ExpectExp_{i,t-1} + \dots + \beta_{3m} ExpectExp_{i,t-m} + \epsilon_{it} \end{aligned} \quad (16)$$

where  $\alpha_t$  captures, among other things, the direct effect of changes in refinancing conditions that are common to all firms. In line with Result 3, we expect that the grant of a Hermes guarantee implies  $\Delta \rho_{it} > 0$ , because it lowers the project-specific risk premium demanded by the firm's bank.

We use a dummy variable,  $Hermes_{it}$ , that indicates whether the firm used a guarantee at time  $t$  to assess this prediction. The model furthermore predicts that the change in the risk premium due to the grant of a guarantee should be stronger if refinancing conditions are tight, or if the government's cost advantages are particularly important, that is, because the transaction's risk is difficult to diversify or because bargaining power in debt renegotiation is of crucial import. We capture the role of refinancing conditions by interacting the  $Hermes_{it}$  dummy with  $Ibrate_{it}$ , the inter-bank interest rate. Regarding the cost of risk diversification and coordination costs, we have to work with a proxy argument since we do not have direct measures. We use the squared size of the covered loan ( $\ln ContractSize_{it}^2$ ) to assess whether lower cost of risk diversification or lower coordination costs in the case of renegotiation matter, assuming that these costs are higher when the amount involved is larger. For the bargaining power channel we use the importer's type of  $Guarantor_{it}$  as a proxy for the relative importance of the government's bargaining advantage. We expect that this advantage will be particularly strong if the foreign government or the foreign central bank is involved.

$Demand_{it}$  is the firm's assessment of its demand conditions, as described in the data section. To account for its categorical nature, we include it in the form of binary indicator variables for positive and negative changes. Coefficients on these indicators are thus to be interpreted as effects relative to the baseline category of "no change (demand as usual)." We include  $l$  lags of the demand variable to capture demand shocks in the past. Since the demand variable is not specific to the firm's export situation, we also include its assessment of future exports ( $ExpectExp_{it}$ ) and  $m$  lags thereof to capture export-specific demand shocks. Our preferred estimation equation sets  $l, m = 6$ . We experiment with a greater number of lags, which turns out not to affect the results but does reduce the size of the estimation sample. Finally,  $\epsilon_{it}$  captures unobserved effects on changes in the firm's export sales.

Our empirical model for the threshold equation (14) is based on a linear approximation of  $\Delta\kappa_{it} \approx (\Delta\bar{R}_t - \Delta\rho_{it})(f - k_i) + \Delta\rho_{it}k_i + \Delta\bar{R}_t(\eta - 1)k_i$  where we hold constant the riskiness of the project, the firm's stock of liquid funds, and the fixed costs. We introduce  $-1 < \eta < 1$  to allow for incomplete pass-through of the banks' refinancing rate to the firm's opportunity cost of internal finance, expecting that the correlation coefficient is positive but smaller 1. We capture the firm's average level of exports and financing cost,  $\ln y_i$  and  $\ln \kappa_i$ , as well as the demand elasticity,  $\ln \varepsilon$ , with a firm fixed effect  $c_i$ , thus arriving at

$$\begin{aligned} \Delta y_{it}^* \geq c_i + \delta_1 Hermes_{it} + \delta_{11} Hermes_{it} \times Ibrate_t + \delta_{12} Hermes_{it} \times (\ln ContractSize)^2 + \\ + \delta_{13} Hermes_{it} \times Guarantor_{it} + \delta_{14} Hermes_{it} \times ExternalFinance_{it} + \\ + \delta_2 \Delta Ibrate_t \times ExternalFinance_{it} + e_{it}. \end{aligned} \quad (17)$$

To proxy the firm's need for *External Finance*, we use the average level of its working capital, or, alternatively, its cash flow, assuming that this reflects a technological characteristic of the firm. In contrast to the stock at time  $t$ , the average level of working capital is not (or much less) reversely affected by changes in the stock of foreign orders. As further proxies for  $ExternalFinance_{it}$  we

use the firm's size, measured by  $\ln Employment$ , and the stock of tangible assets,  $\ln Tangibles_{it}$ , expecting that a larger stock reduces the firm's demand for *risky* credit. Arguably, the more of its loans the firm can cover with collateral, the less important credit default risk should be. The model predicts that changes in refinancing conditions of banks affect firms with high demand for external finance more. We interact  $\Delta Ibrate_t$ , the deviation of the interbanking rate from the sample average at time  $t$ , with the proxies for  $ExternalFinance_{it}$  to assess this prediction.  $e_{it}$  captures unobserved determinants of the threshold level.

### 3.3 Simultaneity, Reverse Causality and Endogenous Selection

Clearly, the decisions to export and to apply for a Hermes guarantee are not taken independently. In fact, for the type of guarantees considered here, firms apply for the guarantee on the basis of a well-defined project. Randomness of treatment is achieved by the fact that the total volume of guarantees granted per year is limited by caps on the amount of risk assumed per country and in total and thus some applications are rejected. Our preferred counterfactuals would be the firms whose applications have been rejected but, unfortunately, this information is not available.<sup>27</sup> Concern over simultaneity is relieved to some extent by the fact that we look at within-firm variation, as well as by the way the survey question is asked. If what the firms refer to as “normal conditions” reflects their normal financing situation, that is, without guarantees, we would be on the safe side. However, if it reflects deviations in the demand situation *beyond* what we capture with the demand and export expectation variables and the numerous lags thereof, the issue of simultaneity persists.

Another cause of endogeneity might be selection based on time-varying financial vulnerability of the firm. As the model suggests, guarantees are particularly effective for firms facing tight credit conditions, which makes them more likely to apply. The firm's financial situation, however, impacts export performance through the cost of finance and credit constraints. Since such an effect would lead to a downward bias of the effect of Hermes, our estimates will be conservative in that respect.

A third issue we need to address is omitted variables bias. We know from earlier empirical research (cp. Felbermayr et al., 2012) that even among the group of exporters, firms using Hermes guarantees are on average more productive. Hence, they appear more likely to have crossed the threshold level already, meaning that, *ceteris paribus*, deviations in the stock of foreign orders are observed more often. We do not observe productivity for our sample, so we can control for this effect only to the extent that it is constant over time and hence captured in the fixed effect.

For these reasons, we avoid making a causal interpretation of our estimated *direct* effect of the guarantees and instead place more confidence in the interaction terms. There are concerns about the interaction terms as well, but we are confident that we can either address them convincingly or that the potential bias works against us finding the hypothesized effect. First, there is an issue of reverse causality, since unusually high exports could adversely affect the firm's stock of liquid assets.

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<sup>27</sup> Furthermore, we would need to observe everything that was observable to the agency when making the decision, at least as far as it is related to the feasibility and success rate of the project, which is not very realistic either.

To circumvent this reverse influence, which is a temporary effect, we use within-firm averages over the sample period. For our alternative proxies,  $\ln Employment_{it}$  and  $\ln Tangibles$ , we would expect that these variables are, if at all, positively affected by higher than usual exports. Hence, a reverse influence would work in the opposite direction as our hypothesized relationships. Second, there could be a concern about a threshold effect similar to the one discussed just above, as the amount of liquid means at hand, the amount of tangibles, or the size of the firm are certainly related to the threshold level. However, since we look for a negative interaction effect, that is, we expect that smaller liquid means and smaller firm size imply a stronger effect, the positive relationship of those variables with the threshold works against us.

### 3.4 Estimation Model

Combining (16) and (17) yields our estimation equation

$$P[\Delta y_{it} = 1] = G[\mathbf{x}'_{it}\tilde{\beta} - c_i] \quad (18)$$

where

$$\begin{aligned} \mathbf{x}'_{it}\tilde{\beta} = & (\beta_1 - \delta_1)Hermes_{it} - \delta_{14}Hermes_{it} \times ExternalFinance_i + (\beta_{11} - \delta_{11})Hermes_{it} \times Ibrate_t + \\ & + (\beta_{12} - \delta_{12})Hermes_{it} \times (\ln ContractSize)_{it}^2 + (\beta_{13} - \delta_{13})Hermes_{it} \times Guarantor_{it} \\ & + \delta_2\Delta Ibrate_t \times ExternalFinance_{it} + \beta_{20}Demand_{it} + \beta_{21}Demand_{i,t-1} + \dots + \\ & + \beta_{2l}Demand_{i,t-l} + \beta_{30}ExpectExp_{it} + \beta_{31}ExpectExp_{i,t-1} + \dots + \beta_{3m}ExpectExp_{i,t-m} + \alpha_t \end{aligned}$$

and  $G$  denotes the distribution function of combined error term  $u = e - \epsilon$ . To estimate (18) parametrically, we need to make assumptions about the joint distribution of  $e$  and  $\epsilon$ .

Assuming that they are independent normally distributed yields a probit model. The main drawback of the probit model in our case is that consistent estimation requires the firm fixed effect  $c_i$  to be uncorrelated with the regressors, thus implying a random effects model. It is possible to relax this assumption to some extent if the correlation can be specified explicitly. For example, if we assume that the fixed effects correlate only with the means of the regressors, then a Mundlak-Chamberlain-type probit model yields consistent parameter estimates.<sup>28</sup> The corresponding assumption on the distribution of the firm fixed effect is

$$c_i | \mathbf{x}_i \sim N(\psi^s + \bar{\mathbf{z}}'_i \mathbf{b}, \sigma_\alpha^2) \quad (19)$$

where  $\bar{\mathbf{z}}_i$  denotes a vector of firm averages of the variables *Hermes*, *Demand*, and *ExpectExp* over the sample period. We also include averages of  $\ln Employment$  and *Unconstrained* as we expect them to partly explain the firm's position relative to the threshold.  $\psi^s$  is a constant that we allow to

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<sup>28</sup> C.p. Wooldridge's (2002) version of the approach proposed by Mundlak (1978) and generalized by Chamberlain (1980).

be sector specific. Under the assumption of normality of  $u$  and the conditional normal distribution of the  $c_i$ 's, pooled probit estimation of  $\Delta y_{it}$  on  $\mathbf{x}_{it}, \bar{\mathbf{z}}_i$  and a vector of sector dummies yields consistent estimates of scaled coefficients,  $\tilde{\boldsymbol{\beta}}_a = \tilde{\boldsymbol{\beta}} \frac{1}{(\sigma_a^2 + \sigma_u^2)^{-1/2}}$ ,  $\mathbf{b}_a = \mathbf{b} \frac{1}{(\sigma_a^2 + \sigma_u^2)^{-1/2}}$  and  $\boldsymbol{\psi}_a^s = \boldsymbol{\psi}^s \frac{1}{(\sigma_a^2 + \sigma_u^2)^{-1/2}}$  (C.p Wooldridge, 2002, p. 488). Robust standard errors are computed to account for serial correlation due to the presence of latent heterogeneity.<sup>29</sup> Based on  $\hat{\boldsymbol{\beta}}_a$ ,  $\hat{\mathbf{b}}_a$ , and  $\boldsymbol{\psi}_a^s$ , we compute predicted probabilities as

$$\hat{P}[\Delta y = 1] = \frac{1}{N} \sum_{i=1}^N (\mathbf{x}'_i \hat{\boldsymbol{\beta}} - \hat{c}_i) = \frac{1}{N} \sum_{i=1}^N \Phi(\hat{\boldsymbol{\psi}}_a^s + \mathbf{x}'_i \hat{\boldsymbol{\beta}}_a + \bar{\mathbf{z}}'_i \hat{\mathbf{b}}_a), \quad (20)$$

the average partial effect of a binary covariate  $x_k$  as

$$d\hat{P}[\Delta y = 1] = \frac{1}{N} \sum_{i=1}^N \left( \hat{P}[\Delta y = 1|x_k = 1] - \hat{P}[\Delta y = 1|x_k = 0] \right), \quad (21)$$

and the average partial effect of a continuous covariate  $x_k$  as

$$\frac{\partial \hat{P}[\Delta y = 1]}{\partial x_k} = \frac{1}{N} \sum_{i=1}^N \hat{\beta}_{ak} \phi(\hat{\boldsymbol{\psi}}_a^s + \mathbf{x}'_i \hat{\boldsymbol{\beta}}_a + \bar{\mathbf{z}}'_i \hat{\mathbf{b}}_a). \quad (22)$$

$\Phi(\phi)$  denotes the cumulative (probability) density function of the standard normal distribution. Standard errors are obtained with the Delta method.<sup>30</sup>

### 3.5 Alternative Assumptions

We employ the conditional logit model as an alternative estimation strategy. This model rests on the assumption that the error terms in the latent variable specification and the threshold equation are independent type I extreme value distributed, so that the composite error term  $u = e - \epsilon$  follows a logistic distribution. An important advantage of this model over the previous one is that it allows for unrestricted correlation of the unobserved fixed effect and the explanatory variables. However, it has disadvantages as well, the most important of which is that, for consistency, it requires assuming that scores are uncorrelated over time. Another drawback that the model has in common with linear fixed effect estimation is that only firms exhibiting variation in  $y_{it}$  over time are included. In contrast to the linear case, this presents us with an additional problem when want to estimate partial effects. To compute partial effects, estimates of the  $c_i$ 's are needed. In principle, these can be backed out based on the data and consistent estimates of the other parameters. However, this is possible only for the firms included in the estimation. Hence, partial effects at the mean can be computed only at the mean value of the  $c_i$ 's for the included firms. Computation of average

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<sup>29</sup> c.p. expression (15.53) in Wooldridge (2002).

<sup>30</sup> Details can be found e.g. Chapter 2.6.4 in Greene and Henscher (2010)

partial effects would require specifying a distribution of the  $c_i$ 's. Given that we explicitly allow for correlation between the  $c_i$ 's and the right-hand-side variables, computations based on the mean or the empirical distribution of the  $c_i$ 's of the included firms only are not attractive. We thus view the results from the conditional logit estimation as robustness checks for our parameter estimates with respect to the orthogonality assumption, but do not compute partial effects.

As another robustness check we estimate a linear probability model (LPM) with fixed effects. Here, the presence of arbitrary correlation between the  $c_i$ 's and the explanatory variables, as well as serial dependence of scores, does not affect consistency of the parameter estimates. Cluster-robust standard errors can be obtained for inference. However, the LPM has the well known drawback of potential predictions beyond the support of probabilities.

## 3.6 Results

### 3.6.1 Baseline Estimations

Table 2 contains the results of our baseline model for assessing the impact of a *Hermes* guarantee on the probability that firms report their stock of foreign orders to be “larger than usual.” Results are based on (18) and (19), except for the interaction terms that we add in a second step below. The results in Column 1 are based on the most parsimonious specification to which we subsequently add further explanatory variables. Except for the avg. *Unconstrained* variable, we find significant estimates which point into the expected direction throughout the different specifications. The grant of a guarantee has a positive effect on the probability that firms report higher than usual exports. Higher (lower) demand and export expectations today are positively associated with a higher (lower) than usual stock of foreign orders. When we add lags of those two variables (6 in Columns (2),(4)-(8) and 12 in Column (3)), we find similar and statistically significant effects of demand conditions in the past.<sup>31</sup> The effect of *Hermes* is very stable, notwithstanding the significant drop in observations that occurs due to the use of more lags. The effect remains positive and significant if we use the log of the volume covered by the guarantee ln *ContractSize* instead of the indicator variable, as shown in Column (5).<sup>32</sup> We also estimate an ordered probit model with three categories of the variable *stock of foreign orders* (“better than usual”, “as usual,” and “worse than usual”), which yields similar results, presented in Column (6). This specification uses more of our available information than does the binary probit, but we prefer the latter because a brant test leads us to reject the parallel lines assumption underlying the ordinal model.

Regarding the role of the threshold, we find that larger firms are more likely to report higher stocks of foreign orders, which, according to the model, is due to the fact that they are more likely to

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<sup>31</sup>For brevity’s sake, these estimates are omitted from the table, but are available from the authors upon request.

<sup>32</sup>Since we know only the duration of the coverage and the total volume, but not the volume per month, we distribute the total volume evenly across the months with coverage. Furthermore, we add a 1 for all observations that do not exhibit a guarantee. Due to these major but necessary modifications, this is not our preferred estimation.

have passed the threshold. The effect of the average number of periods in which firms report being unconstrained in production is not stable, at times even negative. When we extend the threshold equation to include the average values of our independent variables (Column (4)), the estimated effect of *Hermes* becomes much smaller. The coefficient on the contemporaneous effect drops from .3 to .08 and the average of the *Hermes* indicator is strongly significant. This suggests that firms using Hermes grants more often are more likely to have passed the threshold, thus enabling them to translate demand shocks into actual export transactions more frequently, even in periods when they do not receive a grant. This is well in line with the finding of our earlier empirical research that even among the group of exporters, firms using Hermes guarantees are more productive. Hence, the average number of periods with coverage might well pick up the effect of productivity (which we do not observe), pointing toward a violation of the orthogonality assumption. We address this concern to the extent that the characteristics of the firm that jointly determine whether the firm is above the threshold and its potential selection into the guarantee scheme are constant over time by estimating a conditional logit model and a linear probability model with fixed effects. Results are presented in Columns (7) and (8), respectively. Both models can dispense with the orthogonality assumption of the fixed effects and the other right-hand-side variables with regard to consistency. We find mixed results: the conditional logit model yields a highly significant and positive effect for *Hermes*, while the LPM produces an insignificant estimate.

As pointed out above, a pooled probit estimation of (18) and (19) yields estimates of scaled coefficients. To assess the magnitude and economic significance of the effects we compute average partial effects as specified in (21) and (22). Results for our preferred estimation specification (Column (4)) are reported in Column (9). We find that the grant of a Hermes guarantee is associated with a 1.2 percentage point increase in the probability of reporting a higher stock of foreign orders. The average effect of better than usual demand conditions is 4.4 percentage points; a similar result holds for better than usual export expectations.

Taking our results together, we find support for a positive relationship between the grant of a guarantee and positive deviations from firms' normal stock of foreign orders that is in line with the model. However, since we are not fully confident that we have overcome simultaneity and selection issues, we do not interpret the estimates as causal effects. To assess the causality issue further, we use the model's predictions about the heterogeneity of the effect. The model suggests that the channel through which the positive effects materialize is the mitigation of financing constraints that inhibit firms' exports on the extensive and the intensive margin. As detailed in Section 3.2, we assess those predictions by interacting the *Hermes* variable with indicators of the firms' financing conditions.

**Table 2:** Coefficient Estimates of Baseline Model

Dep. variable: <i>Stock of foreign orders</i>	Mundlak-Chamberlain Probit				OProbit	Clogit	LPM	APE
Model:								
<i>Hermes</i>	0.300*** (.0269)	0.293*** (.0302)	0.318*** (.0324)	0.0866** (.0405)	0.100* (.055)	0.259*** (.0811)	0.0270 (.0205)	0.0122** (.00571)
<i>ExpectExp</i> (-)	-0.290*** (.0174)	-0.138*** (.0233)	-0.131*** (.0265)	-0.138*** (.0234)	-0.138*** (.0234)	-0.721*** (.0209)	-0.371*** (.0556)	-0.00549** (.00225)
<i>ExpectExp</i> (+)	0.615*** (.00787)	0.306*** (.0123)	0.283*** (.0142)	0.309*** (.0125)	0.309*** (.0125)	0.280*** (.0156)	0.656*** (.0252)	0.0666*** (.00367)
<i>Demand</i> (-)	-0.355*** (.0119)	-0.263*** (.0147)	-0.267*** (.0167)	-0.247*** (.0147)	-0.247*** (.0147)	-0.527*** (.0139)	-0.689*** (.0349)	-0.0251*** (.0018)
<i>Demand</i> (+)	0.417*** (.00798)	0.299*** (.0107)	0.296*** (.0123)	0.278*** (.0108)	0.278*** (.0108)	0.422*** (.0133)	0.655*** (.0231)	0.0527*** (.00282)
avg. <i>Unconstrained</i>	0.0701*** (.0124)	-0.00109 (.0155)	-0.0278 (.0178)	-0.0283* (.0156)	-0.0290* (.0156)	1.182*** (.0177)		-0.00399* (.0022)
22 avg. <i>ln Emp</i>	0.0470*** (.00225)	0.0396*** (.00274)	0.0285*** (.00309)	0.0366*** (.00277)	0.0364*** (.00277)	0.135*** (.00315)		0.00516*** (.00039)
avg. <i>ExpectExp</i>				-0.124*** (.0263)	-0.124*** (.0263)	-0.271*** (.0303)		-0.0174*** (.00371)
avg. <i>Demand</i>				0.492*** (.0307)	0.491*** (.0307)	0.837*** (.0349)		0.0693*** (.00432)
avg. <i>Hermes</i>				0.524*** (.0639)		0.298*** (.0899)		0.0739*** (.00901)
ln <i>ContractSize</i>					0.00688** (.00299)			
avg. ln <i>ContractSize</i>					0.0384*** (.00462)			
# lags	0	6	12	6	6	6	6	6
N	290113	210258	168076	210258	210258	210244	137940	211063
								210258

Standard errors in parenthesis. \*, \*\*, \*\*\* indicate significance on the 10, 5, and 1% significance level. S.e. in probit (LPM) estimation are (cluster-) robust. All estimations include year  $\times$  month dummies and sector dummies. # lags refers to lags of the categorical variables *ExpectExp* and *Demand*. Coefficients of lagged variables times and sector effects not shown.

**Table 3:** Interaction Terms, Coefficient Estimates

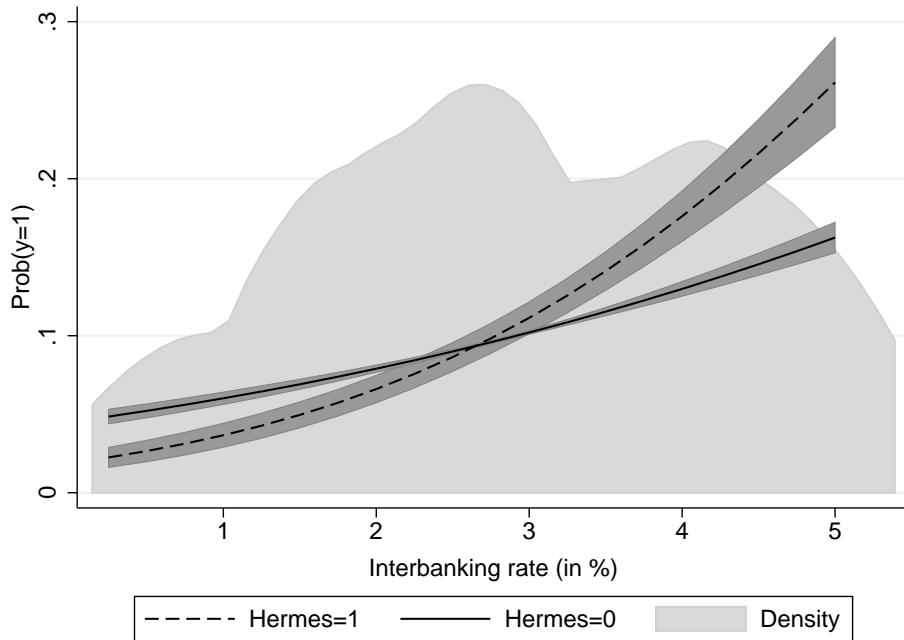
Dependent variable: <i>Stock of foreign orders</i> ; Model: Mundlak-Chamberlain Probit						
<i>Hermes</i>	1.102*** (0.167)	-0.491*** (.0946)	1.204*** (0.228)	1.131*** (0.336)	3.106*** (0.456)	
$\times \ln Emp$	-0.152*** (0.0244)					
$\times Ibrate$		0.184*** (.026)				
$\times \text{avg. ln WorkingCap}$			-0.0683*** (0.0133)			
$\times \text{avg. ln CashFlow}$				0.0168*** (0.00356)		
$\times \ln Tangibles$					-0.189*** (0.0276)	
$\Delta Ibrate$						
$\times \ln Emp$		0.0182*** (0.0019)				
$\times \text{avg. ln WorkingCap}$			0.00698*** (0.00126)			
$\times \text{avg. ln CashFlow}$				-0.00512** (0.00223)		
$\times \ln Tangibles$					-0.00262 (0.00218)	
avg. $\ln Emp$	0.0345*** (0.00283)	0.0364*** (.00277)	0.0355*** (.00389)	0.00141 (.00522)	0.0396*** (.00606)	0.0366*** (.00277)
avg. $\ln WorkingCap$			0.000254 (0.00176)			
avg. $\ln CashFlow$				0.0168*** (0.00356)		
$\ln Tangibles$					-0.00416 (0.00365)	
$\ln ContractSize$						-0.0761*** (.0192)
$\times \ln ContractSize$						0.00596*** (.00135)
N	210258	210258	114209	92989	65352	210258

Estimations are based on the specification in table 2, column 4. Robust standard errors in parenthesis. \*, \*\*, \*\*\* indicate significance on the 10, 5, and 1% significance level. Coefficients of lagged variables, firm averages (except for direct effects of interacted variables), time, and sector FE not shown.

### 3.6.2 Heterogeneity of the Effect of Hermes

Table 3 presents the results for parameter estimates of the interactions in our preferred baseline model as in Table 2, Column (4). We find significant interaction terms with the expected signs for all financial variables of interest. However, assessing the qualitative and quantitative effect as well as statistical significance of interacted variables in non-linear models is not straightforward, see, e.g., Ai and Norton (2003) and Greene (2010). As Greene (2010) points out, the sign of the coefficient of the interacted variables is not necessarily the same as the sign of the actual interaction effect. Furthermore, regarding inference,  $\hat{\beta}_{1k} = 0$  is not sufficient for the interaction effect to be zero. In fact, various combinations of estimated parameters and the data can equate it to zero. Hence, the standard statistical inference results for marginal effects are difficult to interpret economically. Greene (2010) suggests looking at predicted probabilities at different values of the covariates instead. We follow his advice and assess the heterogeneity of the effect of *Hermes* by graphically analyzing differences in predicted probabilities between firms with and without a guarantee at different levels of the covariates.<sup>33</sup>

**Figure 1:** Interbanking rate

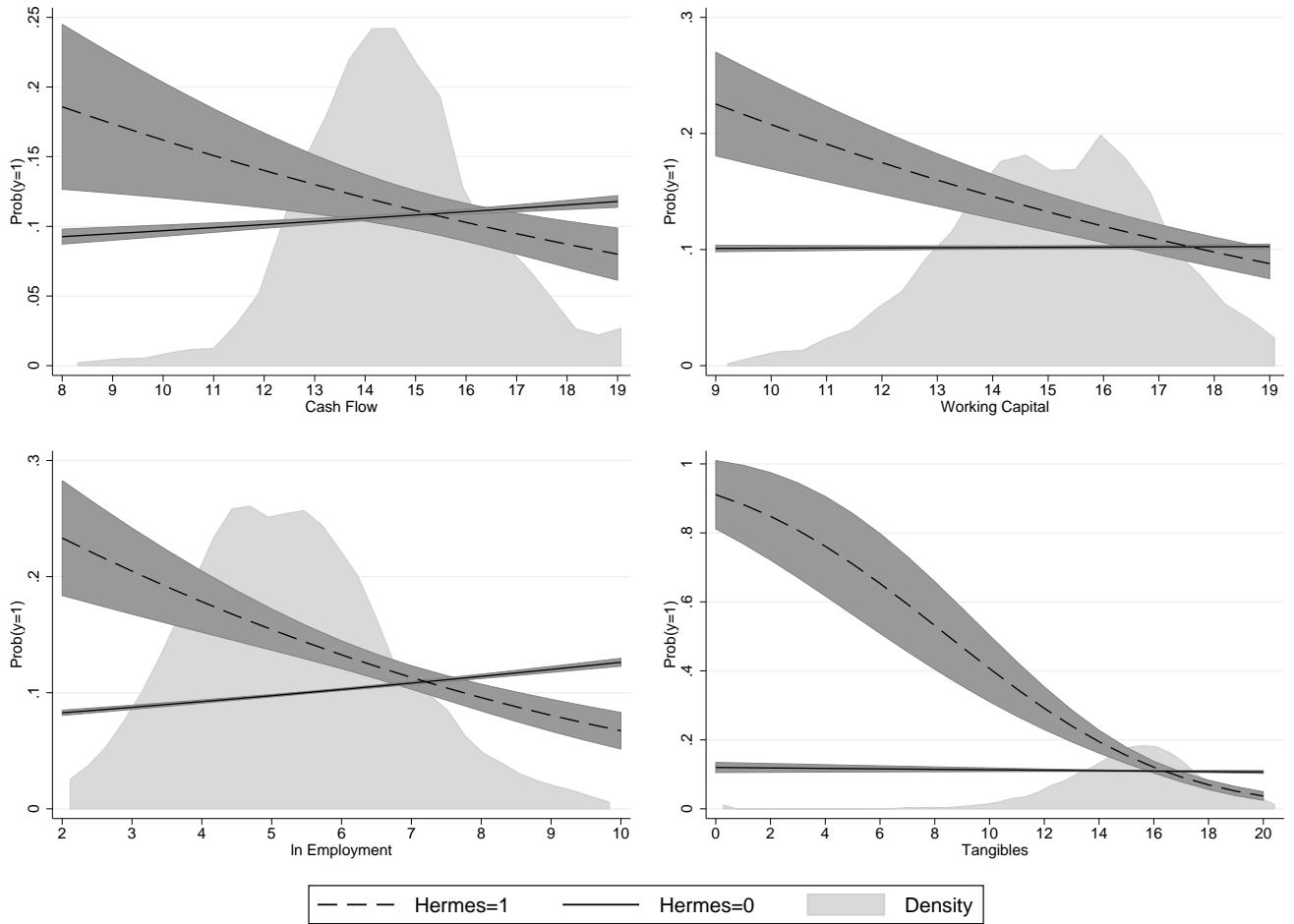


**The role of financing conditions.** We first analyze the role played by the banking sector's refinancing conditions. From our model we expect that higher refinancing costs for banks increase both the variable cost of finance and the threshold level, thus reducing firms' export via a negative

<sup>33</sup>Significance of the coefficient estimates is of course still important, as it influences the precision of the predicted probabilities.

effect on the extensive and intensive margins. We find support for this hypothesis: Figure 1 plots the predicted probabilities of reporting a higher than usual stock of foreign orders for firms with and without a guarantee. The difference between the two reflects the marginal effect of *Hermes*. As the figure shows, this difference becomes larger (in absolute terms) for higher values of the interbanking rate. Shaded bands reflect 90 percent confidence bands, the shaded area plots the estimated density of the interbanking rate. At first glance, it might be puzzling that both probabilities are upward sloping. However, note that the direct effect of the interbanking rate is absorbed in the time fixed effects and thus does not feature in our predictions.

**Figure 2:** External Finance Demand

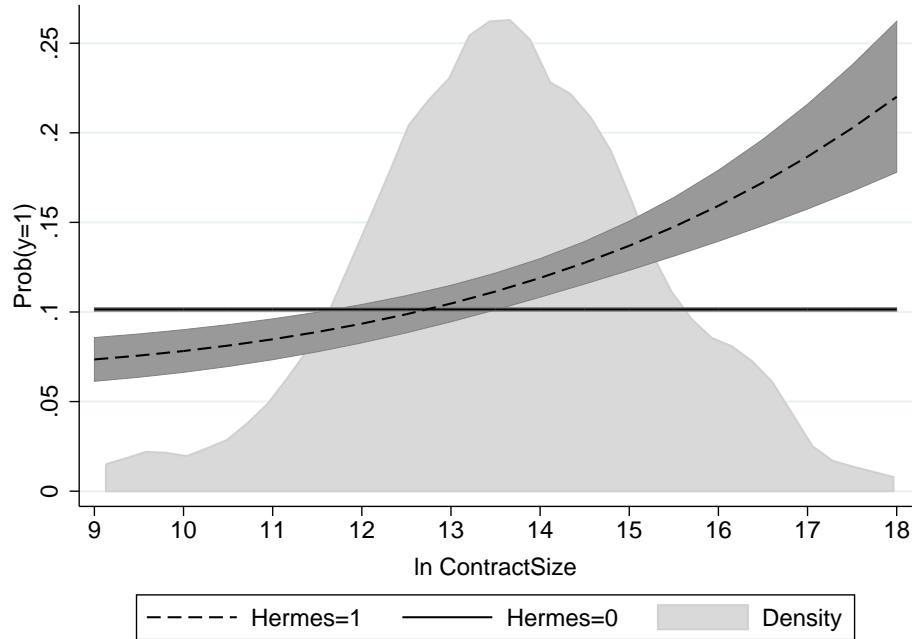


Next, we consider how the need for external finance interacts with the *Hermes* variable. The model suggests that firms with little cash in hand benefit more from a favorable public guarantee scheme as this could move them above the threshold. As detailed above, we use information on cash flow, working capital and firm size measured by employment to test this prediction. For all three measures of external finance demand, we find the expected interaction effects. As the respective figures illustrate, the effect of a *Hermes* guarantee is stronger for small firms and firms with little

working capital or small average cash flows. We also look at the interaction effect with the stock of *Tangibles* as a proxy for the demand for risky credit. We find that firms with small stocks of tangible assets benefit more from the use of a credit guarantee.

The model also suggests, that changes in the banks' refinancing conditions affect firms with high demand for external finance more. We test this prediction with the interaction of  $\Delta Ibrate$  with the external finance proxies. We find positive interaction effects for employment and working capital, suggesting that larger firms and firms with more liquid means cope better with tighter refinancing conditions. See Figure C.1 in the Appendix for plots of the predicted probabilities across different levels of the external finance variables at the 25th, 50th, and 75th percentile of  $\Delta Ibrate$ . Significantly positive interactions for all the proxies are confirmed by LPM-estimates that we present below. This lends support to our model by highlighting the sensitivity of firms' export to lending conditions on private financial markets.

**Figure 3:** Contract size



**Characteristics of the insured contract.** To evaluate the hypothesized cost advantages of the public agency in providing credit guarantees we estimate the effect of the covered volume and, in particular, its non-linearity. We expect that both the costs of risk diversification and the coordination costs of private financiers are higher for larger values at risk. Hence, we expect the public agency's cost advantage to be particularly pronounced for large contracted volumes. To test these presumptions, we add the squared volume of the coverage ( $\ln ContractSize)^2$  and look at predicted probabilities for Hermes firms at different contract sizes (Figure 3). The horizontal line depicts the predicted probabilities for firms without guarantees. For firms with guarantees, the predicted probabil-

ity is increasing in contract size, reflecting the direct effect. The interesting finding is the convexity, implying that the marginal effect of a larger covered loan is increasing.

Another source of government cost advantage is its stronger bargaining power in the event that debt renegotiation becomes necessary. We use information on the importer's type of guarantor to assess this prediction, assuming that bargaining power should be particularly important for contracts where the importer's guarantor is the foreign government or a central bank. Table 4 presents the results: We find no support for this hypothesis. Only in the case of a private guarantor is the predicted probability significantly different from a firm without a guarantee; for state or central bank guaranteed transactions we find no effects.<sup>34</sup>

**Table 4:** Type of the Importer's Guarantor

	$\widehat{\Pr}(y = 1 X)$	90% CI	# obs
<i>Hermes</i> = 0	<b>.102</b>	[.101;.103]	207712
<i>Hermes</i> = 1			
<i>State</i>	<b>.079</b>	[.045;.112]	59
<i>Bank</i>	<b>.121</b>	[.095;.148]	199
<i>Private</i>	<b>.164</b>	[.138;.191]	361
<i>None</i>	<b>.105</b>	[.095;.116]	2695

Predicted probabilities, based on the specification in Table 2, column 4.

### 3.6.3 Robustness

For robustness, we estimate the interaction terms in a linear probability model, where the coefficients on the interaction terms are straightforwardly interpreted as interaction effects. The estimated coefficients are presented in Table 5. We find our results from the Mundlak-Chamberlain probit model confirmed in regards to the signs of the interactions effects, although significance is weaker. The interactions with  $\ln WorkingCapital$ ,  $\ln Tangibles$ , and  $(\ln ContractSize)^2$  are no longer significant. For the interactions with  $\Delta Ibrate$  we find significant interaction effects for all the financial variables. Furthermore, we estimate a conditional logit model and find significant parameter estimates throughout, confirming the signs of the coefficient estimates for the direct effect and the interactions terms. Table C.3 in the Appendix presents the results.

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<sup>34</sup> Estimation of these interactions is likely hampered by our pooling of guaranteed transactions with potentially different guarantor types that take place at the same point in time. This is necessary because our dependent variable is at the firm-level and not at the transaction level.

**Table 5:** Interaction Terms, Linear Probability Model

Dep. variable: <i>Stock of foreign orders</i> ; Model: LPM with FE					
<i>Hermes</i>	0.170** (.0836)	-0.167*** (.0387)	0.0614 (.0936)	0.364*** (.137)	0.193 (.189)
$\times \ln Emp$	-0.0217* (.0118)				
$\times Ibrate$		0.0657*** (.013)			
$\times \text{avg. ln } WorkingCap$			-0.00276 (.00569)		
$\times \text{avg. ln } CashFlow$				-0.0233*** (.00839)	
$\times \ln Tangibles$					-0.0122 (.0106)
$\Delta Ibrate$					
$\times \ln Emp$		0.00583*** (.000835)			
$\times \text{avg. ln } WorkingCap$			0.00190*** (.000337)		
$\times \text{avg. ln } CashFlow$				0.00148* (.000845)	
$\times \ln Tangibles$					0.00149* (.000807)
$\ln ContractSize$					0.000102 (.0136)
$\times \ln ContractSize$					0.000140 (.00103)
N	211063	211063	114607	93323	65616
					211063

LPM with firm fixed effects. Standard errors clustered on firm level in parenthesis. \*, \*\*, \*\*\* indicate significance on the 10, 5, and 1% significance level. Coefficients of covariates and time FE not shown.

## 4 Conclusion

In this paper, we analyze the effect of German public export credit guarantees (“Hermes guarantees”) on firms’ exports. This public instrument is commonly justified as a means of mitigating the negative consequences of financial market frictions for exporting firms and, indeed, previous research finds evidence of a positive relationship. However, due to lack of appropriate data, evidence on the channels through which the policy instrument really works is scarce, even though such is crucial for assessing this instrument’s value added effects for the economy as a whole as well as for its efficient design.

We build a model with heterogeneous exporters and financing constraints and derive conditions

under which public export credit guarantees can mitigate financial market imperfections. Firms will benefit from such a scheme only if the government can provide guarantees at lower cost than private financial agents. We argue that the government has a cost advantage in financing specific types of projects, specifically projects characterized by large values at risk or involving foreign governments. We therefore expect to find positive effects for those types of projects. According to the model, the beneficial effect of a public guarantee scheme should be stronger for small firms that find it difficult to finance their operations externally, and stronger when private market financing conditions are tight.

We test these predictions with a unique firm-level data set that results from joining a data set of Hermes guarantees that were granted between 2000 and 2010 with the Ifo Business Survey. We find that Hermes guarantees indeed have a positive effect on firms' export performance. Moreover, small firms appear to benefit more and the refinancing conditions on private financial markets matter. We find no support for the bargaining power hypothesis, but for contracts of large size, the Hermes effect is particularly strong, suggesting that risk diversification and/or coordination costs matter in private financial markets. Our results lend support to the hypothesis that the positive effect of Hermes guarantees does indeed manifest through mitigating financial constraints by passing through the government's cost advantages to German firms.

As to the welfare effects of the policy instrument, the public guarantee scheme decreases both the variable and the fixed costs of exporting. In the context of the standard general equilibrium Melitz-model, such an adjustment is comparable to a reduction of trade barriers and yields a strictly positive effect on welfare if it is homogeneous across firms. What is less clear is the role of heterogeneity in effective entry cost resulting from differences in the firms' equipments with liquid assets that renders the effect of changes in the cost of external finance heterogeneous across firms. This provides an interesting avenue for future research. Furthermore, welfare effects depend crucially on the validity of several other assumptions that we make in the model and which are hard to verify, especially that the long-term profits of the public agency are indeed non-negative as suggested by observable figures, as well as the negligibility of the threat of government default.

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## A Proofs

**Proof of Result 1.** Since, for a given financing mode  $o' \in (R, G)$ ,  $\frac{\partial r[a]}{\partial R^{o'}} < 0$ , optimal sales fall if the firm is operating under mode  $o'$  and does not switch to  $o \neq o'$ , or if it switches the mode and had not been indifferent in the initial situation. If the firm is operating under mode  $o$  or if it was indifferent in the initial situation optimal sales are unchanged.

Let RHS denote the right-hand-side of (6). Since  $\frac{\partial \text{RHS}}{\partial R^{o'}} > 0$ , due to our assumption that  $f > k$ , and  $\frac{\partial r[a]}{\partial a^{o'}} < 0$ ,  $a^{o'}$  falls as  $R^{o'}$  increases. The threshold productivity that is relevant for the firm increases unless it is operating under  $o \neq o'$  or was indifferent in the initial situation.

Since  $\frac{\partial^2 \text{RHS}}{\partial R^{o'} \partial k} < 0$ , the adjustment in  $a^{o'}$  is stronger the smaller  $k$ . ■

**Proof of Results 2 & 3.** For  $o \in [B, G]$ ,

$$\begin{aligned} \frac{\partial R^o}{\partial \bar{R}} &= \frac{1}{\rho^o} - \frac{1}{(\rho^o)^2} \frac{\partial \rho^o}{\partial \bar{R}} > 0 \quad \text{since} \quad \frac{\partial \rho^o}{\partial \bar{R}} = -c^o(1-\lambda)(1-b^o) < 0 \\ \frac{\partial R^o}{\partial \lambda} &= -\frac{\bar{R}}{(\rho^o)^2} \frac{\partial \rho^o}{\partial \lambda} < 0 \quad \text{since} \quad \frac{\partial \rho^o}{\partial \lambda} = (1-b^o)(1+\bar{R}c^o) > 0 \\ \frac{\partial R^o}{\partial c^o} &= \frac{\bar{R}^2}{(\rho^o)^2} (1-\lambda)(1-b^o) > 0 \\ \frac{\partial R^o}{\partial b^o} &= -\frac{\bar{R}^2}{(\rho^o)^2} [(1-\lambda)(1+\bar{R}c^o)] < 0 \\ \frac{\partial^2 R^o}{\partial c^o \partial \bar{R}} &= -\frac{1}{(\rho^o)} \frac{\partial R^o}{\partial c^o} \frac{\partial \rho^o}{\partial \bar{R}} + \frac{2\bar{R}}{(\rho^o)^2} (1-\lambda)(1-b^o) > 0 \\ \frac{\partial^2 R^o}{\partial c^o \partial \lambda} &= -\frac{1}{(\rho^o)} \frac{\partial R^o}{\partial c^o} \frac{\partial \rho^o}{\partial \lambda} - \frac{\bar{R}^2}{(\rho^o)^2} (1-b^o) < 0 \\ \frac{\partial^2 R^o}{\partial b^o \partial \lambda} &= -\frac{1}{(\rho^o)} \frac{\partial R^o}{\partial b^o} \frac{\partial \rho^o}{\partial \bar{R}} - \frac{1}{(\rho^o)^2} [(1-\lambda) + 2\bar{R}c^o(1-\lambda)] < 0 \\ \frac{\partial^2 R^o}{\partial b^o \partial \lambda} &= -\frac{1}{(\rho^o)} \frac{\partial R^o}{\partial b^o} \frac{\partial \rho^o}{\partial \lambda} + \frac{\bar{R}}{(\rho^o)^2} (1+\bar{R}c^o) > 0. \quad ■ \end{aligned}$$

## B Generalization of the Model and Result 1

In this section, we proof that Result 1 holds without the simplifying assumptions,  $\lambda R^o > \bar{R}$  and  $k < f$ , that we make in Section 2. Let  $\ell$  denote the size of the loan and  $\bar{R}g$  the volume of the guarantee.<sup>35</sup> The generalized form of the profit-maximization problem is then:

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<sup>35</sup>The bank considers a part  $g$  of the loan as risk free, if the firm can provide a guarantee for the amount  $\bar{R}g$ . Since the firm has to buy the guarantee in the first period, the funds it needs to borrow are augmented by the premium payment  $\gamma \bar{R}g$ .

$$\max_{p, \ell, g} \pi = \lambda pq - (aq + f) + \ell - \lambda \bar{R}g - \lambda R^B(\ell - g + \gamma \bar{R}g) + (\bar{R} - 1)(\ell + k - aq - f) \quad (23)$$

$$\text{s.t.} \quad \ell + k \geq aq + f \quad (24)$$

$$pq \geq R^B(\ell + \gamma \bar{R}g - g) + \bar{R}g \quad (25)$$

$$g \geq 0 \quad (26)$$

$$\ell + \gamma \bar{R}g \geq g \quad (27)$$

and subject to demand as in (1). The financing constraint (24) requires that the firm's total means are enough to finance the total cost. The borrowing constraint (25) states that the total payment for the project-specific loan cannot exceed the volume of the project. The third constraint requires that the covered amount is non-negative and the fourth constraint states that coverage cannot exceed the borrowed amount. It takes into account that the amount that is actually borrowed increases due to premium payment  $\gamma \bar{R}g$ . To narrow down the number of possible cases, we assume that whenever the cost of two financing modes are the same, the firm chooses the mode that involves less transactions, i.e., it uses internal finance if this is as costly as external finance and it purchases a guarantee only if this strictly lowers the cost of external finance.

Karush-Kuhn-Tucker conditions:

$$\frac{\partial \pi}{\partial p} = \mu_1 aq' + \mu_2 (pq)' \Leftrightarrow \lambda(pq)' - \bar{R}aq' = \mu_1 aq' + \mu_2 (pq)' \quad (28)$$

$$\frac{\partial \pi}{\partial \ell} = -\mu_1 + \mu_2 R^B - \mu_4 \Leftrightarrow \bar{R} - \lambda R^B = -\mu_1 + \mu_2 R^B - \mu_4 \quad (29)$$

$$\begin{aligned} \frac{\partial \pi}{\partial g} &= -\mu_2 [R^B(1 - \gamma \bar{R}) - \bar{R}] - \mu_3 + (1 - \gamma \bar{R})\mu_4 \\ \Leftrightarrow \lambda R^B(1 - \gamma \bar{R}) - \lambda \bar{R} &= -\mu_2 [R^B(1 - \gamma \bar{R}) - \bar{R}] - \mu_3 + (1 - \gamma \bar{R})\mu_4 \end{aligned} \quad (30)$$

$$\mu_1 [\ell + k - (aq + f)] = 0 \quad \& \quad \mu_1 \geq 0 \quad (31)$$

$$\mu_2 [pq - R^B(\ell - (1 - \gamma \bar{R})g) - \bar{R}g] = 0 \quad \& \quad \mu_2 \geq 0 \quad (32)$$

$$\mu_3 g = 0 \quad \& \quad \mu_3 \geq 0 \quad (33)$$

$$\mu_4 [\ell - (1 - \gamma \bar{R})g] = 0 \quad \& \quad \mu_4 \geq 0 \quad (34)$$

Let's consider first the optimal choice of  $g$ ,  $g^*$ , given  $\ell^*$ . Suppose  $0 < \ell^* < \ell^{max}$  where  $\ell^{max}$  is the maximum loan size determined by the borrowing constraint. For  $\mu_1 \geq 0$ ;  $\mu_2 \geq 0$ , the firm will chose a) no coverage if  $R^G \geq R^B$  and b) full coverage if  $R^G < R^B$ . Sketches of the proofs can be found at the end of this section. By assumption, the firm covers nothing in the knife-edge case  $R^G = R^B$ . If  $\ell^* = 0$ ,  $g^* = 0$  by definition.

Importantly, the decision regarding the financing mode is independent of the choice of  $p^*$ , given  $\ell^*$ . Hence, we can consider the choice  $\ell^*$  and  $p^*$ , taking as given the optimal financing mode  $o^* \in [B, G]$  associated with  $\ell^*$ . To characterize the set of solutions, it is helpful to define a threshold output level  $\bar{q}$ , denoting the maximum quantity the firm could produce *without* relying on external finance, i.e., the quantity that solves the financing constraint (24) for  $\ell = 0$ :

$$k - a\bar{q} - f = 0 \quad \Leftrightarrow \quad \bar{q} = \frac{k - f}{a}$$

We obtain four possible pricing strategies. The firm's choice among these strategies depends on exogenous parameters, most importantly the costs of the two modes of external finance as well as the firm's productivity relative to its stock of liquid means.

**Case 1** ( $\mu_1 = 0, \mu_2 \geq 0$ ): If external finance is cheaper than internal finance ( $\lambda R^{o*} < \bar{R}$ ), the firm borrows the maximum amount given by the borrowing constraint (25).<sup>36</sup> The optimal price  $p^*$  is determined by (28) and results as

$$p^{1*} = \frac{R^{o*}a}{\theta}.$$

Maximum (expected) profits are then

$$\pi^{1*} = \frac{\bar{R}}{\varepsilon R^{o*}} \left( \frac{R^{o*}a}{\theta} \right)^{1-\varepsilon} A - \bar{R}f + (\bar{R} - 1)k.$$

Note that this result also implies that we can safely ignore the possibility that the firm buys a guarantee *without* that exceeds the loan, which might be profitable if the premium is actuarially favorable  $\bar{R}\gamma < 1 - \lambda$ . The above, result, however, implies that under this condition taking out the full loan with coverage is profitable if  $R^B > R^G$ , since  $\bar{R}\gamma < 1 - \lambda \Leftrightarrow \lambda R^G < \bar{R}$ , or conducting the business with pure bank finance is preferred if  $R^B \leq R^G$ .

If external finance is more expensive than internal finance ( $\lambda R^{o*} > \bar{R}$ ), the firm either borrows nothing or the minimum amount given by the financing constraint (24). As regards the optimal price (output), we can single out three cases, which depend on the firm's size relative to its amount of liquid means:

**Case 2** ( $\mu_1 \geq 0; \mu_2 = 0$ ): The firm is small and does not need external finance in the first place because  $q^* \leq \bar{q}$ . Then,  $\ell^* = 0$ .  $p^*$  is determined by (28) and results as

$$p^{2*} = \frac{\bar{R}a}{\lambda\theta}$$

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<sup>36</sup>For a proof see below.

Optimal profits are derived from (23) and result as

$$\pi^{2*} = \frac{\lambda}{\varepsilon} \left( \frac{\bar{R}a}{\lambda\theta} \right)^{1-\varepsilon} A - \bar{R}f + (\bar{R} - 1)k.$$

**Case 3** ( $\mu_1 \geq 0; \mu_2 = 0$ ): The firm is of intermediate size and chooses its optimal price (quantity) such as to avoid borrowing external funds; hence,  $\ell^* = 0$  and  $q^* = \bar{q}$  is given by the financing constraint.  $p^*$  is given by (1) and results as

$$p^{3*} = \bar{q}^{-\frac{1}{\varepsilon}} A^{\frac{1}{\varepsilon}},$$

maximum profits according to (23) result as

$$\pi^{3*} = \lambda \left( \frac{k - f}{a} \right)^{1-\frac{1}{\varepsilon}} A^{\frac{1}{\varepsilon}} - k.$$

**Case 4** ( $\mu_1 \geq 0; \mu_2 = 0$ ): The firm is large and takes out a loan  $\ell^* > 0$ . Then,  $\ell^*$  is given by the financing constraint (24).<sup>37</sup> See below for a proof of this statement. With the financing constraint binding, the optimal loan size  $\ell^*$  is determined given  $p^*$ , which in turn follows from (29) with  $\mu_1 = \lambda R^B - \bar{R}$  if  $o^* = B$  or  $\mu_1 = \lambda - (1 - \gamma \bar{R}) > 0$  if  $o^* = G$  and results as

$$p^{4*} = \frac{R^B a}{\theta}.$$

Maximum (expected) profits are then

$$\pi^{4*} = \frac{\lambda}{\varepsilon} \left( \frac{R^{o*} a}{\theta} \right)^{1-\varepsilon} A - \lambda R^{o*} f + (\lambda R^{o*} - 1)k.$$

It can be shown, that given a certain  $k$ , firm's sort uniquely into pricing strategies (2) – (4) when external finance is more costly, depending on their productivity level. Small firm up to a productivity level  $1/a_1$ , determined by  $\pi^{1*} = \pi_{2*}$ , sort into  $p^1$ , intermediate firms up to  $1/a_2$  choose  $p^{2*}$  and firm above  $1/a_2$  chose  $p^{3*}$ . A decrease in  $k$  implies that the cutoffs  $1/a_1$  and  $1/a_2$  decrease; hence, more firms will need outside finance. Note that the existence of all cutoffs depends on parameter constellations: For example, let  $k$  be sufficiently small, i.e.  $k < f$ , then pricing strategies (2) and (3) are infeasible. This is (one of) the simplifying assumptions we made above.

**Generalization of Result 1.** *An increase in the cost of external finance  $R^o \in [R, G]$  (weakly) increases the profitability threshold and (weakly) decreases the firm's optimal level of sales for a*

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<sup>37</sup>In the simplified model presented above, we consider only a special case of Case 4. Under the assumption that  $k < f$ , all firms, independently of their productivity level, must use external finance (which we assume is more costly than internal finance) in order to produce a positive quantity

given export transaction if they stay within their price-setting mode. The effect on the profitability threshold is (weakly) stronger for firms with little liquid means. Proofs follow analogously to Section A from differentiation optimum sales and the break-even conditions under each pricing strategy.

In contrast to the simpler version of Result 1 presented above, the weakness of (some of) the results is due not only to firms operating in the other financing mode, but owes as well to the fact that some pricing strategies are independent of the cost of external finance and the firm's stock of liquid means. For firm's using pricing strategy (4) both margins are affected unless they were indifferent between (4) and (3) in the initial situation, and the effects on the intensive margin depend on  $k$ . Firms using pricing strategies (2) and (3) are not affected on any margin. However, since smaller  $k$  implies that less firm's can operate under (2) and (3), changes in  $R^o$  become more relevant for more firms  $k$  falls. Firm's using pricing strategy (1) are affected through both margins, but the strength of the threshold effect does not depend on  $k$ , unless the increase in  $R^o$  forces the firm to switch into strategy (3), where  $k$  matters.

### Proofs.

Choice of  $g^*$ :

a) By contradiction. Suppose  $R^G > R^B$  and  $g^* > 0$ :

- Equation (33):  $\mu_3 = 0$
- Equation (30):  $\mu_4(1 - \gamma\bar{R}) = (\lambda + \mu_2)[R^B(1 - \gamma\bar{R}) - \bar{R}] < 0$
- Equation (34):  $\mu_4 \geq 0$

A contradiction.

b) By contradiction. Suppose  $R^G < R^B$  and  $g^* = 0$ :

- Equation (34):  $\mu_4 = 0$
- Equation (30):  $\mu_3 = (\lambda + \mu_2)[\bar{R} - R^B(1 - \gamma\bar{R})] < 0$
- Equation (33):  $\mu_3 \geq 0$

A contradiction.

Case 1. Proof that  $\ell^*$  is determined by the borrowing constraint (25) if  $\lambda R^{o*} < \bar{R}$ . By contradiction. Suppose  $\lambda R^B < \bar{R}$  and  $\ell^* < \ell^{max}$ .

- Equation (32):  $\mu_2 = 0$
- Equation (29):  $\mu_2 R^B = \mu_1 + \mu_4 - \lambda R^B + \bar{R} = 0 \Leftrightarrow \lambda R^B \geq \bar{R}$

A contradiction. Suppose now that  $\lambda R^G < \bar{R}$  and  $\ell^* < \ell^{max}$

- Equation (32):  $\mu_2 = 0$

- Equation (29) & Equation (30):  $\mu_2 \frac{\bar{R}}{1-\gamma\bar{R}} = \mu_1 + \frac{\mu_3}{1-\gamma\bar{R}} + \bar{R} - \lambda R^G = 0 \Leftrightarrow \lambda R^G \geq \bar{R}$

A contradiction.

Case 4. Proof that the financing constraint must be binding.

For  $\mu_1 = 0$ , we proof that  $\mu_2 = 0$  by contradiction.

Let  $\mu_1 = 0$ ,  $\lambda R^G \geq \lambda R^B > \bar{R}$ ,  $\ell^* = \ell^{max}$ .

- Equation (32):  $\mu_2 \geq 0$
- Equation (29):  $\mu_2 R^B = \bar{R} - \lambda R^B < 0$

A contradiction. Suppose now  $\mu_1 = 0$ ,  $\lambda R^B > \lambda R^G > \bar{R}$ ,  $\ell^* = \ell^{max}$ .

- Equation (32):  $\mu_2 \geq 0$
- Equation (29) & (30):  $\mu_2 = 1 - \gamma\bar{R} - \lambda < 0$

A contradiction. It follows that the financing constraint must be binding if  $\ell^* > 0$  since

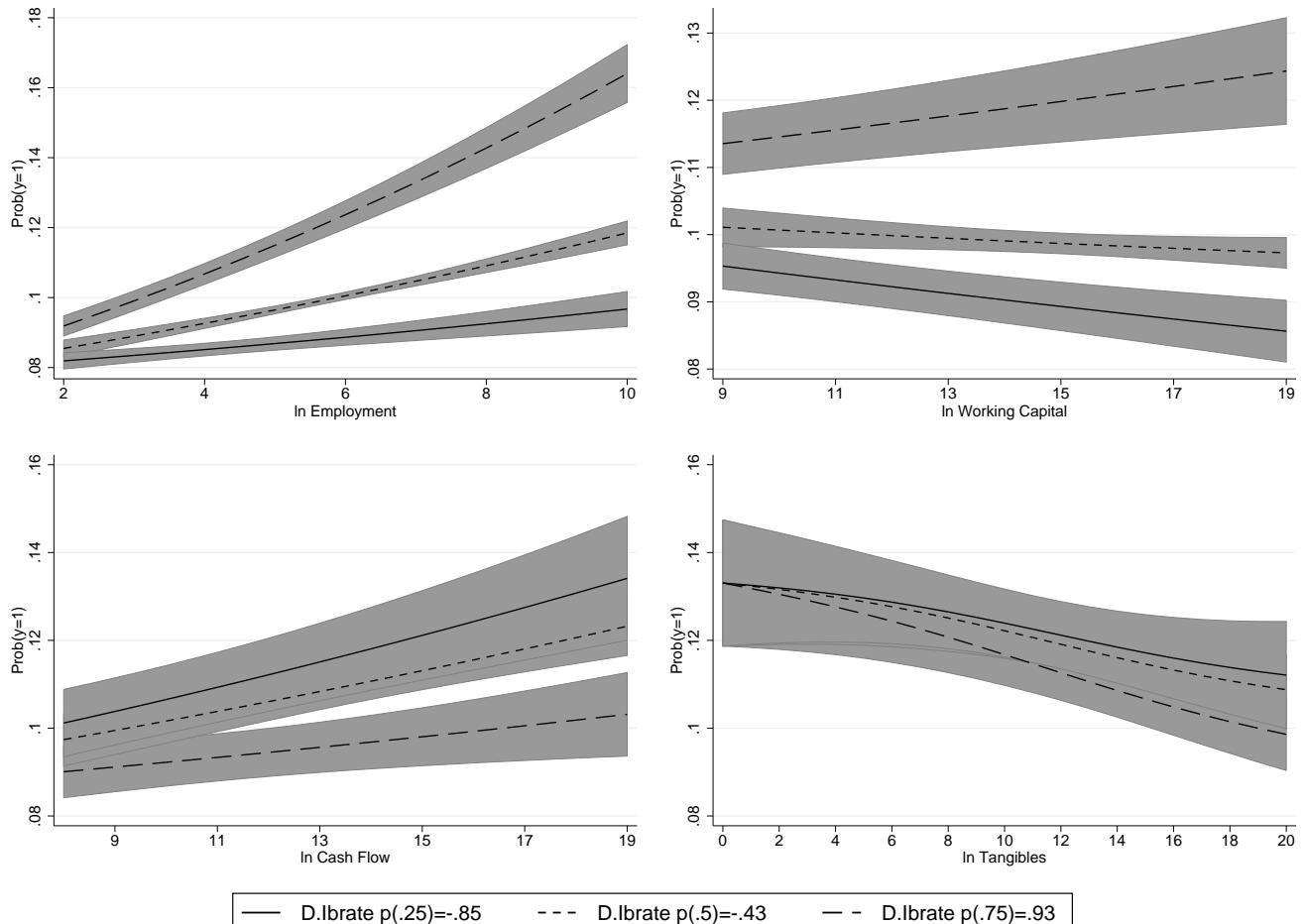
- Equation (29) &  $\lambda R^G > \lambda R^B > \bar{R} \Rightarrow \mu_1 = \lambda R^B - \bar{R} > 0$  or
- Equation (29) & Equation (30) &  $\lambda R^B > \lambda R^G > \bar{R} \Rightarrow \mu_1 = \lambda - (1 - \gamma\bar{R}) > 0$ .

For  $\mu_1 \geq 0$  it must be that  $\mu_2 = 0$  unless firms are making non-positive profits. Suppose  $\mu_1 \geq 0$  and  $\mu_2 \geq 0$ , i.e. the financing constraint (24) and the borrowing constraint (25) are both binding. Then, it follows from (23) that profits cannot be positive.

**Table C.1:** Summary Statistics of Full Sample

Full sample		Obs	Mean	Std. Dev.	Min	Max
<i>Stock of for. orders</i>	binary	326201	0.0913057	0.2880437	0	1
<i>Demand</i>	ordinal	327805	1.993502	0.6470152	1	3
<i>Employment</i>		328052	2102.462	14555.03	1	200000
<i>ExpectExp</i>	ordinal	293505	2.069869	0.5365453	1	3
<i>Unconstrained</i>	binary	325942	1.602021	.2988173	1	2
<i>Ibrate</i>	in %	328053	2.980428	1.317864	0.6438182	5.113087
<i>WorkingCap</i>	in 1000 EUR	91636	3.86E+07	1.36E+08	-1.29E+09	2.55E+09
<i>CashFlow</i>	in 1000 EUR	79035	2.98E+07	1.67E+08	-1.13E+09	4.67E+09
<i>Tangibles</i>	in 1000 EUR	100756	4.39E+07	2.47E+08	0	1.06E+10
<i>ContractSize</i>	in EUR	3183	3.02E+06	1.51E+07	0	4.45E+08
# Firms with <i>Hermes</i>		5741				
		684				

**Figure C.1:** External Finance Demand and Changes in the Interbanking Rate



**Table C.2:** Translated Survey Questions and Answers

Variable	Variable name in original dataset	Question/Answer	Coding	Alternative coding
<i>Stock of for. orders</i>	foreord	<i>Our current stock of foreign orders is</i>		
		larger than usual	3	1
		sufficient (as usual (for the season))	2	0
		too small	1	0
		we do not export	-	0
<i>ExpectExp</i>	expexp	<i>Considering settled deals and deals under negotiation, we expect exports (in the next three months) to</i>		
		increase	3	
		stay the same	2	
		decrease	1	
		we do not export	-	
<i>Demand</i>	demand_vpq	<i>(Last month's tendency) The demand situation has</i>		
	(before 11/2001 "demand")	improved	3	
		not changed	2	
		worsened	1	
<i>Unconstrained</i>	constrain	<i>Our domestic production activity right now is constrained</i>		
		no	2	
		yes	1	

Explanations in brackets were given to firms as supplementary information on how the questions are to be interpreted.

**Table C.3:** Interaction Terms, Conditional Logit Model

Dep. variable: <i>Stock of foreign orders</i> ; Model: Conditional logit						
<i>Hermes</i>	0.259*** (.0811)	1.968*** (.454)	-1.049*** (.194)	1.271 (1.16)	3.323*** (.961)	1.956 (1.33)
$\times \ln Emp$		-0.254*** (.0668)				
$\times Ibrate$			0.414*** (.0546)			
$\times \text{avg. ln WorkingCap}$				-0.0604 (.0679)		
$\times \text{avg. ln CashFlow}$					-0.210*** (.0624)	
$\times \ln Tangibles$						-0.123 (.0805)
$\Delta Ibrate$						
$\times \ln Emp$		0.0480*** (.00446)				
$\times \text{avg. ln WorkingCap}$			0.0220*** (.00308)			
$\times \text{avg. ln CashFlow}$				0.00102 (.00543)		
$\times \ln Tangibles$					0.00491 (.00538)	
$\ln ContractSize$						-0.0421 (.0476)
$\times \ln ContractSize$						0.00442 (.00337)
N	137940	137940	75676	63092	38410	137940

Model conditions on firm fixed effects. Standard errors in parenthesis. \*, \*\*, \*\*\* indicate significance on the 10,5, and 1% significance level. Coefficients of covariates and time FE not shown.