THE IMPACT OF CREDIT CONSTRAINT ON EXPORTING AND INNOVATION: EVIDENCE FROM GHANA AND VIETNAM

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A dissertation submitted to the faculty at the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the Department of Economics.

Chapel Hill
2014

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ABSTRACT

Mai Anh Ngo: The Impact of Credit Constraint on Exporting and Innovation: Evidence from
Ghana and Vietnam
(Under the direction of Patrick J. Conway)

This work examines the impact of credit constraint on firms' exporting and innovation
decisions. On the theoretical front, this chapter contributes by extending the Melitz's (2003)
trade model of firms heterogeneous in productivity, which is devoid of financial factors, to
include endogenous lending and borrowing decisions. This extension creates a framework upon
which theoretical predictions about the impact of credit constraint on firms' exporting and
innovation decisions can be made.

I build a trade model that features (1) firms heterogeneous in productivity, liquidity, and
collateral and (2) endogenous lending decisions with endogenous loan default and interest rate.
Firms finance their fixed costs of exporting through internal financing from retained earnings
and borrowing from banks. The model predicts that credit access has a positive impact on firms'
export propensity, and that this effect is most pronounced for firms in the intermediate range of
productivity. In the empirical application to a panel data set of Ghanaian firms between 1991 and
1997, I look at two types of access to bank credits: access to overdraft facilities and access to
bank loans. My empirical estimation suggests that access to overdraft facilities increased firms'
export propensity while access to bank loans had an insignificant impact on their export

propensity. The effect of access to overdraft is strongest for firms in the intermediate range of productivity.

I also build a theoretical model of innovation for firms heterogeneous in productivity under endogenous lending decisions. In this model, credit constraint arises from the asymmetric information problem, where banks cannot observe a firm's true productivity. The longer time frame and higher risks of innovating result in tighter credit constraints for innovating firms. Thus, the theoretical model predicts a positive relationship between a firm's interest payment per worker and its revenue (profits) per worker. The model also predicts that innovating firms face tighter credit constraint than firms do not innovate, which is shown by a positive, but smaller in magnitude, relationship between innovating firms' interest payment per worker and their revenues (profits) per worker. Empirical evidence from a sample of Vietnamese small and medium enterprises supports these theoretical predictions.

To my wonderful mother, Phuong Hong Thi Le. Thank you for all your support along the way. I could not have finished this without you.

ACKNOWLEDGMENTS

I would like to express my appreciation for my advisor, Patrick Conway. He has provided me with time and guidance throughout the course of my research. I also wish to thank my committee members, Dr. Anusha Chari, Dr. Saraswata Chaudhuri, Dr. William Parke, and Dr. Toan Phan, for their comments and suggestions. Finally, I would like to thank my parents and my friends for their support and love through all of my graduate school years, and to Will Cook for his unconditional support and kind encouragement, especially in the last stage of my dissertation writing.

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CHAPTER 1

Introduction

Exporting and innovation are two activities that receive great interest from policy makers in developing countries since they are often associated with reallocation of market share to the most productive firms, as well as with increases in economic growth and aggregate productivity. While real factors such as firms' efficiency and innovative capacities are important in determining exporting and innovation, lack of access to financing also has the potential to be an important obstacle to these activities.

Firms' exporting and innovation activities tend to be more dependent on external financing than their other activities. Exporters incur higher fixed costs such as advertising and the costs of setting up foreign distribution networks. They also have larger needs for working capital since cross-border shipping takes a longer time, so exporters must fund their operating costs while awaiting payments from abroad. Projects involving innovation are riskier, more expensive, and take a longer time to complete than non-innovative projects.

In addition to high financing needs, exporting and innovation are subject to more severe asymmetric information problems compared to production for the domestic market. It is more difficult for banks to assess profitability of sales in a foreign market or to evaluate the potential of an innovation project. The presence of greater asymmetric information makes exporting and innovation more vulnerable to credit constraint.

Motivated by the fact that exporting and innovation are potentially more vulnerable to credit constraint, I look at the impact of credit constraint on these activities at the firm level. The dissertation contains two self-contained essays with the general theme of examining the effects of credit constraint on firms' activities. The first essay looks at the impact of credit constraint on manufacturing firms' export decisions in Ghana. The second essay looks at the impact of credit constraint for innovating firms in Vietnam, focusing on distinguishing whether innovating firms face a tighter credit constraint. Both essays extend the Melitz (2003) model of firms heterogeneous in productivity by incorporating the borrowing and lending decisions, and, in the second essay, by examining the innovation decision in addition to the export decision.

In the first essay, I build a theoretical model of firms heterogeneous in productivity, internal funds, and collateral capacity that is an extension of the Melitz (2003) model of firms heterogeneous in productivity. The theoretical model predicts that a firm's access to credit has a positive effect on its decision to export. This positive effect of access to credit on export propensity is most pronounced for firms in the intermediate range of productivity levels. To test the theoretical predictions, I examine the effect of access to bank credits on firms' export propensity and distinguish between two different types of bank financing: overdraft and loans. I estimate a dynamic probit regression of firms' export status and examine the heterogeneous effect of access to credit on export propensity. The estimation strategy deals with the "initial condition" problem, and addresses potential endogeneity of the selected proxies for productivity and credit access. The empirical estimation indicates that in the period of 1992-1997, access to banks' overdraft facilities had a positive impact on Ghanaian firms' decision to export, but access to loans had an insignificant impact. Averaging across all time periods and firms, controlling for unobserved heterogeneity, past export status, and other firm characteristics such

as capital, age, and education of the firm's management, access to a bank overdraft facility increases a firm's likelihood to export by 7.6 percentage points. There is also empirical evidence that suggests access to credit matters most for the exporting decisions of firms in the intermediate range of productivity.

In the second essay, I build a model of firms heterogeneous in productivity that incorporate innovation decisions. Because of asymmetric information, banks cannot observe firms' productivity levels. This causes banks to impose a credit constraint by lending to the firms less than the amount the firms need, to ensure that the firms have an incentive to reveal their true productivity when applying for loans. As a result, there is a gap between the firm's actual output level and its first-best level. Innovation results in higher productivity if successful, but involves higher risks and a longer time to complete. For this reason, banks impose an even tighter credit constraint on innovating firms and thus, innovating firms have an even wider gap between their first-best output levels and their actual output level. These predicted relationships are represented in an estimating equation of the production function type, which is derived from the theoretical model. The estimating equation predicts a positive relationship between a firm's interest payment per worker and its revenue or profits per worker for non-innovating firms, and a similar positive relationship, though of smaller magnitude, for innovating firms. To address the endogeneity of the interest payment per worker and innovation, I also estimate an endogenous switching regression where the endogenous switching variable is the credit constraint or innovation indicator, and conduct matching with the treatment being the credit constraint indicator. Overall, the empirical estimation results support the theoretical predictions that credit constraint has a negative impact on firms' revenue (profits) and this effect is higher for innovating firms.

In conclusion, the two essays show the negative impacts of credit constraint on exporting and innovating for two less-studied countries, Ghana and Vietnam, and, in the second essay, a population of firms that is less studied, small and enterprises (SMEs). Ghana and Vietnam are two examples of developing countries that have undergone trade liberalization and some reforms of the financial system. However, despite the fact that the economies in these two countries were open during the period investigated by this chapter, their financial systems were still underdeveloped and credit constraint has been documented to be significant in these countries (Aryeetey et al. 1997, Rand 2005). Studying the impact of credit constraint on exporting and innovation in Ghana and Vietnam has the potential to illuminate the impacts of credit constraint on innovation and exporting for similar developing countries with relatively open market but underdeveloped financial systems. The empirical findings of this work suggest that improving access to credit may be important for the realization of the gains from trade and for supporting innovating firms. However, further studies need to be done regarding specific implementation of financial reforms that improve access to credit, especially access to credit for small businesses. Although my dissertation does not address this directly, it follows that improving access to credit should be done in a way that facilitates the financing of productive firms instead of blindly increasing credit access for all firms, including firms that do not perform well.

CHAPTER 2

Exporting and Firm-Level Credit Constraints – Evidence from Ghana

I.   Introduction

For many developing countries where the financial system is not very advanced, access to financing can be an important hindrance to firm growth and investment. For example, Bartlett and Bukvic (2001) found that the key barriers to the growth of small and medium enterprises (SMEs) in Indonesia were institutional environment characteristics such as bureaucracy and external financial constraints. The difficulty in access to financing is worsened by the fact that many firms in developing countries are small and need to rely on external financing to cover production costs. With evidence of significant fixed costs of entry into exporting documented in the trade literature (Roberts and Tybout 1997, Bernard and Jensen 2004, Girma et al. 2004, Nguyen and Ohta 2007), this raises the question of what role financial constraint has in the decision to export by a firm in a developing country. This study answers the question by analyzing the impact of financial constraints on firms' decisions to export in Ghana.

The impact of firm-level financial constraints has been studied by many scholars. However, most studies focus on the impact of financial constraint on firm growth and/or the firm's investment decision. Recent studies have highlighted the role of firm productivity and fixed costs of entry into exporting (which then becomes sunk) in firms' export participation. However, there are only a few studies that model the interaction between firm-level financial (credit) constraints and firm's export decisions.

Studying the impact of credit constraint on exports is important because compared to domestic production, exporting requires additional financing. For example, exporters may incur fixed costs of learning about foreign markets, advertising, and setting up a distribution network in the foreign markets. Exporters also have to cover additional variable costs associated with exporting, such as duties, shipping, and freight insurance. Because of cross-border, long-distance shipping, the delay for exporters to receive order payments tends to be longer than for domestic producers. This implies that exporters have higher working capital requirements than domestic producers. Lenders may be more reluctant to finance exporting, since information about foreign markets and potential profitability is more difficult to obtain than for domestic sales. Payment enforcement is also more difficult in a foreign country, so exporters may face a higher risk of late payment or non-payment from clients.[1]

This chapter explains the link between a firm's credit access and its export participation. In doing so, this chapter highlights the importance of credit access in firm exporting decisions and the interaction between credit access and firm productivity in determining a firm's export status. The chapter includes a theoretical model that links financial and export decisions, and empirical testing of the model. Similar to previous literature on exporting from the new trade theory, my model recognizes the role of firm productivity and fixed costs of export. The theoretical contribution of this chapter is that it models explicitly how firms can cover their costs of exporting through borrowing, incorporates endogenous loan default, and models the banks' lending decisions that are based on their assessment of the firm's characteristics and collateral.

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[1]A more detailed list of the various reasons why exporting requires additional external financing compared to domestic sales can be found in Manova (2013).

My theoretical model builds on Melitz (2003) and Chaney (2005). I assume that firms face

difficulty in overcoming financial constraints in exporting but not in producing for the domestic

market.[2] The assumption is reasonable since exporting involves more uncertainty, which reduces

the willingness of investors to lend money for exporting. I also assume that firms draw

exogenous liquidity shocks. Since my focus is on firm-level financial constraints, I abstain from

analyzing financing differences across sectors and countries as in the approach in Manova (2008)

and in Muûls (2008). I extend Chaney's model (2005) by allowing firms with liquidity shortage

to borrow from banks to cover fixed costs of exporting. More importantly, the main difference

between my model and those of Chaney (2005), Muûls (2008), and Suwantaradon (2008) is that

I model explicitly the firm's borrowing decision and the bank's lending decision under imperfect

information as well as endogenous bankruptcy caused by a combination of firm-level shocks in

export income and the bank's lending decisions based on firm characteristics.[3]

My model predicts that a firm's credit constraint has a negative impact on its export

propensity, especially if the firm is in the intermediate productivity range. The empirical section

of this chapter distinguishes between two types of external financing: (1) the financing for

working capital and unexpected liquidity shortage with bank overdraft facilities and (2) the

financing of investments and longer-term costs with bank loans. The results of the empirical

estimation suggest that having access to overdraft facilities increases a firm's likelihood to

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[2] Both Chaney (2005) and my model assumes that firms can borrow to cover fixed costs of production for domestic market at zero interest rates.

[3] Chaney (2005) does not model external financing. In Manova (2008) and Muûls (2008), firms are assumed to default at an exogenous rate λ_j that only varies across countries. My model allows for a more realistic assumption, where the firm's default probability depends on its productivity and net worth and thus, allows for different default probabilities across firms with different characteristics. Suwantaradon (2008) does not model firm's default on debts. She also assumes that every firm can borrow at the risk-free interest rate and thus, does not model firm's financial constraints in terms of the differential interest rates they face when borrowing.

export, but access to loans does not significantly affect a firm's export propensity. Furthermore, the empirical results also confirm the heterogeneous effect of access to credit: the positive effect of access to overdraft on export likelihood is only present for firms in the intermediate range of productivity.

II. Literature Review

The literature relevant to this chapter comes from two branches: the literature on exporting by heterogeneous firms with costs of entry into the export markets, and the literature on the effect of firm's financial constraint on firm's investment and export decisions. Throughout this chapter, the term "sunk export (entry) costs" refers to a one-time fixed cost of entry that firms need to pay to start exporting. This fixed cost of entry into exporting will become sunk once it is paid. Similarly, the term "sunk costs of operation" or "sunk costs of beginning production" refers to a one-time fixed cost that the firm has to pay in order to begin operation; this entry cost will become sunk once it is paid.

Melitz's model (2003) introduced a framework of international trade with heterogeneous firms under monopolistic competition and differentiated goods that has been widely adopted. Melitz (2003) predicts a self-selection effect where firms with the highest productivity export, firms in the intermediate range of productivity sell only in the domestic market, and firms with the lowest productivity do not produce. This prediction of self-selection into exporting has been tested by a number of empirical studies, most of which find supporting evidence. For example, Kimura and Kiyota (2006) analyzed panel data of Japanese firms and found evidence that the most productive firms engage in either exporting or foreign direct investment (FDI), and the least productive firms focus only on domestic market. Arnold and Hussinger (2005) find a causal relationship from high productivity to entry into foreign markets among German manufacturing

firms. Positive effects of productivity on a firm's probability to export were found in Colombia and Morocco (Clerides et al. 1998), and in nine sub-Saharan African countries during the period 1992-1996 (Van Biesebroeck 2005). On the other hand, no self-selection effect into exporting was found for the UK manufacturing sector in the period 1989-2002 (Girma et al. 2004), in Indonesia during the period 1990-1996 (Blalock and Gertler 2004) or in Mexico during 1986-1990 (Clerides et al. 1998). Bernard and Jensen (2004) find that firm heterogeneity is substantial and important in the export decision: firms that have larger size, higher labor quality, or product innovation are more likely to self-select to become exporters. However, firm productivity is found to have no significant effect on the probability of exporting in the specification preferred by the authors. Rankin (2005) investigated firms' export decisions using panel data of manufacturing firms in five African countries (Kenya, Ghana, Tanzania, South Africa, and Nigeria). He finds that firm size is a robust determinant for the firm's export participation decision, but productivity is not. Nguyen and Ohta (2007) also find productivity to be insignificant in determining export propensity.

In contrast, several studies have looked at the reverse causation direction, i.e., the learning-by-exporting channel, or both the selection and learning-by-exporting channel. The empirical evidence for learning-by-exporting has been mixed and is weaker than empirical support for selection into exporting. Kimura and Kiyota (2006) found evidence of learning-by-exporting; their results indicate that exports and FDI appear to improve firm productivity once the productivity convergence is controlled for. De Loecker (2013) also finds evidence of learning-by-exporting for Slovenian manufacturing firms during the period 1994-2000. On the other hand, Wagner (2007) provides a survey of the literature and reports strong evidence of self-

selection across a large number of countries and industries, but concludes that there is not necessarily a learning-by-exporting effect.

In addition to firm heterogeneity, other authors have focused on the role of sunk entry costs in exporting. Most studies confirm that there are significant sunk costs associated with entry into exporting. Roberts and Tybout (1997) model how firm (profit) heterogeneity and sunk costs of entry into the export market affect firms' decision to export. Based on this theoretical model, a dynamic probit regression is run with the dependent variable being the firm's current export status and the independent variables being the firm's export participation in previous years and firm characteristics. They find a significant effect of sunk entry costs with prior export experience being estimated to increase the probability of exporting by as much as 60 percentage points. Bernard and Jensen (2004) find that exporting today raises the probability of exporting tomorrow by 39 percent for U.S. manufacturing firms. Girma et al. (2004), and Nguyen and Ohta (2007) find past export participation to be positively correlated with export propensity for the U.K. manufacturing sector in the period between 1989 and 2002 and for Vietnamese firms in the period of 2002-2004.

In the finance literature, there have been many studies of firms' access to financing and the implications of firms' financial constraints on firm investment, growth, or innovation. Most of these studies find a negative impact of financial constraint on firm's investment, growth, and innovation. For example, Becchetti and Trovato (2002) find that small surviving firms have higher than average growth potential, but this potential is limited by the scarcity of external finance and lack of access to foreign markets. Scellato (2007) finds that financial constraints negatively affect Italian firms' ability to generate patents.

While the majority of studies on firm financial constraints have focused on the impact of financial constraint on firms' growth, investment, and/or innovation decisions, some recent studies have begun to examine the role of financial constraint on firms' exports. Garcia-Vega and Guariglia (2012) extend the Melitz (2003) model by incorporating a new dimension of firm heterogeneity: random income volatility, $\sigma \in [0, \infty)$.[4] Their model predicts that it is more costly for more volatile firms to obtain external financing from banks. Also, assuming that demand shocks in the national and international markets are negatively correlated and the fixed costs of exporting are not too high, firms with higher national income volatility are more likely to export than those with low national income volatility because trade helps these firms to reduce their probabilities of bankruptcy.

Pratap and Urrutia (2004) study the balance sheet effects of the 1994 Mexican crisis. They build a dynamic model where firms are heterogeneous in productivity, capital stock, and level of foreign debts, and firm productivity follows a first-order Markov process. The authors impose financial market imperfections by assuming that firm investment can only be financed with internal funds or from the international financial market. As a result, their model predicts a positive correlation between foreign debts and exports, and between capital and exports. Using panel data of Mexican firms, Pratap and Urrutia observe that large firms get larger loan amounts at lower interest rates prior to the credit crisis. They also observe that the loan interest rate is an increasing function of the size of the loan.

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[4] Specifically, a firm's income in period t is given by $z_t(\sigma) p(\varphi) y(\varphi)$ where $p,\ y,\ \varphi$ and z_t are price, firm's output, firm productivity, and the firm's demand shock. z_t follows a normal distribution with mean equal to one and standard deviation σ.

On the theoretical side, Chaney (2005) is the closest to my model. Chaney extends the Melitz framework by incorporating randomly drawn liquidity shocks. Under these assumptions, compared to Melitz (2003), the most productive firms are further partitioned into the most productive firms that can export because they generate enough liquidity from domestic sales to overcome liquidity constraints, and the less productive firms that would find it profitable to export but cannot because of liquidity constraints. This prediction is in line with the empirical facts that few firms export, and that exporters are typically not liquidity constrained. Chaney's model also predicts that the scarcer the available liquidity and the more unequal the distribution of liquidity among firms, the lower are total exports. It should be noted that there is no borrowing channel in the Chaney model, where firms can finance (fixed) costs of exporting with only their internal funds, while my model allows for borrowing from banks.

Manova has been pursuing the topic of the impact of credit constraint on exporting under extensions of the Melitz (2003) framework. However, her focus is on the sector and country's comparative advantage in terms of financing rather than on firm-level financial constraints (see Manova 2008, 2013). Sectors are different in terms of tangibility and need for external finance, and countries are different in terms of financial development. Manova defines "financially vulnerable" sectors as those with a greater need for external finance and/or those with fewer tangible assets. Credit constraint has a negative impact on exports, affecting only the extensive export margin (whether a firm exports, the number of export destinations, and the number of export varieties) if firms face credit constraint only in financing fixed costs of exporting. If firms face credit constraint in financing both fixed costs and variable export costs, credit constraint will affect both the extensive and intensive margins of exports. Manova predicts that the negative impact of credit constraint on exporting is higher in countries with lower levels of financial

development, and in more financially vulnerable sectors. Manova (2013) tests her predictions with unidirectional bilateral exports for 107 countries and 27 sectors over the 1985-1995 period and concludes that the regression results support her hypotheses.[5]

Muûls (2008) seeks to analyze whether there is any interaction between firm-level constraints and exporting. Her model combines the Chaney (2005) model and the external financing element from Manova (2008). Specifically, firms have three sources of liquidity to finance the fixed costs of exporting: internal financing and exogenous random liquidity shocks as in Chaney (2005) as well as external financing as in Manova (2008).[6] Muûls' predictions are a hybrid between those of Chaney (2005) and Manova (2008). In particular, her model predicts that (1) there are firms that would find exporting profitable but are prevented from exporting because of credit constraints, (2) more productive and less credit-constrained firms will export to more destinations and to relatively smaller markets, and (3) an appreciation of the exchange rate between the domestic and the foreign currencies has three effects: (a) existing exporters become less competitive and reduce their exports, (b) the least productive existing exporters stop exporting, and (c) the most productive constrained non-exporters start exporting. Muûls then tests her model's predictions with a data set of Belgian manufacturing firms. She uses the Coface

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[5] Her main measure of a country's financial development is the amount of credit by banks and other financial intermediaries to the private sectors as a share of GDP. Other measurements of financial development that are used for robustness checks are repudiation of contracts, accounting standards, and risk of expropriation. A sector's need for external finance is the share of capital expenditures not financed with cash flow from operations for the median firm in each industry. A sector's asset tangibility is defined as the share of net property, plant and equipment in total book-value assets for the median firm in the sector. These industry measures are constructed from U.S. data.

[6] As in Chaney (2005), Muûls assumes that there is no liquidity constraint for firms to finance their domestic production. It is also assumed that firms can finance the variable costs of exporting internally. External financing is modeled as in Manova (2008). The external credit constraints are modeled with two parameters: t_s, the proportion of fixed costs of exporting that firms have to pledge tangible assets as collateral in sector s; and λ, the level of financial contractibility which varies across countries.

score as a measure of credit constraints.[7] Her empirical results confirm the model's second and third predictions. However, for the regression of the propensity of becoming a new exporter that is used to test the first prediction, although the impact of firm productivity (log TFP) and firm size (log employment) are found to be significantly positive, credit constraint is found to have an insignificant impact on firms' export propensity.

Suwantaradon (2008) also assumes heterogeneous firms (with a random draw of productivity), but assumes a different production function where capital is the only input.[8] A firm finances capital with its own net worth and one-period debt. Firms, however, can only borrow up to a fixed multiple of their net worth. This fixed multiple is identical across firms and is interpreted as representing the degree of financial frictions in an economy. With this assumption, the borrowing constraint that firms face depends only on net worth and not on other factors such as firm productivity. Suwantaradon's model predicts that under financial constraints, even among a group of firms with the same productivity level, firms that are more financially constrained operate on a less efficient scale and, as a result, may no longer find operating and/or exporting profitable. Furthermore, financial frictions can have persistent impacts on firms' dynamics. Productive firms with very low starting net worth will never accumulate enough to

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[7] According to Muûls, *Coface International* is a credit insurance company that provides credit information and insurance services. The company manages an international buyer's risk database on 44 million companies. The Coface score is constructed by *Coface International* as a bankruptcy measure. The Coface score ranges from 3/20 to 19/20. *Coface International* separates firms into three categories based on their scores: "maximum mistrust" (3 to 6/20), "temporary vulnerable" (7 to 9/20) and "normal to strong confidence" (10 to 19/20)

[8] The production function is as follows: for a domestic firm, $y_t = z_t Max\{k_t - f^d, 0\}$; for an exporter, $y_t = z_t Max\{k_t - f^d - f^x, 0\}$ where y_t, z_t, k_t, f^d and f^x are firm's output, productivity, capital, fixed costs of domestic production and fixed costs of exporting respectively. Capital stock is determined as: $k_t = i_t + b_t$ where i_t is the amount of internal financing and b_t is the one-period debt.

overcome credit constraints and therefore, will never start operating and exporting even if they are very productive.

Regarding the empirical literature about the impact of credit (financial) constraint on firms' exports, Campa and Shaver (2002) uses a panel of Spanish manufacturing firms in the 1990s to test the effects of firm financial constraints on export status. They find that exporters face less severe liquidity constraints and have more stable cash flows than non-exporters. They interpret this as evidence for causality from export status to liquidity constraint as foreign sales help firms relax the liquidity constraint. It should be noted that Chaney (2005) argues that since Campa and Shaver find that export intensity does not matter for liquidity constraint, their empirical results actually point to the causality direction from liquidity constraint to export.

Correa et al. (2007) find that having loans increased Ecuadorian firms' exports. However, this result should be taken with caution since Correa et al. do not control for the role of sunk entry costs in exporting. Zia (2008) uses a different approach to identify the impact of firm-level financial constraint: the natural experiment approach. She studies the impact of the Pakistani government's removal of subsidized export loans. Zia finds that after the policy change, privately owned firms experience a significant decline in their exports, while large and publicly listed firms were unaffected. There was no evidence that less productive firms are more affected by the removal of loan subsidies. On the other hand, large firms, firms in corporate networks, or firms that have relationship with multiple banks are better in overcoming their financial constraints.

In the macroeconomics literature, there is a large literature on the impact of liquidity constraints or financial frictions. For example, Mendoza (2010) models collateral constraint in an

equilibrium real business cycle model to explain sudden stops in emerging countries following a severe financial crisis. Gertler et al. (2007) find that financial frictions explain half the decline in economic activities in Korea during the financial crisis of 1997-1998.

Since the empirical part of this chapter uses proxies for firm-level credit constraint, I would like to mention measures of firm-level constraints that have been used in the literature. These measures can be grouped as follows. First, there is a large literature started by Fazzari et al. (1988), that identifies financially constrained firms by testing whether, after controlling for other variables, financial variables that capture the availability of internal sources of finance and the net-worth position of firms, such as cash flows, would have a significant effect on investment decisions for firms that are thought (a priori) more likely to face information and incentive problems. The theoretical rationale behind these analyses is that firms that suffer from more asymmetric information problems are more sensitive to variations in their net worth or changes in the availability of internal funds. This approach often faces a critique that the financial variables may capture the effect of unobserved investment opportunities instead of financial constraint. The second approach is to use financial variables from firms' balance sheets (such as cash flow, leverage ratio, liquidity ratio, etc.) to proxy for financial (credit) constraint. The third approach is to use indicators that capture access to loan, etc. as proxies for firms' credit constraint. The fourth approach is to use a firm's subjective report of considering credit access as one of the biggest obstacles. In this chapter, I will use the third approach, but instead of looking just at access to bank loans, I will also look at access to overdraft facilities.[9]

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[9] The data set of Ghanaian firms that I use in the empirical estimation has many missing values in investment, and does not have enough balance sheet variables (such as cash on hand, financial assets) to code balance sheet measures that can proxy for firms' credit constraint.

III. Theoretical Model

My model shares several similarities with the models in Melitz (2003) and Chaney (2005): constant elasticity of substitution (C.E.S) preference, firms that are heterogeneous in productivity, and a market equilibrium characterized by the zero-profit condition and the free-entry condition. However, in my model, firms are also heterogeneous in two other dimensions, their liquidity and collateral. Thus, while the segmentation of firms into non-producer, domestic producers, and exporters in Melitz's model is only based on productivity, the segmentation of firms in my model is not only based on productivity but also on firm's liquidity and collateral. In addition, I also introduce an exogenous income shock to exporters, which can be caused by a shock to the demand for the exported variety, a feature that is borrowed from Garcia-Vega et al. (2012).[10] This shock allows me to achieve a more realistic equilibrium where because of the uncertainty at the lending time, banks still lend to some firms that end up going bankrupt.

1. Consumers (Demand)

There are two symmetric countries. In each country, the preferences of a representative consumer are given by the following intertemporal utility function:

$$U_t = \int_0^\infty (x_{0t} + \log Y_t) e^{-\beta t} dt$$

where β is the discount factor, x_0 is the consumption of a numeraire good, and Y_t is an index of consumption of the differentiated products that reflects consumers' taste for varieties in period t.

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[10] Garcia-Vega et al. (2012) assume that the standard deviation of the shocks varies across firms and such, represent firm's income volatility. On the other hand, my model assumes that firm's income shock is a random draw from a common normal distribution, i.e. the standard deviation of firm's income shock is the same for every firm.

$$Y_t = \left[\int_0^{M_t} y_{z,t}^\rho \, dz \right]^{1/\rho}$$

with $0 < \rho < 1$, $y_{z,t}$ is the quantity of variety z of the differentiated product demanded by consumers in period t, M_t is the mass of firms in the stationary competitive equilibrium, and $\mu = 1/(1-\rho)$ is the elasticity of substitution among varieties.

The aggregate price index for the differentiated product is a weighted price index of the prices of each individual variety $p_{z,t}$:

$$P_{Y,t} = \left[\int_0^{M_t} p_{z,t}^{1-\mu} \, dz \right]^{1/(1-\mu)}$$

The aggregate expenditure, R_t, is normalized to one, and the demand for variety z in period t can be expressed as follows:

$$y_{z,t} = \frac{p_{z,t}^{-\mu}}{P_{Y,t}^{1-\mu}} \tag{2.1}$$

2.   Firms

For simplification of notation, I omit the firm and time subscripts (i and t) in this section. In terms of notation, the superscripts D and X refers to the domestic market and the foreign market respectively.

2.1.   Firm production

In each country (home or foreign), there is a continuum of firms. There are three sources of heterogeneity among firms: (1) their level of productivity φ, (2) exogenous liquidity endowment n, and (3) collateral value A, $\varphi, n, A \in R^+$. I assume φ, n, A are independently distributed with joint distribution $F(\varphi,n,A)$ and density $f(\varphi,n,A) = f(\varphi)g(n)k(A)$ where $f(\varphi)$, $g(n)$

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and $k(A)$ are density functions for productivity, liquidity endowment, and collateral respectively, and $F(\varphi)$, $G(n)$ and $K(A)$ are the respective cumulative distribution function, hereafter referred to as c.d.f. All of the three distributions are known to both firms and banks.

Both domestic and exporting firms are hit by exogenous death shocks with probability p every period. In each period t, if firm i decides to export, it will face an export income shock z_{it} (domestic production involves no income shocks). The income shock follows a normal distribution $N(1, \sigma^2)$ which is left-truncated at zero. In other words, the distribution of the income shock is common across firms and across time periods. This distribution is known to everyone in the economy, including the firms and banks. The export income shock can be thought of as a shock to the price of the exported goods caused by a reduction in foreign demand for those goods. When the firm makes its export decision in period t, it knows its productivity shock for that period but it does not know the export income shock for that period yet. To operate, potential entrants have to pay a sunk entry cost f^e to start operation. If a firm wants to enter the export market, it has to pay a sunk entry costs in exporting f^{ex} to start exporting.

The firm production function is as in Melitz (2003):

$$l^D(\varphi) = \omega f^D + \frac{y^D(\varphi)}{\varphi}$$

$$l^X(\varphi) = \omega f^X + \frac{y^X(\varphi)}{\varphi}$$

where l is labor, y is output and ωf is the fixed costs of production. In the production functions above, a firm's productivity φ is just the inverse of its marginal costs. A higher productivity is

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equivalent to having lower marginal costs. To produce the same amount of output (y), a more productive firm will need less labor than a less productive one.

As common in the literature, exporting is assumed to be subject to iceberg transportation costs such that for each τ units of the goods that are shipped abroad, only 1 unit arrives. Profit maximization leads to the following pricing rules that equate marginal revenue and marginal cost in the domestic and in the foreign markets:

$$p^D(\varphi) = \frac{\omega}{\rho\varphi}$$

$$p^X(\varphi) = \frac{\tau\omega}{\rho\varphi}$$

where ω is the common real wage rate in the home country. The optimal pricing rule implies that more productive firms charge a lower price both domestically and abroad since they have lower marginal costs.

Revenue from selling in domestic market and from exporting for a firm with productivity φ is:

$$r^D = R(P\rho\varphi)^{\mu-1} = (P\rho\varphi)^{\mu-1}$$

$$r^X = \tau^{1-\mu} r^D$$

Since $\mu > 1$, both revenue from domestic sales and from exporting are increasing in firms' productivity levels. Intuitively, more productive firms sell more since they charge lower prices, and these more productive firms also have higher revenue.

2.2.   Firms' Decisions

Firms can borrow at zero interest rate to cover the fixed costs of production for the domestic market (ωf^D). However, if they want to export and their liquidity is lower than ωf^X, they face a cash-in-advance constraint for exporting in each period. If these firms decide to export, they have to borrow from banks a loan equal to the fixed costs of exporting (ωf^X) at an interest rate r where $r > r_0$, the interest rate on riskless assets.[11] To make the analysis simple, I assume that the liquidity of a firm is fixed, i.e. firms cannot add their profits to the stock of liquidity but just distribute all the profits as dividend payments. At the end of the period, if paying back the loan makes the firm's net worth negative, the firm defaults, exits, and the bank gets the firm's net worth and collateral at that time. Otherwise, the firm will pay back the original loan amount plus interest.

Profits from selling in the domestic market, hereafter called domestic profits, are:[12]

$$\pi^D = p^D(\varphi)y^D(\varphi,\overline{\varphi}^D) - \frac{\omega * y^D(\varphi,\overline{\varphi}^D)}{\varphi} - \omega f^D = \frac{r^D(\varphi,\overline{\varphi}^D)}{\mu} - \omega f^D \qquad (2.2)$$

where $\mu = 1/(1-\rho)$, $r^D(\varphi,\overline{\varphi}^D)$ is domestic revenue, and $\overline{\varphi}^D$ is the productivity cutoff that solves $\pi^D = 0$. It can easily be seen that domestic profit is increasing in productivity. This

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[11] Since lending to exporting firms involve a risk that some firms may default, the interest rate that banks charge on these loans are higher than the interest rate on riskless assets.

[12] The firm's income from domestic production is:

$$I^D = p^D(\varphi)y^D(\varphi,\overline{\varphi}^D) - \frac{\omega * y^D(\varphi,\overline{\varphi}^D)}{\varphi} - \omega f^D + (1+r_0)n = \frac{r^D(\varphi,\overline{\varphi}^D)}{\mu} - \omega f^D + (1+r_0)n$$

However, firm profit, in this paper, is the extra income the firm earns compared to its outside opportunity of not operating, $(1+r_0)n$.

implies that every firm that has a productivity draw less than the cutoff $\overline{\varphi}^D$ will exit the market immediately while every firm with productivity above this cutoff will produce (at least) for the domestic market.

Let $\overline{\varphi}^{X,NB}$ be the productivity cutoff that solves:

$$
\begin{aligned}
E(\pi^{X,NB}) &= p^X(\varphi,\tau)y^X(\varphi,\overline{\varphi}^X) - \frac{\omega\tau * y^X(\varphi,\overline{\varphi}^X)}{\varphi} - (1+r_0)\omega f^X \\
&= \frac{r^X(\varphi,\overline{\varphi}^{X,NB})}{\mu} - (1+r_0)\omega f^X = 0
\end{aligned}
\tag{2.3}
$$

where E is the expectation operator.[13] As is common practice in the trade literature, I assume the fixed costs and iceberg transportation costs are such that $\overline{\varphi}^D < \overline{\varphi}^{X,NB}$.[14] Under this assumption, firms with $\overline{\varphi}^D \leq \varphi < \overline{\varphi}^{X,NB}$ will produce only for domestic market regardless of the level of their liquidity n and collateral A. These are unconstrained domestic producers because they would not export even if the loan for export has zero interest rate.

Firms with $n \geq \omega f^X$ and $\varphi \geq \overline{\varphi}^{X,NB}$ will find it profitable to use their own liquidity to finance fixed costs of export.[15] They also earn the riskless interest rate on the remaining liquidity after paying for the fixed costs of exports. Thus, their income in period t is:

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[13] Again, this cutoff is deduced by equating the firm's expected income for non-borrowing exporting with its outside opportunity of producing for only the domestic market.

[14] Specifically, as shown in Melitz (2003), $\overline{\varphi}^{X,NB} > \overline{\varphi}^D$ if and only if $\tau^{\mu-1}\omega f^x > \omega f^D$

[15] The costs of using firm's own liquidity to cover fixed costs is the forgone interest earned at the riskless interest rate r_0 while the costs of borrowing from banks are the interest payments at the loan interest rate $r > r_0$. Therefore, given that it has enough liquidity to cover fixed costs, a firm will always prefer using its own liquidity to borrowing from the bank. This assumption is based on the "pecking order" theory which claims that because of asymmetric information, new equity-holders and new debt-holders do not have as much information about the firm as the firm itself. To account for these uncertainties, these people will expect a higher rate of return on their investments than the opportunity cost of internal funding. Thus, firms will prefer internal funding than external financing.

$$I^{X,NB} = \pi^D + z_{it} p^X(\varphi,\tau) y^X(\varphi,\overline{\varphi}^X) - \frac{\omega\tau * y^X(\varphi,\overline{\varphi}^X)}{\varphi} + (1+r_0)(n - \omega f^X) \qquad (2.4)$$

The probability that a non-borrowing exporter does not survive the export income shock is:

$$\Phi^{X,NB} = \text{Probability}\left[\pi^D + z_{it} p^X(\varphi,\tau) y^X(\varphi,\overline{\varphi}^X) - \frac{\omega\tau * y^X(\varphi,\overline{\varphi}^X)}{\varphi} + (1+r_0)(n - \omega f^X) < 0\right]$$

$$= \text{Probability}\left[z_{it} < \frac{\omega\tau * y^X(\varphi,\overline{\varphi}^X)/\varphi - (1+r_0)(n - \omega f^X) - \pi^D}{p^X(\varphi,\tau) y^X(\varphi,\overline{\varphi}^X)}\right]$$

$$= \Phi\left[\frac{\omega\tau * y^X(\varphi,\overline{\varphi}^X)/\varphi - (1+r_0)(n - \omega f^X) - \pi^D - 1}{\sigma p^X(\varphi,\tau) y^X(\varphi,\overline{\varphi}^X)}\right]$$

$$(2.5)$$

where Φ is the c.d.f of the standard normal distribution that is left truncated at $-1/\sigma$ (since z_{it} follows a truncated normal distribution $N(1,\sigma^2)$ which is left truncated at zero).

Firms with $n < \omega f^X$ that find borrowing for exporting profitable will borrow to export. If they obtain a loan from the bank at the loan interest rate r, their income would be:

$$I^{X,B} = \pi^D + z_{it} p^X(\varphi,\tau) y^X(\varphi,\overline{\varphi}^X) - \frac{\omega\tau * y^X(\varphi,\overline{\varphi}^X)}{\varphi} - (1+r)\omega f^X + (1+r_0)n$$

Let $\overline{\varphi}^{X,B}$ be the productivity cutoff that solves

$$E(\pi^{X,B}) = p^X(\varphi) y^X(\varphi) - \frac{\omega\tau * y^X(\varphi)}{\varphi} - (1+r)\omega f^X = \frac{r^X(\varphi)}{\mu} - (1+r)\omega f^X = 0 \qquad (2.6)$$

Firms with $n < \omega f^X$ and $\varphi < \overline{\varphi}^{X,B}$ will produce only for the domestic market. Note that

$\overline{\varphi}^{X,B} > \overline{\varphi}^{X,NB}$ so firms with $n < \omega f^X$ and $\overline{\varphi}^{X,NB} \leq \varphi < \overline{\varphi}^{X,B}$ are credit constrained firms because

if they have enough liquidity to cover fixed costs of export, they would have found it profitable

to export. Also, note that the cutoff $\overline{\varphi}^{X,B}$ is a function of the loan interest rate that the bank

charges to a firm.

Next, I solve for the export decision for firms with $\varphi \geq \overline{\varphi}^{X,B}$ and $n < \omega f^X$. These are the firms

that have an incentive to export but will have to decide whether to borrow for export. Suppose

that the bank offers firms a fixed loan amount equal to ωf^X at interest rates that differ across the

firms, depending on the bank's evaluation of the firm's probability of defaulting on loan. In

period t, for a firm i that gets a loan from the bank at an interest rate r_{it}, the probability of default

is:

$$\Phi(\varphi_{it}, \overline{\varphi}^D, \overline{\varphi}^{X,B}, r_{it}, n_{it})$$

$$= P\left(\pi^D(\varphi, \overline{\varphi}^D) + z_{it} p^X(\varphi, \tau) y^X(\varphi, \overline{\varphi}^X) - \frac{\omega\tau * y^X(\varphi, \overline{\varphi}^{X,B})}{\varphi} - (1+r)\omega f^X + (1+r_0)n \leq 0 \right)$$

$$= P\left(z_{it} \leq \frac{(1+r)\omega f^X - (1+r_0)n + (\omega\tau * y^X / \varphi) - \pi^D}{p^X y^X} \right) \qquad (2.7)$$

$$= \Phi\left(\frac{(1+r)\omega f^X - (1+r_0)n + (\omega\tau * y^X / \varphi) - \pi^D - 1}{p^X y^X \sigma} \right)$$

$$\equiv \Phi^{X,B}$$

where again, Φ denotes the c.d.f of a standard normal distribution left-truncated at $-1/\sigma$. It can

be shown that the probability of default is decreasing in firm liquidity and under certain

conditions, decreasing in firm productivity.[16]

Firms with $\varphi \geq \overline{\varphi}^{X,B}$ and $n < \omega f^X$ will decide to export in period t if the expected discounted

profit from borrowing to export, $V^{X,B}$, is greater than or equal to the expected discounted profit

from producing domestically, V^D. Since the liquidity endowment, productivity and market

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[16] See *Appendix C* for the proof.

structure do not change over time, a firm that decides to borrow to export in period t will still decide to borrow to export in the following periods given that it survives the exogenous death shock and has not defaulted on a loan. Similarly, a firm that decides to produce only domestically in period t will continue to produce only for the domestic market in the following periods given that it has survived the exogenous death shock in previous periods.

Recall that β is the discount rate. Let $V_t^{X,B}$ and V_t^D be the firm's expected value at time t of borrowing to export and of producing only for domestic market respectively. Then:

$$V_t^{X,B}(n,\varphi,r_{it}) = \frac{1}{1-\beta(1-p)(1-\Phi^{X,B})}\left[\pi^D + p^X y^X - \frac{\omega\tau * y^X}{\varphi} - (1+r_{it})\omega f^X + (1+r_0)n\right] - f^{ex}$$

$$V_t^D(n,\varphi) = \frac{1}{1-\beta(1-p)}\left[\pi^D + (1+r_0)n\right]$$

where f^{ex} is the sunk cost of entry into the foreign market and

$$\pi^D = p^D(\varphi)y^D(\varphi,\overline{\varphi}^D) - \frac{\omega * y^D(\varphi,\overline{\varphi}^D)}{\varphi} - \omega f^D$$

It can be shown that when $\Phi < \dfrac{[1-\beta(1-p)]\tau^{1-\mu}}{\beta(1-p)}$, productivity is positively related to export propensity (see Appendix C). Specifically, among firms with $\varphi \geq \overline{\varphi}^{X,B}$ and $n < \omega f^X$, the more productive the firm is, the more likely it will borrow to export. It can also be shown that when

$\dfrac{\Phi}{\phi} < \dfrac{\{\pi^D + (1+r_0)n\}}{p^X y^X \sigma}$ with ϕ being the p.d.f of the truncated normal standard distribution which

is left-truncated at $-1/\sigma$, a firm with higher liquidity level will more likely borrow to export.[17]

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[17] Detailed proof can be found in *Appendix C*.

This is because a firm with a higher liquidity level can earn more from the interest rate payments to their liquidity and thus, more likely to avoid bankruptcy if it borrows to export.

Note that since $\bar{\varphi}^D < \bar{\varphi}^{X,NB} < \bar{\varphi}^{X,B}(r_{it})$ for any positive loan interest rate r_{it}, the model implies that all exporters also produce for the domestic market.[18]

3. Bank's Lending Decisions

I assume a competitive banking industry in which banks make zero profits. A representative bank offers a fixed loan amount, ωf^X. The bank observes the firm's liquidity level and collateral but does not observe the firm's productivity. However, the bank forms an evaluation of this productivity as a function of the firm's characteristics:

$$\varphi^B = f(Z)$$

where Z is a vector of firm characteristics. Based on this evaluation, the bank expects the probability of default for the firm to be $\Phi^{X,B}(\varphi^B, n)$. To keep the model general, I do not specify the elements of Z in the model but in the empirical section, I will estimate the determinants of credit constraint (access).

For firm i in period t, let $z_{it}^{B,Default}$ be the cutoff export income shock such that a shock less than $z_{it}^{B,Default}$ will cause a borrowing exporter with productivity φ^B and liquidity n to go bankrupt. Then $z_{it}^{B,Default}$ solves:

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[18] One objection can be that in reality, we may have a corner solution where some firms serve only the foreign market. However, in the empirical estimation, I analyze a panel data of Ghanaian manufacturing firms that has only 2% of the firms serving only foreign markets without serving the domestic market. Therefore, I consider the implication of the model that all exporters also serve domestic market to be reasonable.

$$I^{X,B}(z_{it},\varphi^{B},n) = \pi^{D} + z_{it} p^{X} y^{X} - \frac{\omega\tau * y^{X}}{\mu} + (1+r_{0})n - (1+r_{it})\omega f^{X} = 0 \qquad (2.8)$$

Let $z_{it}^{B,Min}$ be the lowest export income shock below which the firm's net worth becomes negative. Then $z_{it}^{B,Min}$ solves:

$$I^{X,B}(z_{it},\varphi^{B},n) = \pi^{D} + z_{it} p^{X} y^{X} - \frac{\omega\tau * y^{X}}{\mu} + (1+r_{0})n = 0 \qquad (2.9)$$

Let $E_{t}\left[I^{X,B}(\varphi^{B},n)|default\right]$ be the bank's expectation of the firm's net worth (excluding collateral) in the next period if the firm suffers from a bad export income shock and has to default. This expectation is based on the bank's prediction of firm's productivity φ^{B} and the firm's liquidity stock n. Note that the firm's liquidity is observable to the bank but the firm's productivity is not.

$$E_{t}\left[I^{X,B}(\varphi^{B},n)|default\right] = \int_{z_{it}^{B,Min}}^{z_{it}^{B,Default}}\left[\pi^{D} + z_{it} p^{X} y^{X} - \frac{\omega\tau * y^{X}}{\mu} + (1+r_{0})n\right]l(z)dz$$

where $l(z)$ is the density function of the export income shock assumed as above to follow a truncated normal distribution $N(1,\sigma^{2})$ left-truncated at zero.

For firm i that comes to borrow for export in period t, the bank will choose a loan interest rate r_{it} such that its expected return from lending equals the expected returns if the firm had invested in riskless assets:

$$(1+r_{0})\omega f^{X} = \left[1-\Phi^{X,B}(\varphi^{B},n)\right]\left(1+r_{it}\right)\omega f^{X} + \Phi^{X,B}(\varphi^{B},n)\left\{E_{t}\left[I^{X,B}(\varphi^{B},n)|default\right]+ A_{it}\right\} \quad (2.10)$$

The left-hand-side (LHS) of the equation above is the return on riskless assets. The right-hand-side (RHS) consists of the expected repayments to the bank if the firm does not default (the first term on the RHS) and the expected collection the banks can make if the firm defaults (the second term on the RHS). $E_t\left[I^{X,B}(\varphi^B,n)\middle|default\right]$ is increasing in the (bank's evaluation of) firm productivity level and liquidity level.[19] As shown earlier, $\Phi^{X,B}(\varphi^B,n)$ is decreasing in both the firm's liquidity level and the bank's evaluation of the firm's unobserved productivity. Therefore, it is obvious from the equation above that the bank's loan interest rate to the firm is decreasing in the firm's collateral value, in the firm's liquidity level, and in the bank's evaluation of the firm's unobserved productivity.

As a summary, the segmentation of firms predicted by the model can be summarized in Figure 2.1, which is drawn holding collateral fixed. The graph holding liquidity fixed would be similar. Firms that have productivity less than the cutoff $\overline{\varphi}^D$ do not operate at all (regardless of their liquidity and collateral) since they are not profitable. For firms that have sufficient liquidity (n) to finance the fixed costs of exporting, the productivity cutoff for exporting does not depend on liquidity n or collateral A. For these firms, the decision to export depends only on productivity and not on financial factors or collateral capability. For firms with insufficient liquidity, i.e., firms with $n < \omega f^X$, the productivity cutoff for exporting depends on both the firm's liquidity and collateral. Specifically, this cutoff is lower for firms with higher liquidity and/or collateral. In other words, for firms with insufficient liquidity, the importance of productivity on export decision is reduced as the export decision also depends on financial factors and collateral capability. The segmentation just described can be summarized in Figure 2.1. To achieve

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[19] See proofs in *Appendix C*.

analytical equilibrium solutions, I will assume that on average, the bank's expectation of the probability that a firm defaults is correct, i.e. equal to the actual probability of default.

4.   Aggregation

Denote M as the mass of firms in the equilibrium. Let M^D be the number of firms in the home country that produce domestically only. Let $M^{X,B}$ be the number of borrowing exporters and $M^{X,NB}$ be the number of non-borrowing exporters. As in the Melitz (2003) model, in equilibrium, the weighted average productivity of all firms in the home country (including both domestic and foreign firms) with the weight being the relative shares of firm outputs is:

$$\tilde{\varphi} = \left\{ \frac{1}{M} [M^D (\tilde{\varphi}^D)^{\mu-1} + M^{X,B} (\tau^{-1}\tilde{\varphi}^{X,B})^{\mu-1} + M^{X,NB} (\tau^{-1}\tilde{\varphi}^{X,NB})^{\mu-1}] \right\}^{\frac{1}{\mu-1}} \tag{2.11}$$

Aggregate variables can be expressed as a function of this average productivity:

$$P = M^{1/(1-\mu)} \frac{1}{\rho\tilde{\varphi}} \tag{2.12}$$

$$Q = M^{1/\rho} q(\tilde{\varphi})$$

The equilibrium is characterized by two equilibrium conditions: the zero cutoff profit conditions (ZCP) and the free entry condition (FE). The ZCP in the domestic market solves for the productivity of the "marginal" firm in the domestic market whose profits from domestic sales are exactly zero. Since profits are increasing in productivity levels, all firms with productivity below this cutoff will not produce at all and all firms with productivity above this cutoff will produce. Similarly, the ZCP condition for exporting solves for the export productivity cutoff where only firms with productivity equal or above this cutoff will export. Finally, the free-entry

condition ensures that *ex-ante* expected profits from entering the market is driven down to zero since as long as expected profit is positive, more firms will enter which increases competition and drives the expected profits down until it comes to zero at which point a potential entrant is indifferent about entering the market. [20]

$$\pi^D(\overline{\varphi}^D) = 0$$
$$\pi^{X,B}\left[\overline{\varphi}^{X,B}(n,A)\right] = 0$$
$$\pi^{X,NB}(\overline{\varphi}^{X,NB}) = 0$$

Let $\gamma^D(\varphi)$ be the equilibrium distribution of productivity levels for incumbent firms, i.e. firms that are productive enough to stay in the market, then $\gamma^D(\varphi)$ is the conditional distribution of $f(\varphi)$ on $[\overline{\varphi}^D, \infty)$:

$$\gamma^D(\varphi) = \begin{cases} \dfrac{f(\varphi)}{1 - F(\overline{\varphi}^D)} & \text{if } \varphi \geq \overline{\varphi}^D \\ 0 & \text{otherwise} \end{cases}$$

Similarly, $\gamma^{X,NB}(\varphi) = \dfrac{f(\varphi)}{1 - F(\overline{\varphi}^{X,NB})}$ is the equilibrium distribution of productivity levels for non-borrowing exporters, and $\gamma^{X,B}(\varphi) = \dfrac{f(\varphi)}{1 - F\left[\overline{\varphi}^{X,B}(n,A)\right]}$ is the equilibrium distribution of productivity levels for borrowing exporters.

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[20] In the *Firm's Decision* section, we can see that $\overline{\varphi}^{X,B}$ is a function of the bank's loan interest rate, r_{it}. On the other hand, by assumption, r_{it} is a function of firm collateral, liquidity and the bank's evaluation of the firm unobserved productivity. Given our assumption that the expected value of the bank's valuation of firm productivity is equal to the firm's real productivity, $\overline{\varphi}^{X,B}$ is a function of n and A_{it} only.

$$\gamma^{X,NB}(\varphi) = \begin{cases} \dfrac{f(\varphi)}{[1-F(\overline{\varphi}^{X,NB})][1-G(\omega f^X)]} & \text{if } \varphi \geq \overline{\varphi}^D \text{ and } n \geq \omega f^X \\ 0 & \text{otherwise} \end{cases}$$

$$\gamma^{X,B}(\varphi,n,A) = \begin{cases} \dfrac{f(\varphi)}{[1-F(\overline{\varphi}^{X,B}(n,A))]G(\omega f^X)} & \text{if } \varphi \geq \overline{\varphi}^D \text{ and } n < \omega f^X \\ 0 & \text{otherwise} \end{cases}$$

Using these conditional distributions, we can rewrite the three aggregate average productivities in terms of the corresponding productivity cutoffs as follows:[21]

$$\tilde{\varphi}^D = \left[\int_{\overline{\varphi}^D}^{\infty} \varphi^{\mu-1} \gamma^D(\varphi) d\varphi \right]^{\frac{1}{\mu-1}}$$

$$\tilde{\varphi}^{X,NB} = \left[\int_{n=\omega f^X}^{\infty} \int_{\overline{\varphi}^{X,NB}}^{\infty} \varphi^{\mu-1} \gamma^{X,NB}(\varphi) d\varphi \right]^{\frac{1}{\mu-1}}$$

$$\tilde{\varphi}^{X,B} = \int_{A=0}^{A=\infty} \int_{n=0}^{n=\omega f^X} \left[\int_{\overline{\varphi}^{X,B}}^{\infty} \varphi^{\mu-1} \gamma^{X,B}(\varphi,n,A) d\varphi \right]^{\frac{1}{\mu-1}} g(n)k(A) dndA$$

Thus, the zero-profit conditions can be written as:[22]

$$\pi^D(\tilde{\varphi}) = \omega f^D q(\overline{\varphi}^D, \tilde{\varphi})$$

$$\pi^{X,NB}(\tilde{\varphi}) = \omega f^X q(\overline{\varphi}^{X,NB}, \tilde{\varphi})$$

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[21] Note that the segmentation of firms into non-borrowing exporters and borrowing exporters not only depends on firm productivity but also depends on firm liquidity level. However, because I have assumed the distributions of liquidity and productivity are independent of one another, I can define the aggregate average productivity for domestic producers and for non-borrowing exporters independently of the liquidity level.

[22] Since $(1+r)n$ is the deposit and interest earnings on firm liquidity that the firm would earn regardless of whether it produces or not, firm profit should be considered against this opportunity cost. Therefore, a firm profit is defined as its revenue from selling products net its labor costs and fixed costs and net the loan payments (loan amount plus interests) if the firm borrows to export. With this definition of profit, all of the aggregate profits can be written as functions of productivity cutoffs and fixed costs of production.

$$\pi^{X,B}(\tilde{\varphi}) = \omega f^{X} h(\overline{\varphi}^{X,B}, \tilde{\varphi})$$

where $q(\overline{\varphi}^{D}, \tilde{\varphi}) = [\tilde{\varphi}/\overline{\varphi}^{D}]^{\mu-1} - 1$, $q(\overline{\varphi}^{X,NB}, \tilde{\varphi}) = [\tilde{\varphi}/\overline{\varphi}^{X,NB}]^{\mu-1} - 1$, and

$$h(\overline{\varphi}^{X,B}, \tilde{\varphi}) = \int_{A=0}^{A=\infty} \int_{n=0}^{n=\omega f^{X}} \left\{ [\tilde{\varphi}/\overline{\varphi}^{X,B}(n,A)]^{\mu-1} - [1 + r(\tilde{\varphi},n,A)] \right\} g(n)k(A)dndA$$

This implies that average aggregate profit can be expressed as:

$$\overline{\pi} = \pi^{D}(\tilde{\varphi}^{D}) + p^{X,NB}\pi^{X}(\tilde{\varphi}^{X,NB}) + p^{X,B}\pi^{X}(\tilde{\varphi}^{X,B}) \qquad \text{(ZCP)}$$

$$= \omega f^{D}k(\overline{\varphi}^{D}, \tilde{\varphi}) + p^{X,NB}\omega f^{X}k(\overline{\varphi}^{X,NB}, \tilde{\varphi}) + p^{X,B}\omega f^{X}h(\overline{\varphi}^{X,B}, \tilde{\varphi})$$

where $p^{X,NB}$ and $p^{X,B}$ are the *ex-ante* probability that an operating firm will export without

borrowing, and the *ex-ante* probability that an operating firm will borrow to export, respectively.

These probabilities are calculated as follows:

$$p^{X,NB} = \frac{[1 - F(\overline{\varphi}^{X,NB})][1 - G(\omega f^{X})]}{1 - F(\overline{\varphi}^{D})}$$

$$p^{X,B} = \frac{G(\omega f^{X})}{1 - F(\overline{\varphi}^{D})} \int_{A=0}^{A=\infty} \int_{n=0}^{\omega f^{X}} \left[1 - F[\overline{\varphi}^{X,B}(n,A)] \right] g(n)k(A)dndA$$

where *F* and *G* are defined above as the cumulative distribution functions of productivity and

liquidity. The *ex-ante* probability an entrant is a non-borrowing exporter ($p^{X,NB}$) is the

probability that an entrant picks both a draw of productivity that is greater or equal to the cutoff

for non-borrowing exporting and a draw of liquidity that is greater than the fixed costs of

exporting, conditional on having a productivity draw that is greater than the productivity cutoff

for operating ($\overline{\varphi}^{D}$). Similarly, the probability an entrant is a borrowing exporter ($p^{X,B}$) is the

probability that conditional on drawing a productivity level greater than the productivity cutoff for operating ($\bar{\varphi}^D$), an entrant draws a liquidity that is less than the fixed costs of exporting and has a combination of liquidity and collateral such that it is profitable to borrow to export. The *ex-ante* probability that one of the surviving firms will export is:

$$p^X = p^{X,NB} + p^{X,B}$$

Let υ_e denote the *ex-ante* net value of entry and $\bar{\upsilon}$ denote the average present value of operating firms. Free entry implies that potential entrants will enter the market as long as the expected net value of entry is positive. Therefore, in equilibrium, the *ex-ante* net value of entry is zero, hence called the free entry condition.

$$\upsilon_e = \text{Probability (firms get a productivity draw high enough to stay in the market)} * \bar{\upsilon} - f^e = 0$$

or $\upsilon_e = \left[1 - F(\bar{\varphi}^D)\right] * \bar{\upsilon} - f^e = 0$

where $\bar{\upsilon} = \sum_{t=0}^{\infty} [\beta(1-p)]^t \bar{\pi} = \dfrac{\bar{\pi}}{1 - \beta(1-p)}$, β is the discount rate, f^e is the fixed cost of entry which is sunk thereafter, and p is the probability firms will be hit by a death shock in each period. Thus, the free-entry condition can be rewritten as:

$$\bar{\pi} = \frac{\left[1 - \beta(1-p)\right] f^e}{1 - F(\bar{\varphi}^D)} \qquad \text{(FE)}$$

The (ZCP) and (FE) conditions determine the productivity cutoffs. The mass of firms in equilibrium can be determined as:

$$M = \frac{R}{r(\tilde{\varphi})} = \frac{\omega L}{r(\tilde{\varphi})}$$

where L is the country's population. The mass of export firms is $p^X M$.

The model yields two predictions. The first prediction implies that access to finance, on average, increases firms' export propensity. This prediction is illustrated in Figure 2.1. For the group of firms that does not have enough internal funds to cover the fixed costs of exporting but is productive enough to be profitable from exporting, only some firms - those that have access to bank financing - can export. This implies that access to bank financing should have a positive effect on firms' export status.

The second prediction is that the effect of access to credit on firms' export propensity is heterogeneous: access to credit has the most positive effect on export propensity for firms that are in the intermediate range of productivity. For firms that have very low productivity levels, i.e., less than $\overline{\varphi}^{X,NB}$, whether the firms have access to financing does not affect their export decisions. In addition, the model implies that the cutoff productivity for exporting for borrowing firms ($\overline{\varphi}^{X,B}$) is decreasing in productivity, illustrated in Figure 2.1 by the downward-sloping curve of $\overline{\varphi}^{X,B}$. This means that firms that are very productive are much more likely to be profitable from exporting even when they have to borrow. For these reasons, access to credit does not have much effect on the export decisions of the least and most productive firms, but has most impact on the export decision of firms that are in the intermediate range of productivity. Intuitively, the most productive firms can generate enough internal funds from their domestic sales to cover most of the costs of exporting, so external financing is not as important for their export decision. The least productive firms would not export even when there is no credit constraint since these firms are not productive enough to be profitable from exporting. Therefore, the group that is potentially most affected by having access to external financing would be firms

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in the intermediate range of productivity. These firms have the potential to gain profits from exporting, but need external financing to export since they are not productive enough to generate sufficient internal funds to finance exporting. In the empirical estimation, I will test the two hypotheses above.

IV.   Empirical Testing

1.   Credit Constraints in Ghana

Ghana is a country in West Africa with a population in 2014 of about 25 million. The period 1991-1997 was one of moderate growth rates for Ghana, with GDP growth averaging 4.3%. Manufacturing was the second largest sector, contributing on average 10.1% of total value added (International Financial Statistics). During the period 1983-1989, Ghana went through significant trade liberalization and economic restructuring guided by an Economic Recovery Program (ERP) under the IMF and the World Bank (1983-1986), and a Structural Adjustment Program (SAP) starting in 1989. By the end of 1989, Ghana had a liberalized trade regime. The SAP also included the Financial Sector Reform Program (FINSAP), the first phase of which was implemented during 1989-1990. The FINSAP restructured distressed banks with government taking over non-performing loans, eliminated government's control over loan interest rates, reduced state shareholdings in Ghanaian banks, and implemented changes in policy relating to credit allocation (Aryeetey et al. 1994). In the year 1994, the second phase of FINSAP was implemented with the major objective of privatizing the state-owned banks and developing Non-Bank Financial Institutions to fill gaps in the financial markets not served by the banks. By the end of 1994, Ghana had thirteen commercial, savings, development and merchant banks,

together with rural banks that mainly served smaller loan demand.[23] However, financial reforms had not left much impact. The Ghana Stock Exchange (GSE) came into operation in 1990 and the GSE remains an important source of funds for Ghanaian firms. In 1997, only 21 firms were listed in the GSE. Aryeetey et al. (1994) concludes that despite the FINSAP and a program target SME credits, SMEs in Ghana still faced credit constraint.

Empirical application of the chapter's model requires a data set that satisfies the following criteria: (1) the data set comes from a country where firms face financial constraints, (2) bank credit is an important source of financing for firms, (3) banks make lending decisions based on firm characteristics such as age, collateral, and evaluation of firm productivity, and (4) significant heterogeneity among firms in terms of productivity or profitability is observed. The first two criteria ensure that the ability to obtain bank credits is critical for financially constrained firms to overcome their constraints. The last two criteria ensure that the data fit well with the model's assumptions. The Ghanaian firm data set used in this chapter is suitable since it satisfies these four criteria as explained below.

First, there is empirical evidence that firms in Ghana do face substantial credit constraints. Lack of access to financing, especially problems arising from imperfect information in the lending and borrowing process, is likely to be most pronounced in developing countries where gathering information is costly because of poor communications. In Ghana, an uncompetitive financial market structure, lack of a central credit information system, lack of cooperation among banks in sharing customer information, and weak enforcement of creditors' rights result in severe

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[23] Commercial banks offer traditional banking services, with a focus on universal retail services. Merchant banks are fee-based and focus mostly on corporate banking services. Development banks specialize in medium and long-term finance.

credit constraint. According to Aryeetey et al. (1997), "in Ghana as well as in Malawi, Nigeria and Tanzania, most banks operated in an extremely constrained environment with underdeveloped market-supporting infrastructure and a poor base of information. Lending remained constrained, resulting in a low-lending trap despite excess demand for credit – particularly by small-scale enterprises with good opportunities but insufficient collateral." Steel and Webster (1992) comment that for small firms that adapted to changes under the ERP successfully, the most critical constraint was lack of access to finance for working capital and new investment. In addition, most deposits into banks in Ghana are of a short-term nature. In addition, "the enforcement of creditors' rights is weak compared with the sub-Saharan African average" (Buchs and Mathisen 2005).[24] Because of these limitations, lenders favor short-term debt to force borrowing firms to account regularly for their actions: Fafchamps et al. (1994) commented that in Ghana and Kenya, "banks *de facto* limit themselves to overdrafts and to medium term bank loans" (page 13).[25]

With trade liberalization, one expects to see an increase in Ghanaian exports and in the productivity of Ghanaian exporters as predicted by Melitz (2003)'s model and other following

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[24] Buchs and Mathisen (2005) provides a very detailed summary and statistics of the banking system in Ghana 1998-2003. While not covered in the data set I analyze in this paper, this period directly follows the period I analyze 1992-1997 and so many of the features of the banking system in Ghana outlined in Buchs and Mathisen (2005) are likely to also apply to the period of my empirical application.

[25] According to Fafchamps et al. (1994), bank overdrafts are the biggest source of external finance to Kenyan firms, and that Kenyan firms use their overdraft facility overwhelmingly to finance working capital. Two third of the firms in their data set have at least one overdraft facility. Slightly more than half the case study firms hold a bank overdraft but only one sixth have an outstanding bank loan. A loan-overdraft coupling package is common so that if a firm cannot meet a loan payment, it can use the overdraft to temporarily cover the interest payment. While this is just evidence of the role of overdraft in Kenya, the data set of Ghanaian firms that I analyze in this paper also indicates that overdraft is much more common than bank loans for Ghanaian firms. Leith and Söderling (2000) list possible reasons for why Ghanaian banks mostly offer short-term or medium-term loans (instead of long-term loans) including severe asymmetric information problems, weak enforcement of creditor rights, crowding out of credit to the private sector by the Ghanaian government's demand for funds to finance its deficits (the treasury bill rates have been set at about "the same level to the lending rates since the beginning of the 1990s"), and the short-term characteristics of deposits into banks with nearly 50 per cent of total deposits being demand deposits.

studies. However, as my model also implies, productivity may not be the only factor that affects export participation. Financial constraints may hinder productive but small firms from exporting. Given that trade barriers were reduced significantly but the impact of financial reforms in Ghana was still limited for the period 1991-1997, analyzing the Ghanaian data set for this period will highlight the importance of access to financing in firms' export participation.

As for the second criterion, Bigsten et al. (2003) document that African firms have to rely mainly on internal funds or borrow from the credit market. They also find that "in Ghana, the financial sector is the main source of external funds" and "though informal credit market is viable in Ghana, it is relatively unimportant for the manufacturing sector." This suggests that using barriers to bank loan and overdraft to proxy for financial constraint, as is done in the empirical section of the chapter, is appropriate for this data set of Ghanaian manufacturing firms.

The third criterion requires that in practice, banks do base on a firm's liquidity measures such as cash flows, proxies for productivity, and collateral in determining the firm's ability to pay back the loan. While there has not been empirical study of the correlation between a firm's liquidity amount and its chance of obtaining loans from banks in Ghana, a number of studies have pointed out that banks' lending decisions are based on some signal of productivity, such as age or expected profitability, and collateral. For example, Storey (1994) and Berger and Udell (1998) find that firms are more likely to get loans if they have collateral in the forms of tangible assets. Bigsten et al. (2003) note that "in Ghana, 69% of the firms provided collateral for formal loans and the collateral is on average 2.39 times the loan size." Abor (2008) finds that in Ghana, fixed assets are important in obtaining long-term debt, and that older SMEs are more likely to get loans than young SMEs. Bigsten et al. (2003) find that for six African countries including Ghana, "banks allocated credits based on expected profits."

As for the fourth criterion, there is also evidence that Ghanaian firms differ in their productivity. For example, Steel and Webster (1992) observe that following the ERP program, there are two groups among small firms: the successful adapters with good prospects and stagnant producers who had not adapted to the new competitive environment. In addition, while manufacturing grew at a slow rate (2.6 percent) during the period of 1990-1996, the share of manufacturing in Ghana's total exports increased from 3.87 percent in the period before trade liberalization to 18.24 percent in the period of liberalized trade regime (1990-1994). This documented expansion of exporters fits with the prediction of models of firm heterogeneity in productivity that trade liberalization leads to an expansion in the market share of exporters.

2. Firm-Level Data

The data used in my empirical estimation are compiled from surveys of Ghana's manufacturing firms for the period of 1991-1997 administered by the Centre for the Study of African Economies (CSAE) at Oxford University. Survey information was collected in face-to-face interviews. The data for 1991 to 1993 were collected annually as part of the RPED (Regional Program on Enterprise Development) led by the World Bank. The CSAE took over the project in 1994. The data for 1994 and 1995 were collected in a single survey conducted in 1996. Similarly, data for 1996 and 1997 were collected in a single survey conducted in 1998.

The initial sample was drawn from the 1987 Census of Manufacturing Activities in Ghana. The sample was stratified by size, sector, and location of the firm. Four size categories, four regions and, initially, four sectors were used to structure the sample. In later survey waves, more sectors were added in the surveys. When firms had gone out of business, they were replaced by

firm of the same size category, sector, and location. Table 2.1.2 gives a summary of firms'
participation in the surveys.

One important thing to note from Table 2.1.2 is that there are firms that chose to drop out of
the surveys but still operated and sold goods (uncooperative firms). In the data, these firms will
appear as if they exited. However, there are only 19 uncooperative firms in total, so this should
not affect the empirical analysis much.[26]

The data set includes information about several firm characteristics, such as age, location,
industry, value added, raw material costs, wages, employment, capital, export status, and
intensity, as well as information about firms' borrowing, such as loan application status and
access to banks' overdraft facilities. In addition, the data set has output price and price for raw
materials at the firm level.[27]

Measures of firm-level credit access are important for testing the model's hypotheses in this
chapter. The data set does not provide direct information on firms' level of liquidity/cash, so I
cannot control for their internal funds in the empirical estimation. However, the survey
questionnaire included several multiple-choice questions on firms' applications for bank loans
and their access to banks' overdraft facilities. To proxy for firms' access to credit, I use an
indicator of access to overdraft facilities called *Overdraft* and an indicator of constraint in access
to loans called *Loan Constraint*. The *Loan Constraint* indicator includes both firms whose loan
applications were rejected and discouraged borrowers (firms that did not apply for loan even

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[26] As a robustness check, it would be good to check whether the regression results are robust when including and
excluding uncooperative firms in the regression sample. However, this cannot be done since uncooperative firms are
not identified in the data.

[27] I deflated wages using CPI values obtained from the World Bank. Firm-level output prices were used to deflate
firms' value added, and firm-level prices of raw material were used to deflate raw material costs.

though they had demand for bank loans). Specifically, the definition of the indicator *Loan Constraint* includes quantity rationing (in bank loans) but also includes two forms of non-price rationing: risk rationing and transaction-cost rationing. Quantity-rationed firms are firms that have excess demand for credit that is not met by banks. I consider firms to be quantity-rationed in loans if their applications for loans were rejected or if they did not apply for a loan because of one of the following reasons: (1) the firm had inadequate collateral, (2) the firm did not think it would get a loan, or (3) the firm was already heavily indebted.[28] On the other hand, risk-rationed and transaction-cost rationed firms have access to loans that may raise their earnings but choose not to apply for loans. Risk-rationed firms are those that choose not to apply for loans because of their aversion to the risk that is involved. Transaction-cost rationed firms are those that choose not to apply for loans because of the transaction costs involved in applying for loans (see Table 2.2 for more detailed explanation about the coding of these categories).[29]

For comparison, I also include estimation results where these two measures are combined into a measure called *Overdraft-Loan Constraint*, which is defined to equal one if the firm has access to overdraft facilities and has no loan constraint. The combined indicator applies to the scenario

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[28] It is debatable whether firms that were already heavily indebted should be categorized as credit constrained. On one hand, if banks usually reject loan application from heavily indebted firms, then firms that are heavily indebted are quantity-rationed in loans and can be included into the group of credit constrained firms. However, banks may not reject but just offer loans at an interest rate premium to firms that have large debts. In this case, these firms are not quantity-rationed but price-rationed in loans and do not fit the definition of credit constrained firms above. As a practical issue, this is not a big problem for the empirical estimation since the percentage of firms that did not apply for loans because they were already heavily indebted is very small. Only 1.79% of the firms gave this reason why they did not apply for a loan (see Table 2.5).

[29] A drawback of the measures of credit constraint used in the empirical testing is that both measures, *LoanConstraint* and *Overdraft*, are binary and thus, do not capture the different degrees of financial constraint. The firm's interest payment is a continuous variable and potentially can capture different degrees of financial constraint, so it would be good for sensitivity analysis to include regressions using interest payment. However, in the Ghanaian data set, there is a much higher number of missing observations in interest payment than in *LoanConstraint* and *Overdraft*.

where overdraft and loan are often offered in combination or when both types of financing are important for export financing. My preferred specification, however, is where *Overdraft* and *Loan Constraint* enter the estimating equation separately.[30] The reason for this preference is that these two indicators may proxy for constraints in meeting two different types of financing needs.

Overdraft facilities are often used to cover working capital and as a backup source for unexpected short-term liquidity shocks such as payment delay or sudden liquidity demand. Firms can take their overdraft limits into account when planning liquidity for the future.[31] Firms only withdraw on overdraft (up to the overdraft's maximum limit) if they have liquidity needs. They only have to pay interest on the amount they borrow from the overdraft and can repay the debts at any time.[32] In the data set, most firms have access to overdraft facilities renewed annually or monthly, with the majority of firms having overdraft facilities renewed annually. As mentioned earlier, exporting involves higher working capital requirements and is subject to longer payment delay, which means that having access to overdraft facilities should be more important for firms that want to export than for firms that do not.

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[30] Overdraft and loan can be set up separately. For example, the Stanbic Bank's web site lists separate information on application procedures for overdraft and loans. In addition, in the data, there are cases where a firm has access to overdraft facilities but did not get a loan or vice versa.

[31] While businesses still need to have accounts with banks in order to have overdrafts with the banks and the overdraft is often linked to the firms' business accounts with the bank, firms can borrow from the overdraft facility more than the amount of money they have in their banking account. Thus, having access to overdraft facilities mean that firms do not have to ensure that sufficient cash is always available for operating activities in the short term.

[32] Source: http://www.stanbic.com.gh/ghana/Business-banking. According to the information on the web site of Stanbic Bank (as of April 2014), a Ghanaian bank, an overdraft is a borrowing facility attached to the firm's bank account, set at an agreed limit. It can be drawn upon at any time and is ideal for the firm's day-to-day expenses, particularly to help the firm through cash flow problems. Although this information is not for the period studied (1991-1997), no historical records of similar information are available, and I have no reason to believe the bank's criteria for granting overdraft and loan access has changed much.

In contrast to overdraft facilities, a loan is an amount of money borrowed for a set period with an agreed repayment schedule. In comparison to overdraft facilities, loans are less flexible in terms and conditions and take a longer time to arrange so it is unlikely that businesses would use bank loans to cover unexpected cash flow shocks. Loans are better than overdraft in financing fixed investments such as the purchase or upgrade of equipment, building of new plants, or startup costs. While a firm's past and projected cash flow and credit history are common important criteria for banks to grant access to overdraft facilities or loans, some other criteria, such as collateral, are subject to different requirements between access to overdraft and access to loans. For example, Stanbic Bank states on its web site that for granting overdraft access, the "evaluation principles are based on cash-flow assessment" and "collateral is based on conditions of grant". On the other hand, for term loan, the bank requires "first class collateral (tangible or easy, reliable security), on which the bank is able to fall back on as an alternative source of repayment".[33]

Although there is not a direct link between these measures of credit access (i.e. *Overdraft* and *Loan Constraint*) and the model's parameters, access to overdraft can be thought of as playing a role that is similar to the firm's liquidity *n* in the model in terms of protecting the firm from having to default when there is a bad shock to the firm's exports.[34] Since a reduced default probability implies higher expected profit, having access to overdraft facilities increases the likelihood a firm decides to export. The *Loan Constraint* indicator captures the financing of the portion of fixed cost of exporting, i.e. the portion of wf^X, that is longer term. However, it is

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[33] Source: http://www.stanbic.com.gh/ghana/Business-banking

[34] While the theoretical model only models shock to export sales, practically, overdraft can also be used when the firm incurs cash flow shortage due to late payment from foreign customers, etc.

possible that some of the fixed costs of exporting may also be covered by overdraft if these costs are unexpected or have a short cycle. In addition, if financial constraint in the model is extended to variable costs of exporting, i.e. firms have to pay for these costs upfront before receiving export revenues, then access to overdraft will also play a role in helping firms to finance working capital for exporting when the firms does not have enough internal funds. For more detailed definition of the key variables used in the empirical estimation as well as descriptive statistics and correlation of these variables, refer to Table 2.2, Table 2.3, Table 2.4.1 and Table 2.4.2.

Using the indicators of overdraft and loan constraint directly as adopted in the chapter's empirical analysis does not account for the selection effect. Accounting for selection requires modeling the sequential nature of credit decisions. For example, for the indicator of having an overdraft facility with a bank, the sequential nature would be as follows: First, a firm decides whether to apply for overdraft privileges. Factors that influence this decision include the size of the firm's internal funds, whether overdraft is an appropriate financial tool to fund the specific activity that the firm wants to finance, and the firm's expectation of its chance to get the overdraft privileges versus the costs of applying for overdraft. Once a firm decides to apply for overdraft, the bank then decides whether to grant the firm an overdraft facility.

The estimation of sequential credit decisions can be done using the two-step approach. In the first stage, the dependent variable is whether a firm applies for overdraft. In the second step, the dependent variable is whether a firm is granted an overdraft facility by the bank. In the two-step approach, the second-stage regression includes an inverse Mills ratio on the right-hand side (RHS) to correct for the selection effect. To estimate the impact of credit constraint on firms' export decisions, the predicted overdraft could be used on the RHS of the estimating equation

(2.14) in Section 4.1 instead of the actual overdraft indicator. A similar sequential approach can be used with constraint in bank loans, *Loan Constraint.*

I choose not to adopt the sequential modeling approach described above because of the following reasons. For access to overdraft, the sequential-decision approach requires information on whether a firm applied for overdraft, which is an outcome of the first stage. In my data, I only have information about whether a firm had an overdraft facility with a bank, which is the outcome variable in the second stage. Because of this lack of data, I cannot use sequential modeling for modeling access to overdraft. However, I suspect that the selection problem is not too severe for overdraft access since the transaction cost of applying for overdraft privileges for the firm is low. As discussed above, compared to application for bank loans, overdraft application requires less documentation and a shorter processing time. In addition, the firm only has to pay interest if it actually withdraws money from the overdraft facility so the costs of having an overdraft facility are low for the firm. As for the *Loan Constraint* indicator, there is information in the Ghanaian data set about whether a firm applied for bank loans and whether the firm got the loan. However, for identification of the sequential estimation, the availability of good exclusion variables is very important. Since I could not find a good exclusion variable in the data set, I did not adopt the sequential-decision modeling approach for constraint in bank loans.

3.   Determinants of Credit Access

The theoretical model implies that observed access to credit is a function of both the firm's demand for credit and the bank's decision to provide credits. In the model, a firm's demand for credit depends on its internal funds and productivity. On the supply side, the bank's decision to

grant credit depends on the bank's evaluation of the firm's productivity, collateral and liquidity. To examine empirically the factors that affect a firm's access to credit, I estimate the following regression:

$$CreditAccess_{it} = \alpha_0 + \alpha_1 * X_{i,t-1} + \alpha_2 * Network_{it} + \alpha_3 * T_t + \alpha_4 * S_{it} + \alpha_5 * Area_{it} + \varepsilon_{it} \quad (2.13)$$

In the specification above, *CreditAccess* is *Overdraft*, *Loan Constraint*, or the *Overdraft-Loan* indicator. *X* is a vector of continuous firm-level regressors: physical capital stock, age, TFP, and raw material costs per worker, as well as an indicator of whether a firm is a limited liability company. All continuous regressors (except firm age) are in logarithms and lagged. *Network* is the number of people firms know that are in one of the following categories: civil servants, politicians, bank officials, in larger businesses, or living outside of Ghana. To avoid extreme values of the network variables, values in each network category are Winsorized at the 99th percentile.[35] Since the data only include information on firm's network for the years 1994-1997, the regression sample for the regression equation above was limited to those years.

Recall that the theoretical model predicts that the bank's credit-supply decision depends on collateral, firms' internal funds and the bank's assessment of firms' productivities. Firms' demands for bank credits depend on their internal funds and productivity, and the interest rate which is a function of collateral, internal funds and productivity. In relation to the theoretical model, capital is a proxy for collateral and affects the bank's credit supply decision. Proxies for firms' productivity such as TFP, age and capital, affect both credit supply and demand. Network affects the bank's evaluation of the firm's productivity, which according to the model, would

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[35] For example, for the variable that measures the number of bank officials in the firm's network, I find the 99th percentile of the variable. I then recode every value of this variable that is above this 99th percentile to be equal to the 99th percentile.

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affect bank's lending decision. While not directly implied in the model, the following variables are included in the regressions to control for further factors that may affect supply and demand of bank credit. Raw material costs per worker are included as a proxy for the firm's need of working capital. A dummy for limited liability companies is included to capture difference in credit access between different ownership forms. Time, sector and regional dummies are included to capture the difference across time periods, regions and sectors in credit availability.

It is expected that a large capital stock will increase the likelihood of having access to credit.[36] I expect the sign of the coefficient of raw material costs to be positive since a firm with greater need for working capital is more likely to want access to overdraft facilities. I also expect that older firms will have easier access to credit both because banks are more likely to be able to get more information about older firms including their credit history and because having survived a longer time is a good signal to the bank of a firm's good performance and ability to repay loans. Firms' TFP (or value added per worker) is included to capture the additional effect of productivity on access to credit. The sign of a firm's TFP (or value added per worker) on its likelihood to have access to credit is not clear. If all the effects of productivity on access to credit are already captured by a firm's size and age or if banks cannot observe firms' productivity levels, the coefficient of TFP (or value added per worker) is expected to be insignificant. However, if TFP has a direct effect on access to credit such as when banks makes decision to grant credit access based on productivity and can observe or predict firms' TFPs accurately, the coefficient of TFP will be positive. While my model assumes that firms' productivity levels stay

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[36] I would like to use the ratio of tangible assets over total assets as a proxy for the firm's collateral capacity since this measure is less susceptible to the scale effect than using the level value of physical capital. However, the Ghanaian data set does not have information on financial assets, cash on hand, or intangible assets so I cannot use this measure of tangible asset ratio.

constant throughout time, in the empirical estimation, I allow for the evolution of firm

productivity by using estimates of TFP using the Levinsohn-Petrin (2003) method that assumes

an exogenous Markov process for TFP and accounts for unobserved shocks to input usage.[37] In

the remainder of this chapter, TFPs refers to estimates of firms' TFPs using the Levinsohn-Petrin

(2003) method. The people in the network can either provide firms with valuable credit

information, or act as reference or guarantee for the firm when the firm applies for overdraft or

loans from a bank. Therefore, it is expected that a larger network will help firms have easier

access to credit.

The regression results for *Overdraft* in Table 2.6.1 confirm that older and larger firms are

more likely to have access to overdraft facilities. Firms with higher expenditures on raw

materials are also more likely to have overdraft facilities. A larger network also increases the

chance that a firm has access to overdraft facilities. The effects of TFP and ownership form

(limited liability companies) are insignificant. If TFP is replaced by another proxy for firm's

productivity, the value added per worker, the estimation results are qualitatively the same. While

one may argue that overdraft is just a proxy for collateral, the estimation results above suggest

that there are other factors that influence access to overdrafts. Also, as mentioned above,

collateral requirements may differ between overdraft and bank loans, i.e. collateral may not be as

important to gain access to overdraft facilities as in obtaining a bank loan.

When the combined measure of credit access, *Overdraft-Loan Constraint*, is used instead of

the *Overdraft* dummy, a similar pattern of access to credit is obtained. Capital, age and network

are still positively correlated to the chance that a firm has both access to overdraft facilities and

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[37] For more information about the procedure for estimating TFPs using the Levinsohn-Petrin (2003) method, see
Appendix B.

did not have problem getting bank loans conditional on having a demand for bank loan. However, raw material costs per worker become insignificant in the regression using TFP (see Table 2.6.2). This could be because raw material cost per worker is a proxy for working capital needs. As mentioned above, empirical studies of bank financing in Ghana indicate that overdraft is much more frequently used by firms to cover working capital needs than bank loans. Therefore, as a proxy for working capital needs, raw material cost per worker is expected to have a more significant effect on overdraft access than on the combined access to overdraft and loans.

Table 2.7 presents the empirical estimation of the determinants of whether a firm has constraint in access to bank loan. The only significant factors are capital and productivity. The coefficient estimate of the raw material costs per worker is insignificant, confirming the assumption that overdraft, not bank loans, is the primary source of financing working capital. The regression estimates also suggests that requirements for granting bank loans are more stringent since firm age and network becomes insignificant determinant compared to access to overdraft.

4.   Estimating Equation

There are two approaches to test the theoretical model: the structural approach and the reduced-form approach. While modeling all endogenous choices allows for the identification of all parameters in the theoretical model (under further restrictive assumptions) and a good connection between the model and the empirical estimation, the structural estimation approach often requires restrictive parameterizations in order to make identification possible. The Ghanaian data have the limitation in that many interesting variables are not available for all survey waves or have many missing values. Also, like many firm-level data sets for developing

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countries, measurement errors are likely to be an issue for many variables. This would make it even more difficult to implement structural estimation. The main interest of this chapter is to examine the impact of credit access (constraint) on a firm's export propensity, for which I believe structural estimation is not needed. Because of all these reasons, I choose the reduced-form approach. Admittedly, a reduced-form approach does not allow me to obtain estimates of the parameters of the model. However, since my purpose is to detect whether there is a positive or negative direction to credit access for firms' export participation rather than the magnitude of this effect, the reduced-form approach is adequate to address this question by allowing me to investigate the significance and the causation direction of credit access on firms' exporting decision.[38]

As mentioned above, this chapter's theoretical model predicts that everything else equal, credit access has a positive impact on export propensity. More precisely, credit access is most important in export participation for firms in the intermediate range of productivity. To test the model's predictions, I estimate two main regression specifications: a dynamic probit regression of export status and a regression of export status against credit access interacting with quartiles of initial TFPs. In the following sections 4.1 and 4.2, I will outline these estimating equations.

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[38] Related to the rationale for using the reduced-form approach is my rationale for focusing on estimating a single equation of export status instead of estimating a system of equation for export status and other potential endogenous choices such as access to finance. While estimating the export equation as part of a system of equations where the dependent variables in the other equations are other endogenous firm choices yield more efficient estimates under correct specification of all equations, estimation of the export equation alone, if done correctly, should still yield consistent estimates. In the system-of-equation approach, if one equation in the system of equations is misspecified, the estimation of the other equations will be affected by this misspecification (Kennedy 2003, p190). Furthermore, the system of equations approach requires exclusion variables for good identification. Since it is very difficult to model correctly all of the endogenous firm choices and find good exclusion variables for all of the endogenous choices, I choose to adopt the single-equation approach.

4.1.   Dynamic Probit Regression of Export Status

To test whether credit access has a positive effect on firms' export propensity, I estimate a dynamic probit regression of firms' export status. The estimation results of this regression are valid conditional that there is no reverse causation or simultaneity, which would be checked in Section VI (Sensitivity Analyses). The dynamic probit regression equation to be estimated is:

$$Export_{it} = \beta_0 + \beta_1 Export_{i,t-1} + \beta_2 LoanConstraint_{it} + \beta_3 Overdraft_{it} + \beta_4 X_{i,t-1}$$
$$+ \beta_5 S_{it} + \beta_6 D_t + \eta_i + \varepsilon_{it} \qquad (2.14)$$

where the subscripts i and t are firm and time subscripts, $Export$ denotes a firm's export status, S_{it} and D_t are the industry and time dummies respectively. X is a vector of control variables such as capital stock to capture the size and productivity effect[39], TFP and firm's age to capture efficiency differences, and weighted education of management to capture differences in management qualities across firms. All the continuous variables are lagged and in logarithms. The error term is composed of a time-invariant unobserved heterogeneity η_i and an idiosyncratic error term ε_{it}.

In the theoretical model, there is a one-to-one relationship between firm's size and its productivity so capital can be considered as a proxy for a firm's productivity and so one only needs to control for capital or TFP. However, to allow for the possibility that capital also captures other effects besides the productivity effect such as a scale effect, I also estimate a

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[39] The data set I use only covers manufacturing firms and all firms in the data set had output value and paid wages and input costs so none of these firms are "pure" trading intermediaries which do not produce but act as intermediaries between producers and foreign buyers. The export indicator is coded based on the firm's answer to the survey question: "Do you export (some of) your products" so it seems that the export dummy only captures the exporting of the products that firms actually produce. For this reason, I believe we can rule out the case that some exporters in the data are just trading intermediaries.

regression of export decision with both capital and TFP in the right-hand-side as a robustness

check. In the theoretical model, more productive firms are less likely to default when facing an

adverse export shock z_{it} since they can use their generated profits to overcome the liquidity

shocks. Thus, the model implies that more productive firms are more likely to survive to an older

age. Therefore, firm age is also included in the regression. It should be noted that for

simplification of the algebra, the chapter's theortical model assume a time-invariant productivity

to focus on the role of credit constraint. In the empirical estimation, I use estimates of TFP using

Levinsohn-Petrin (2003) method that allows for an exogenous evolution of firm's productivity

while still retaining the theoretical model's assumption that a firm makes choices based on its

TFP values.

   Lagged export status is included in the estimating equation to account for (1) the persistence

of exporting history due to the presence of large fixed cost in starting to export, which becomes

sunk cost once the firm enters into exporting, and (2) the role of lagged productivity on export

status. The presence of this sunk entry cost to enter foreign markets has been documented widely

in the trade literature such as in Roberts and Tybout (1997). In addition, the model in this chapter

predicts a positive relationship between export and productivity, which implies that lagged

export is also a proxy for lagged productivity. The industry and time dummies are added to

control for different characteristics between different industries, and macro factors that may

affect firms' export decisions such as changes in the exchange rate or macroeconomic condition.

The variables of interest in this chapter are the two indicators *Loan Constraint* and *Overdraft*

which are proxies for credit access (constraint). If a firm has *Loan Constraint* equal to one and/or

Overdraft equal to zero, the firm is more likely to be credit constrained.

According to this chapter's model as well as the empirical literature on firm export, such as Roberts and Tybout (1997), Bernard and Jensen (2004), Girma et al. (2004), and Nguyen and Ohta (2007), I expect the sign of the coefficients on lagged export status to be positive because of the presence of high sunk costs in entry into exporting. The coefficient of capital is expected to be positive since large firms may have advantage in activities such as setting up distribution network, and also because firm size is correlated with productivity. Since there are a large number of studies that model and document the selection of more productive firms into exporting (Melitz 2003; Manova 2008), the sign of the coefficient on TFP is expected to be positive if firm heterogeneity in productivity is not picked up entirely by the regressors capital or age. The sign of the coefficient on *LoanConstraint* is expected to be negative and the sign of the coefficient on *Overdraft* is expected to be positive since having a *LoanConstraint* equal to one or *Overdraft* equal to zero means that the firm is more likely to be credit constrained, which as predicted by the theoretical model would negatively affect the firm's export participation.

In order to obtain consistent estimates for the dynamic probit regression specified above, the following estimation issues need to be addressed. First, to deal with the "initial condition" problem present in a dynamic probit regression and the endogeneity of the lagged dependent variable on the RHS due to the presence of persistent unobserved heterogeneity, I use the Wooldridge (2005) method. Following Wooldridge (2005)'s suggestions, I model the unobserved time-invariant heterogeneity as a function of the initial value of the dependent variable and time-averages of all exogenous regressors.[40] This method also alleviate the

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[40] Wooldridge (2005) specifies a more general function form for the time-invariant unobserved firm heterogeneity as a function of the initial value of the dependent variable and all the past, and future values of all exogenous regressors (see Appendix A for more detailed explanation). However, this specification would place too much demand on the data for the Ghanaian data set so I choose to model the time-invariant unobserved heterogeneity as a special case of the Wooldridge's proposal: as a function of the initial value of the dependent variable and time-averages of all

endogeneity concern since it accounts for the correlation between the regressors and the time-invariant unobserved heterogeneity η_i by modeling η_i as a function of the initial value of the dependent variable and the time-averages of all exogenous regressors. Detailed information about this estimation method can be found in *Appendix A*.

Secondly, one may be concerned about the endogeneity of other regressors in the regression of export status. In my estimating equation, other regressors besides measures of credit access and TFP are capital, age and the weighted education of firms' management. Age is predetermined and it takes time to accumulate capital or increase education of firms' management. Therefore, I believe these regressors are not subject to simultaneity problem and thus, are not correlated with the contemporaneous component of the error term in the export regression equation. However, I also follow convention in empirical studies by using the lag of these regressors to alleviate potential simultaneity problem.

Thirdly, there may be reverse causation from export to TFP or from export to credit access, or simultaneity between export and TFP (or credit access). Since the TFP estimate obtained using the Levinsohn-Petrin (2003) method is a state variable, a contemporaneous shock that is unexpected by the firm will not be correlated with TFP so the endogeneity of TFP will not come from the correlation with the independent and identically distributed (i.i.d.) shock ε_{it} .[41] However, if there are persistent unobserved firm-specific characteristics that influence both export decision and TFP, then TFP will be endogenous. The Wooldridge (2005) method already alleviated this

exogenous regressors. This is also the approach that is used in many empirial studies using the Wooldridge (2005) method.

[41] For detailed explanation for why the TFP estimates obtained using the Levinsohn-Petrin (2003) method is not correlated with contemporaneous shock, see *Appendix B*.

problem of unobserved heterogeneity causing both higher productivity and export participation since the unobserved firm-specific component of the error term (μ_i) as a function of the export status in the first year of the sample, i.e. year 1991, and the time-averages of the exogenous regressors. To further alleviate the problem, I include additional control variables (all in lags to alleviate the simultaneity problem) that may capture some of the unobserved firm characteristics such as firm age and the weighted education of the firm's management. To address concerns about reverse causation from export to TFP or from export to credit access, or simultaneity between export and productivity, or whether TFP is affected by credit access, I conduct several robustness checks in Section VI (*Sensitivity Analyses*).

Under this approach, the estimating equation is:

$$
\begin{aligned}
Export_{it} = {} & \beta_0 + \beta_1 Export_{i,t-1} + \beta_2 \text{LoanConstraint}_{it} + \beta_3 Overdraft_{it} + \beta_4 X_{i,t-1} \\
& + \beta_5 S_{it} + \beta_6 D_t + \beta_6 \overline{X}_{i,t-1} + \beta_7 Export_{i0} + a_i + e_{it}
\end{aligned}
\tag{2.15}
$$

where $X_i = \dfrac{1}{T} \sum\limits_{t=1}^{t=T} X_{i,t-1}$ denotes the time-averages of $X_{i,t-1}$ for each firm i, $Export_{i0}$ is the export

status of firm i in year 1991. The error term consists of a firm-specific component (a_i) and an i.i.d component (e_{it}), a_i follows a normal distribution and follows the standard normal distribution $N(0,1)$. Both a_i and e_{it} are independent of all the regressors.

4.2.　Heterogeneous Effects of Credit Access on Export Propensity

To examine whether credit access is most important in export participation for firms in the intermediate range of productivity, I will estimate a linear probability model of exporting:

$$
Export_{it} = \alpha_0 + \alpha_1 Export_{i0} + \sum_{j=1}^{4} \alpha_2^j * \Delta OverdraftLoan_{it} * Q_i^j + \alpha_3 Capital_{i,t-1} + \varepsilon_{it}
\tag{2.16}
$$

In the specification above, Q_i^j are indicators that take the value of one if in the initial period of the data set, i.e. in the year 1991, firm i has TFP in quartile j of the distribution of firms' TFPs in 1991. Using the quartiles of TFP in 1991 reduces the endogeneity problem between TFP and the error term of the export equation. $Export_{i0}$ is the export status in year 1991, *OverdraftLoan* is the Overdraft-Loan indicator and Δ denotes first-differencing. While the above specification assumes no sunk costs of exporting, i.e. not including lagged exports, it is good as a suggestive test of whether the impact of access to credit on export propensity is different for firms in different ranges of TFP.[42]

V.   Estimation Results

1.   Estimation Results for Regression of Export Status

To check robustness of the estimation results for this regression, I estimate the regression equation without credit access measures and with credit access measures, using pooled probit that ignores the initial condition and unobserved heterogeneity, and using Wooldridge (2005) method for dynamic probit regression. Across all specifications, the role of access to overdraft facility, or having both access to overdraft facilities and having no loan constraint, are positively associated with higher export propensity.

The estimation results for the pooled probit without the measures of credit access (Table 2.8) indicate that lagged export and capital are statistically significant and positive, confirming the size effect and the existence of significant sunk costs in exporting. While these estimation results

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[42] The Arrelano and Bond (1991) and Blundell and Bond (1998) system GMM method can be used to estimate a dynamic linear probability model. It requires that the associated autocorrelation AR(2) test is insignificant. If the AR(2) test is significant, then lags of the dependent variable, which are used as a subset of the instruments, are endogenous and thus, are not valid instruments. The regression of the dynamic linear probability of export status does not pass the AR(2) test so I cannot estimate this estimating equation in its dynamic form but instead, choose to include the export status in period 1991 in the right-hand-side (RHS).

have not controlled for unobserved heterogeneity and thus, tend to overestimate the coefficient of

lagged exports, they suggest that firm size and past export history are important in determining

firms' export propensities. TFP is positively correlated with export decision but this effect

becomes insignificant when past export status is included in the regression. A possible reason for

why the effect of TFP goes away when the lagged export status is included is that the effect of

TFP on exporting has been picked up by lagged export.[43]

Table 2.9 and Table 2.10 present the regression results when credit access measures are

included. The coefficient of lag exports is statistically significant and positive across all

specifications, suggesting significant sunk costs of entry into exporting. Greater capital is

associated with higher export propensity but significant only in the most parsimonious

specification. The estimates of the coefficients on the *Overdraft* and *Overdraft-Loan Constraint*

are statistically significant and positive across all specifications. The coefficient of the *Loan*

Constraint variable is statistically insignificant but has the negative sign as predicted by the

model. Together, these results are consistent with the story that having access to overdraft

facilities increases the likelihood that a firm exports by providing working capital for firms that

want to export and as a backup source of liquidity in the event of adverse export shocks.

One reason that *Loan Constraint* is insignificant could be because most of the financing needs

for exporting are for working capital rather than financing of fixed assets for firms in Ghana.

This would be consistent with the exporting of labor-intensive products where firms that want to

export could do so without having to invest a lot in equipment and fixed assets. Another reason

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[43] This is consistent with the model's prediction that export status is a function of TFP, which means that lagged export status is a function of lagged TFP. Therefore, when both lagged export status and lagged TFP are included in the regression, the effect of TFP goes away. As noted in Section 4.1., the empirical estimation uses estimates of TFP using the Levinsohn-Petrin (2003) method that allows for an exogenous evolution of firm TFPs.

for the insignificant estimate of the coefficient on *Loan Constraint* is that bank loans are likely to include both short-term and long-term loans. Long-term loans are often used for financing investments that are not recurring yearly. For example, if a firm borrows this year to finance the building of a new plant or the purchase of a new machine, it will not need to incur these investments in the next year and so won't have needs for loans to cover these investments. Therefore, the value of Loan Constraint may depend on whether a firm has had investments in fixed assets recently. Unfortunately, the data set does not have information on the maturity of bank loans or information on whether the loan that a firm applied for was short-term or long-term loan. Without this information, I cannot separate the component of Loan Constraint that is due to short-term financing and the component of Loan Constraint that is due to long-term financing. To account for the infrequent needs of loans for investment relative to working capital, I also estimate regressions where the Loan Constraint variable in year t is replaced by the average of *Loan Constraint* between 1991 and year t.-1. As predicted by the theoretical model, this variable shows up as negatively correlated with export propensity in most specifications (see Table 2.11). This result suggests that constraint in access to bank loans also has negative impact on firms' export propensity.

Tables 2.12 and 2.13 present the estimation results using the Wooldridge (2005) method for dynamic probit regression. Since it is possible that credit access (constraint) variables are endogenous, I do not include the time-averages of the credit access variables in the regression because the Wooldridge (2005) method requires that the unobserved heterogeneity is modeled as a function of only exogenous variables and the initial value of the dependent variable. The results still confirm the positive effect of overdraft access and past export on a firm's export propensity. Across all specifications, access to overdraft facilities is found to be positively correlated with

export propensity. The results on the combined indicator *Overdraft-Loan Constraint* are similar.

In all regressions, the coefficient of capital is statistically insignificant, possibly because of a

high correlation between capital and its time-average, which leads to inefficient estimates of the

coefficient of capital. Initial condition does not seem to be a problem in firm's export status for

the Ghanaian data since the coefficients on the export status in the year 1991 are insignificant

across all regression specifications. There is significant unobserved heterogeneity as shown by

the statistically significant estimate of the coefficient of the time-average of TFP. This partly

explains why the coefficient of TFP shows up as insignificant. Also, it should be noted that

including TFP in the estimating equation of export participation is a crude test of the model's

assumption of self-section of most productive firms into exporting. First, the model predicts that

the effect of TFP on export status is non-linear. TFP only affects exporting decisions of firms

around the exporting productivity threshold. In addition, there are other factors that may affect a

firm's decision to export that would blur this classification of firm into exporting based on

productivity. The chapter's theoretical model, in fact, proposes one such factor, credit constraint.

In the model, the segmentation of firms into exporting is clear-cut and based solely on

productivity only if firms are not credit constrained. However, for credit constrained firms, the

productivity threshold for exporting depends on other factors such as the firm's internal funds

and collateral.

Table 2.19 presents the average partial effects (APE) estimates for the dynamic probit

regression of export status.[44] The results in column 1 show that averaged across all time periods

and firms, and controlling for unobserved heterogeneity, overdraft and loan access, capital, age,

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[44] Information about the calculation of the APEs for a dynamic probit regression can be found in *Appendix A*.

and education of firm's management, the probability that a firm exports in period t is 15.8

percentage points higher if the firm exported in year t-1. Access to overdraft increases the

probability of exporting by 7.6 percentage points. Column 2 presents similar results except that

only unobserved heterogeneity, capital, and overdraft and loan access are controlled for. In

addition, the APE for access to overdraft is about half the APE for lagged export, suggesting that

effect of access to overdraft is important in magnitude.

2.   Heterogeneous Effects of Credit Access

One of the predictions of this chapter's model is that credit access mostly affects firms that

are in the intermediate range of productivities. Intuitively, this is because the most productive

firms can generate enough internal funds from profits to finance export costs and the least

productive firms would not find it profitable to export even if they face no financing obstacles. I

use firms' TFP in year 1991 as a proxy for productivity. I then calculated the difference between

a firm's TFP in 1991 and the sector's average TFP in 1991, and then divided these productivity

differences into 4 quartiles (Q1-Q4). Because of this calculation, the regression sample only

includes firms that were in the survey in 1991 and thus, excludes firms that entered in later years.

However, the advantage of this approach is that it is much less likely that the quartiles of firm

productivity, calculated back in 1991, would correlate with current export shocks. I then estimate

the estimating equation in subsection 3.2 of section IV for the sample of firms from 1992-1997.

The magnitudes of the coefficient estimates of the interaction term between the change in

overdraft-loan access and the TFP quartile are largest for the second and third quartiles of TFPs,

and the estimate of this interaction term is statistically significant only for firms in the third

quartile of TFPs (see Table 2.14). In other words, the estimation results confirm the model's

predictions that only firms in the intermediate range of productivity levels are more likely to export when they have improved access to credit.

VI.   Sensitivity Analyses

1.   Examining the Endogeneity of Productivity

As mentioned above, because of the method used to calculate TFPs in this chapter, the TFP estimates are not correlated with contemporaneous export shocks and thus, they do not suffer from the simultaneity bias problem (see Section IV, 4.1). However, it is possible that productivity is endogenous due to reverse causation from exporting to productivity (learning-by-exporting). To investigate this concern, I have included estimation results for estimating equations with and without TFP on the RHS as presented above to see whether results are robust to the inclusion of TFP. I also use lagged TFP to alleviate the simultaneity problem. In addition, I also conducted two investigations to rule out the existence of reverse causation for the Ghanaian data set (Section 1.1 and 1.2).

1.1.   Estimate a regression of TFP against past export participation

If exporting leads to improvement in productivity, I expect the effect would not be in the same period but in the following period since it takes time for firms to learn from their exporting experience.[45] In other words, exporting in period t may lead to an increase in period $t+1$ but not in period t. To check whether there is this reverse causation from exporting to productivity, hereafter called learning-by-exporting, for the Ghanaian data set, I estimate a regression of TFP against past export participation alone and when additional regressors such as lagged TFP and

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[45] This assumption is widely adopted in the empirical literature that tests for the presence of learning-by-exporting such as De Loecker (2013), and several other studies surveyed in Wagner (2007).

lagged investment indicator are included. In all regression specifications, sector and time

dummies are included in the regression equation to control for sector-specific differences and

difference in the macroeconomic conditions across the years that may impact a firm's TFP. In all

regression specifications, the coefficient on lagged export status is insignificant. This result is

suggestive that reverse causation is not a severe problem with the data in this chapter (see Table

2.15).

1.2. Re-estimating TFP allowing for the possibility that exporting may affect future productivity

De Loecker (2013) argues that the TFP estimates from the Levinsohn-Petrin (2003) method

are derived based on the assumption of an exogenous evolution of firm productivity that does not

allow for the possibility that exporting may affect future productivity. He argues that in order to

test for learning-by-exporting, one should at least use TPF estimates derived from a framework

that directly allows past export experience to (potentially) affect firms' current productivity. To

illustrate De Loecker (2013)'s argument, recall that the motion equation for firm's TFP in Olley-

Pakes (1996) and Levinsohn-Petrin (2003) is as follows:

$$\omega_{it+1} = g_1(\omega_{it}) + \varepsilon_{it+1} \tag{2.17}$$

where $g_1(\omega_{it})$ is expected productivity given a firm's information set (which includes any

lagged choice variable of the firm) and ε_{it+1} is assumed to be uncorrelated with the information

set. In other words, a firm's productivity is comprised of the firm's expected productivity based

on its information set in the preceding period and an exogenous shock in the current period.

De Loecker (2013) points out that the equation above does not allow for the possibility that a firm's productivity is impacted by whether it has exported before. To remedy this, De Loecker proposes to model the productivity process as follows:

$$\omega_{it+1} = g_1(\omega_{it}, E_{it}) + \varepsilon_{it+1} \tag{2.18}$$

where E_{it} captures a firm's export experience such as an export dummy.

To account explicitly for possible reverse causation from past export participation to TFP (i.e., learning from exporting), I re-estimated firms' TFPs using the De Loecker (2013) method where g_1 is proxied by a cubic polynomial in productivity and export dummy. Then I regressed the estimated TFP against the variables in the proxy function for the motion equation of TFP, g_1. In other words, I regressed the estimated TFP against the one-period lag values of TFP, TFP squared, TFP cubed, export dummy and the interaction term between lagged export dummy and lags of TFP, TFP squared and TFP cubed. The regression results are presented in Table 2.16. If there is learning from exporting, I would expect the coefficient of the regressors that contain the lagged export dummy, i.e. the coefficient of lagged export dummy and the coefficients of the interaction terms between the lagged export dummy and TFP, TFP squared, TFP cubed, to be statistically significant. Since none of these four coefficients are statistically significant, I interpret the result as an indication that reverse causation from export to TFP is not present in the Ghanaian data set.

2.   Examining the Endogeneity of Credit Access Measures

2.1.   Examining whether there is reverse causation from past export to credit access

To check whether there is reverse causation from past export to credit access, I conducted propensity-score matching. Matching provides a good control group and eliminates endogeneity

bias caused by observable firm characteristics.[46] In matching, the treatment is the *Overdraft*

indicator, and the matching covariates include lagged export status and other factors that may

affect a firm's access to credit such as the size of a firm's network, age, the lag of the natural

logarithm of capital, and lagged export status. The outcomes are export variables in the next

period including export status, export intensity, percentage of the firm's output exported to other

African countries, and percentage of the firm's output exported to countries outside of Africa.

Since matching is data intensive and the size of the data sample is not large, it is hard to do a

rigorous matching. For example, when I control for industries in matching, the common support

(overlap) condition is not satisfied.[47] Therefore, the matching results presented below are only

suggestive. The average treatment effects on the treated (ATT) estimates for most export

outcomes (export status, export intensity for all export destinations, and export intensity for

export to countries outside of Africa) are all statistically significant and positive. Given that the

matching controls for lagged export status, i.e. controlling for the possibility that past export

affects access to overdraft, the matching results provide some confidence that the positive

relationship between access to overdraft and export status is not driven by reverse causation from

export to access to overdraft (see Table 2.17). Interestingly, the ATT for export intensity of

exports to countries in Africa is insignificant. This result points to a story of the important role of

overdraft in financing working capital for exporting. Exporting to outside Africa involves longer

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[46] Merits of matching method are discussed in Blundell and Costa Dias (2000). A number of empirical studies have applied matching in investigating the effects of export such as Girma et al. (2004), Greenaway et al. (2005), or Yasar and Rejesus (2005).

[47] For matching results to be valid, the common support (overlap) condition has to be satisfied. The common support condition states that for each value of the vector of matching covariates *X*, there is a positive probability of being both treated and untreated. Intuitively, if there is not much overlap, there are many treated observations that cannot be matched with observations in the control group that have similar characteristics. This means that counterfactual cannot be constructed for these observations and thus, renders matching results invalid. For more information on the common support (overlap) condition, see Heinrich et al. (2010), page 15-16.

shipping time and thus, tends to increase the lag time before the firm can receive payment for its export sales. This increases the firm's need for financing of working capital relative to the case of exporting to other African countries. Therefore, having access to overdraft facilities should impact the export intensity for exports to outside of Africa more than it impacts the export intensity for exports to countries within Africa.

Restricting the analysis to the subsample that includes only export starters, defined as firms that exported in year *t* but did not export in period *t*-1, would provide a robustness check since export starters all have not exported and so causation from exporting to credit access would not be present. However, as mentioned above, since the data set only has a limited numbers of firms, the sample of export starters is too small for reliable statistical analysis.

3.   Address the Concern that TFP is affected by Credit Constraint

There may be concern that credit constraint affects TFP. This would be a possibility if credit constraint prevents firms from investing in productivity-enhancement activities such as R&D. If this is the case, since productive firms self-select into exporting, my estimate of the impact of credit access (constraint) would be a conservative estimate since it does not include the dynamic effect of credit constraint which reduces TFP and thus, reduces export propensity through the selection effect channel.

To allow for the causation channel from credit constraint to TFP, I re-estimate the TFP under a framework that models the productivity evolution as a function of firm's current TFP and credit access. Specifically, the productivity process is assumed to be:

$$\omega_{it+1} = g_1(\omega_{it}, C_{it}) + \varepsilon_{it+1} \tag{2.19}$$

where ω is the TFP measure to be estimated, C_{it} is a measure of firms' credit access, ε_{it+1} is an i.i.d shock. In this estimation of TFP, I use the combined *Overdraft-Loan* access indicator as a proxy for firms' credit access, and use a cubic polynomial as a proxy for the function g_1. In essence, this is an approach that extends the Petrin-Levinsohn (2003) method to allow for an endogenous evolution process of TFP that may depend on a firm's credit access. This approach is similar to De Loecker (2013)'s approach except that De Loecker includes export experience while I include credit access in the motion equation for TFP

It should be noted that in order to obtain consistent estimates of the coefficient of the production function (and consequently firms' TFPs), the Levinsohn-Petrin (2003) method uses input demand as a proxy. The critical assumption for this method to work is that conditional on other state variables (which is just capital in Levinsohn-Petrin (2003) framework), input demand is monotonically increasing in productivity. Since I also use raw material in my estimation as a proxy, my estimation of TFP will only be valid if input demand is monotonically increasing in productivity conditional on capital and credit access. When the credit access indicator equals one, this assumption is likely to be valid since a firm with credit access is likely unconstrained in purchasing inputs and can purchase the amount of inputs needed for first-best output level. This output level is monotonically increasing in the firm's productivity. Therefore, the input demand is also monotonically increasing in the firm's productivity for firms with access to credit. However, the monotonic relationship between a firm's productivity and its input usage may break down for firms without credit access when credit access does not depend on only productivity but other factors. However, this test is still a good robustness check to see whether credit constraint affects firm's TFP.

To test whether credit access affects the evolution of TFP, I regressed the *TFP* estimated under the above framework against all the terms in the polynomial g_1, i.e. the lags of *TFP*, of TFP squared, of TFP cubed, the lag of *Overdraft-Loan,* and the interaction between the lag of *Overdraft-Loan* and the former *TFP* terms. If credit constraint had important impact on TFP evolution in the Ghana data set, I would expect at least one of the coefficients of the regressors that contain lag of Overdraft-Loan to be statistically significant. Since these coefficients are not statistically significant (see Table 2.18.1), I interpret the result to suggest that credit access does not influence the evolution of TFP in this case.[48]

4.   Other Robustness Checks

For a robustness check, I also use firm size categories instead of capital in the regression of firm's export. The firm size categories are defined based on the World Bank's guideline where medium firms are firms with employment between 50 and 100 workers, and large firms employ more than 100 workers. For a robustness check, I also use another firm size categorization by using an indicator of large firm, where the indicator takes value of one if a firm has more than 50 workers. Since the estimation results are still qualitatively the same as when using capital as a regressor, I do not include the regression results with separate categories of firm size here.

VII.   Conclusion

This chapter looks at a potential obstacle to exporting: access to credit. In the chapter, I built a theoretical model of firms that are heterogeneous in productivity, internal funds, and collateral with endogenous borrowing lending and borrowing. The model predicts that credit constraint has a negative impact on firms' export propensity. More importantly, credit constraint diminishes the

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[48] The correlation between different TFP measures can be found in Table 2.18.2

selection of productive firms into exporting markets. This is because less productive firms are able to enter the market due to having higher internal funds or collateral, while more productive firms with less financial or collateral resources must stay domestic. Thus, the model implies that trade liberalization without improving the financial system would result in smaller gains from trade.

The empirical section of the chapter looks at the two main types of bank financing in Ghana: bank loans and overdraft. While access to bank loans has been widely studied, access to overdraft has received little study. Yet, overdraft has been documented to be a popular bank financial instrument for firms in Ghana and some other developing countries, such as Kenya (Fafchamps et al. 1994). I find that overdraft has a significant impact on firms' export propensity and access to bank loans does not. This result is robust to many different sensitivity analyses. Since overdraft is used by firms in Ghana to cover working capital, the empirical result suggests that having access to overdraft enables firms to finance working capital and thus, increases their likelihood to export. The effect of access to bank overdraft is heterogeneous: access to overdraft increases firms' export propensity but only for firms in the intermediate range of productivity (the third quartile of TFP distribution). While my empirical estimation indicates that the impact of access to bank loans is insignificant, it does not necessarily imply that access to bank loans is unimportant for exporting. Rather, given the context of Ghana where banks are very reluctant to give out long-term loans and the small number of firms in the data set that obtained bank loans, it could be that there is too little variation in the data for the statistical analysis to distinguish the effect of access to loans. I also find that besides the conventional factors that affect a firm's access to credit, such as firm size, age and location, there is evidence for the existence of

relationship-based lending as network is found to have a positive effect on firm's access to overdraft.

While this chapter only looks at the static effect of credit access on firms' export decisions, it is quite possible that the effects of credit constraint would be even larger if there is a positive feedback between exporting and firms' performance. Future research could look into this dynamic impact of credit constraint in other economies. Another interesting research direction, conditional on more data availability, is to look at the cost components of exporting and break these down into different types of costs that are funded with different financial instruments. If financing these costs components has a different degree of importance to the firm's ability to export, access to different types of financial instruments would also have a different level of importance to the firm's exporting. Another focus of future research would be to evaluate the relative importance of credit constraint and other potential obstacles to exporting.

Table 2.1.1 – Ghana Macroeconomics Statistics

	1991	1992	1993	1994	1995	1996	1997
Exports of goods and services (% of GDP)	17	17	20	25	24	32	32
GDP growth (annual %)	5	4	5	3	4	5	4
Industry, value added (% of GDP)	17	17	25	25	24	24	26
Domestic credit to private sector by banks (% of GDP)	3.66	4.94	4.84	5.25	5.07	6.01	8.20
Listed domestic companies, total	13	15	15	17	19	21	21
Deposit interest rate (%)	21.32	16.32	23.63	23.15	28.73	34.50	35.76

Sources: The Centre for the Study of African Economies at Oxford University (CSAE), and World Bank Indicator database.

Table 2.1.2 – Sample Sizes

	Continuous	Dormant	Exit	Lost	Uncooperative	Total
Number of firms	191 (a)	4	34	5	19	253
Number of firms with						
7 waves of data	106	0	0	0	0	106
6 waves of data	16	0	0	0	0	16
5 waves of data	8	0	13	1	0	22
4 waves of data	29	0	3	0	3	35
3 waves of data	4	3	5	1	1	14
2 waves of data	27	1	6	1	9	44
1 wave of data	1	0	7	2	6	16

Notes: Data come from http://www.csae.ox.ac.uk/datasets/Ghana-rped/docs/datanotes.pdf. The data in the table are from the original data set before cleaning up.

Table 2.2 – Definitions of Regression Variables

Variable Name	Definition
Export	An Indicator of firm's export status which takes a value of one if the firm exports and zero if the firm does not export in the year.
Capital	Firm's physical capital stock
Overdraft	An indicator that takes value of one if a firm has overdraft facilities with banks in the year
Loan Constraint	An indicator that takes value of one if a firm is quantity rationed, risk-rationed or transaction-cost rationed. Firms that are quantity rationed are either those that applied for a formal loan and were rejected or those that did not apply for a loan because of one or a combination of the following reasons: inadequate collateral, the firm did not think it would get a loan, or the firm was already heavily indebted. Firms that are transaction-cost rationed are those that did not apply for a loan because "the process was too difficult". Firms that are risk rationed are those that did not apply for a loan because they did not want to incur debt.
Overdraft-Loan	An indicator that takes value of one if *Overdraft*=1 and *Loan Constraint*=0
TFP	Firm's total productivity factor obtained using the Levinsohn-Petrin (2003) method[49]
Management Education	Weighted average education of a firm's management

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[49] More information about the Levinsohn-Petrin (2003) method for calculating firms' TFPs can be found in *Appendix B*. Note that TFP can also be estimated using the Olley and Pakes (1996) method. However, this method restricts the sample to only firms with positive investments. Since the number of firms with missing or zero investments is substantial in the sample while the number of firms with missing raw material costs is close to zero, I choose to use the Levinsohn-Petrin method.

Table 2.3 – Descriptive Statistics for Key Variables (1991-1997)

	Mean	Standard Deviation
Export	0.12	0.32
Overdraft	0.23	0.42
Loan Constraint	0.45	0.5
Overdraft-Loan	0.19	0.39
Capital (million US dollars)	257	1450
Log of Capital	15.59	2.88
Log of TFP	11.05	1.36
Firm Age	16.37	11.72
Log of Firm Age	2.53	0.8
Education of Firm's Management	14.47	1.82

Notes: N=740. Capital, TFP are in 1991 US dollars.

Table 2.4.1 – Correlation of Key Variables

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Export	1								
Lag Export	0.6954	1							
Overdraft	0.3373	0.2643	1						
Loan Constraint	-0.1101	-0.1521	-0.2465	1					
Overdraft-Loan	0.2807	2.22E-01	0.8614	-0.4143	1				
Capital	0.357	0.3584	0.5412	-0.3174	0.5243	1			
TFP	0.2517	0.2653	0.45	-0.2498	0.4137	0.4776	1		
Age	0.105	0.0987	0.1895	-0.0934	0.1563	0.2923	0.2428	1	
Management Education	0.0458	0.0039	0.1249	-0.0537	0.1327	0.1436	0.0774	0.076	1

Notes: Capital, TFP are in logarithm, and lagged. Age is in logarithm, and Management Education is lagged.

Table 2.4.2 – Correlation of Regression Variables and their Time-Averages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Export	1							
Export in 1991	0.5151	1						
Capital (K)	0.357	0.4328	1					
Average of K	0.3673	0.4312	0.9977	1				
TFP	0.2634	0.2447	0.4723	0.4752	1			
Average of TFP	0.3131	0.3028	0.5839	0.5794	0.7961	1		
Education of Management (Education)	0.0124	0.0194	0.1189	0.1081	0.0772	0.1129	1	
Average of Education	0.0898	0.0471	0.2749	0.2691	0.1944	0.2334	0.471	1

Notes: Capital, TFP are in logarithm, and lagged. Age is in logarithm, and Management Education is lagged. Average refers to time-averages of the variable for each firm.

Table 2.5 – Reasons for Not Applying for a Loan

Reasons	Percentage
Inadequate collateral	9.47
Do not want to incur debt	6.83
Process too difficult	10.79
Did not think need a loan	25.33
Did not think the firm would get a loan	25.55
Interest rate too high	12.78
Already heavily indebted	1.76
Other	7.49

Notes: N=642. Percentage is out of the number of firms that gave reasons why they did not apply for loan.

Table 2.6.1 – Determinants of Access to Overdraft

	(1) Overdraft b/se	(2) Overdraft b/se
Capital	0.207***	0.203***
	(0.04)	(0.05)
Age	0.303*	0.384**
	(0.12)	(0.13)
Raw Material Costs per Worker	0.197*	0.260**
	(0.09)	(0.10)
TFP	0.168	
	(0.09)	
Limited Liability Company	0.006	0.078
	(0.22)	(0.23)
Accra	-1.350**	-1.482***
	(0.42)	(0.43)
Kumasi	-1.210**	-1.308**
	(0.42)	(0.43)
Takoradi	-0.903	-1.045*
	(0.49)	(0.50)
Network Size	0.006**	0.005*
	(0.00)	(0.00)
Value Added per Worker		0.143
		(0.10)
Constant	-8.547***	-9.469***
	(1.30)	(1.42)
N	485	468

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Sector and year dummies are included in all regressions. The excluded region is Cape Coast. Capital, TFP, raw material costs per worker, and value added per worker are lagged, and in logarithms. Firm age is in logarithms.

Table 2.6.2 – Determinants of Access to Both Overdraft and Loan

	(1) Overdraft-Loan b/se	(2) Overdraft-Loan b/se
Capital	0.225***	0.236***
	(0.05)	(0.05)
Age	0.387**	0.435**
	(0.13)	(0.13)
Raw Material Costs per Worker	0.151	0.251*
	(0.10)	(0.10)
TFP	0.145	
	(0.09)	
Limited Liability Company	0.001	0.020
	(0.24)	(0.24)
Accra	-0.856	-0.884
	(0.48)	(0.49)
Kumasi	-0.619	-0.654
	(0.48)	(0.49)
Takoradi	-0.713	-0.735
	(0.55)	(0.56)
Network Size	0.005*	0.004*
	(0.00)	(0.00)
Value Added per Worker		0.047
		(0.10)
Constant	-9.140***	-9.771***
	(1.40)	(1.49)
N	485	468

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Sector and year dummies are included in all regressions. The excluded region is Cape Coast. Capital, TFP, raw material costs per worker, and value added per worker are lagged, and in logarithms. Firm age is in logarithms.

Table 2.7 – Determinants of Loan Constraint

	(1) Loan Constraint b/se	(2) Loan Constraint b/se
Physical Capital	-0.146*	-0.130*
	(0.06)	(0.07)
Age	-0.167	-0.198
	(0.18)	(0.18)
Raw Material Costs per Worker	0.123	0.097
	(0.09)	(0.10)
TFP	-0.301**	
	(0.09)	
Limited Liability Company	-0.418	-0.466
	(0.35)	(0.36)
Accra	0.704	0.788
	(0.82)	(0.83)
Kumasi	1.332	1.453
	(0.82)	(0.83)
Takoradi	0.693	0.828
	(0.91)	(0.93)
Network Size	-0.002	-0.001
	(0.00)	(0.00)
Value Added per Worker		-0.259**
		(0.10)
Constant	3.273*	3.370*
	(1.60)	(1.64)
N	588	569

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Sector and year dummies are included in all regressions. The excluded region is Cape Coast. Capital, TFP, raw material costs per worker, and value added per worker are lagged, and in logarithms. Firm age is in logarithms.

Table 2.8 – Regression of Export Status without Credit Access Variables (Pooled Probit)

	(1) Export b/se	(2) Export b/se	(3) Export b/se	(4) Export b/se	(5) Export b/se	(6) Export b/se
Physical Capital	0.187***	0.149**	0.120**	0.103*	0.118**	0.103*
	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.05)
TFP		0.209*		0.091		0.093
		(0.10)		(0.09)		(0.08)
Lagged Export			2.026***	2.044***	2.036***	2.052***
			(0.20)	(0.20)	(0.21)	(0.21)
Age					0.006	-0.015
					(0.12)	(0.12)
Management Education					0.015	0.016
					(0.04)	(0.05)
Constant	-4.044***	-5.803***	-3.415***	-4.189***	-3.633***	-4.401***
	(0.98)	(1.31)	(0.76)	(1.02)	(0.94)	(1.13)
Observations	740	737	740	737	740	737

Notes: $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. Capital, TFP are lagged, and in logarithms. Age is in logarithm and Management Education is lagged. Sector and year dummies are included in all regressions. Standard errors are clustered by firm.

Table 2.9 – Regression of Export Status with *Overdraft* and *Loan Constraint* Indicators –

Pooled Probit Estimation

	(1) Export b/se	(2) Export b/se	(3) Export b/se	(4) Export b/se	(5) Export b/se	(6) Export b/se
Physical Capital	0.103*	0.091	0.043	0.045	0.043	0.046
	(0.05)	(0.05)	(0.04)	(0.04)	(0.04)	(0.04)
Overdraft	0.786***	0.676**	0.812***	0.782***	0.811***	0.781***
	(0.22)	(0.21)	(0.23)	(0.23)	(0.23)	(0.23)
Loan Constraint	-0.216	-0.162	-0.060	-0.014	-0.061	-0.015
	(0.23)	(0.23)	(0.24)	(0.24)	(0.23)	(0.24)
TFP		0.132		0.012		0.014
		(0.10)		(0.09)		(0.09)
Lagged Export			2.038***	2.091***	2.044***	2.094***
			(0.21)	(0.20)	(0.22)	(0.21)
Age					-0.009	-0.029
					(0.13)	(0.13)
Management Education					0.010	0.008
					(0.05)	(0.05)
Constant	-2.828**	-4.115***	-2.399***	-2.596*	-2.529*	-2.671*
	(0.87)	(1.24)	(0.72)	(1.04)	(1.02)	(1.19)
Observations	740	737	740	737	740	737

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Capital, TFP are lagged, and in logarithms. Age is in logarithm and Management Education is lagged. Sector and year dummies are included in all regressions. Standard errors are clustered by firm.

**Table 2.10 – Regression of Export Status with Overdraft-Loan Constraint Indicator –
Pooled Probit Estimation**

	(1) Export b/se	(2) Export b/se	(3) Export b/se	(4) Export b/se	(5) Export b/se	(6) Export b/se
Physical Capital	0.121*	0.103	0.052	0.049	0.050	0.049
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Overdraft-Loan Constraint	0.760**	0.649**	0.784**	0.763**	0.783**	0.761**
	(0.24)	(0.22)	(0.26)	(0.26)	(0.26)	(0.26)
TFP		0.151		0.019		0.020
		(0.09)		(0.08)		(0.08)
Lagged Export			2.046***	2.092***	2.053***	2.096***
			(0.21)	(0.20)	(0.21)	(0.21)
Age					0.013	-0.008
					(0.13)	(0.13)
Management Education					0.010	0.008
					(0.05)	(0.05)
Constant	-3.164**	-4.547***	-2.532**	-2.717**	-2.681**	-2.831*
	(0.97)	(1.24)	(0.78)	(1.02)	(0.98)	(1.12)
Observations	740	737	740	737	740	737

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Capital, TFP are lagged, and in logarithms. Age is in logarithm and Management Education is lagged. Sector and year dummies are included in all regressions. Standard errors are clustered by firm.

Table 2.11 – Regression of Export Status with Lag of Time-Average of Loan Constraint – Pooled Probit Estimation

	(1) Export b/se	(2) Export b/se	(3) Export b/se	(4) Export b/se	(5) Export b/se	(6) Export b/se
Export						
Physical Capital	0.102*	0.091	0.036	0.040	0.035	0.041
	(0.05)	(0.05)	(0.04)	(0.05)	(0.04)	(0.05)
Overdraft	0.752***	0.661**	0.763***	0.749**	0.761***	0.747**
	(0.22)	(0.21)	(0.23)	(0.23)	(0.23)	(0.23)
Lagged Time-Average of Loan Constraint	-0.772*	-0.708	-0.676*	-0.623*	-0.678*	-0.622*
	(0.36)	(0.37)	(0.30)	(0.30)	(0.30)	(0.31)
TFP		0.102		-0.019		-0.017
		(0.09)		(0.08)		(0.08)
Lagged Export			2.029***	2.081***	2.037***	2.086***
			(0.21)	(0.20)	(0.21)	(0.20)
Age					0.001	-0.016
					(0.13)	(0.13)
Management Education					0.013	0.010
					(0.05)	(0.05)
Constant	-2.621**	-3.595**	-2.082**	-1.964*	-2.256*	-2.091
	(0.92)	(1.11)	(0.76)	(0.99)	(1.04)	(1.15)
Observations	740	737	740	737	740	737

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Capital, TFP are lagged, and in logarithms. Age is in logarithm and Management Education is lagged. Sector and year dummies are included in all regressions. Standard errors are clustered by firm.

Table 2.12 – Estimation of the Dynamic Probit Regression with Overdraft and Loan Constraint Indicator

	(1) Export b/se	(2) Export b/se	(3) Export b/se	(4) Export b/se
Lagged Export	1.422***	1.514***	1.416***	1.495***
	(0.33)	(0.34)	(0.33)	(0.34)
Physical Capital	-0.299	-0.234	-0.296	-0.247
	(0.64)	(0.64)	(0.66)	(0.67)
Overdraft	1.042**	0.913**	1.061**	0.942**
	(0.33)	(0.35)	(0.34)	(0.36)
Loan Constraint	0.172	0.177	0.176	0.200
	(0.31)	(0.32)	(0.31)	(0.33)
Export in 1991	0.263	0.197	0.248	0.188
	(0.55)	(0.56)	(0.55)	(0.56)
Average of Physical Capital	0.455	0.333	0.455	0.353
	(0.66)	(0.66)	(0.68)	(0.69)
TFP		-0.295		-0.303
		(0.16)		(0.17)
Average of TFP		0.711*		0.749*
		(0.31)		(0.32)
Age			0.094	0.054
			(0.26)	(0.26)
Management Education			0.015	-0.007
			(0.06)	(0.07)
Average of Management Education			-0.187	-0.263
			(0.22)	(0.23)
Constant	-4.904**	-8.791**	-2.742	-5.534
	(1.74)	(3.23)	(3.28)	(4.01)
lnsig2u	0.202	0.196	0.222	0.218
	(0.61)	(0.64)	(0.61)	(0.65)
Observations	740	737	740	737

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Capital, TFP are lagged, and in logarithms. Age is in logarithm and Management Education is lagged. Average refers to time-averages of the variable for each firm. Sector and year dummies are included in all regressions. Standard errors are clustered by firm.

Table 2.13 – Estimation of the Dynamic Probit with Overdraft-Loan Constraint Indicator

	(1) Export b/se	(2) Export b/se	(3) Export b/se	(4) Export b/se
Lagged Export	1.427***	1.502***	1.427***	1.488***
	(0.32)	(0.33)	(0.33)	(0.33)
Physical Capital	-0.214	-0.182	-0.212	-0.197
	(0.62)	(0.64)	(0.65)	(0.66)
Overdraft-Loan Constraint	0.835**	0.768*	0.867**	0.801*
	(0.31)	(0.33)	(0.32)	(0.34)
Export in 1991	0.340	0.288	0.325	0.276
	(0.51)	(0.54)	(0.51)	(0.54)
Average of Physical Capital	0.361	0.274	0.359	0.293
	(0.64)	(0.65)	(0.66)	(0.68)
TFP		-0.289		-0.296
		(0.16)		(0.16)
Average of TFP		0.698*		0.727*
		(0.29)		(0.30)
Age			0.096	0.061
			(0.24)	(0.25)
Management Education			0.019	-0.005
			(0.06)	(0.06)
Average of Management Education			-0.180	-0.246
			(0.21)	(0.22)
Constant	-4.576**	-8.470**	-2.537	-5.356
	(1.52)	(2.95)	(3.01)	(3.77)
lnsig2u				
Constant	0.016	0.088	0.030	0.099
	(0.61)	(0.63)	(0.61)	(0.63)
Observations	740	737	740	737

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Capital, TFP are in logarithm, and lagged. Age is in logarithm and Management Education is lagged. Average refers to time-averages of the variable for each firm. Sector and year dummies are included in all regressions. Standard errors are clustered by firm.

Table 2.14 – Heterogeneous Effects of Access to Credit

	(1) Export b/se
Export in 1991	0.203^{**}
	(0.06)
Physical Capital	0.021^{**}
	(0.01)
ΔOverdraftloan*Q_1	0.010
	(0.07)
ΔOverdraftloan*Q_2	0.076
	(0.06)
ΔOverdraftloan*Q_3	0.080^{*}
	(0.04)
ΔOverdraftloan*Q_4	0.006
	(0.03)
Constant	-0.221
	(0.12)
N	740

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Capital is in logarithm, and lagged. ΔOverdraftloan is the change in the value of Overdraft-Loan indicator between wave 2 and wave 1. Q1, Q2, Q3 and Q4 are dummies referring to the first, second, third and fourth quartiles of firms' TFPs in the year 1991. Sector and year dummies are included in all regressions. Standard errors are clustered by firm.

Table 2.15 – Checking Reverse Causation from Lagged Export status to TFP

	(1) TFP (log) b/se	(2) TFP (log) b/se	(3) TFP (log) b/se	(4) TFP (log) b/se
Lagged Export	0.042	0.229	0.045	0.209
	(0.16)	(0.14)	(0.16)	(0.14)
Lag of Logarithm of TFP		0.625***		0.606***
		(0.08)		(0.08)
Lag of Investment Indicator			0.039	0.154
			(0.08)	(0.11)
Constant	10.956***	4.236***	10.903***	4.401***
	(0.08)	(0.87)	(0.10)	(0.85)
Observations	737	737	737	737
AR(2) (p-value)		0.511		0.480
Sargan (p-value)		0.214		0.140
Hansen (p-value)		0.171		0.280

Notes: $^{*}\,p < 0.05$, $^{**}\,p < 0.01$, $^{***}\,p < 0.001$. Investment Indicator is an indicator of whether the firm invested in plant or equipment. Columns 1 and 3 are fixed-effect estimations. Columns 2 and 4 are Arellano-Bond's GMM estimates of the dynamic linear regression. Standard errors are clustered by firm. AR(2) is the Arellano and Bond test of second order autocorrelation. Sargan (p-value) and Hansen (p-value) is the p-value of the Sargan and Hansen tests of overidentification restrictions.

Table 2.16 – Checking Reverse Causation from Lagged Export status to TFP (Continued) – Regression of TFP According to the Fitted Evolution Equation of TFP

	(1) TFP_NP b/se
Lag of TFP_NP	1.979***
	(0.18)
Lag of TFP_NP squared	-0.196***
	(0.04)
Lag of TFP_NP cubed	0.009***
	(0.00)
Lag of Export	7.820
	(14.21)
Lag of TFP_NP * Lag of Export	-3.730
	(5.36)
Lag of TFP_NP squared * Lag of Export	0.551
	(0.67)
Lag of TFP_NP cubed * Lag of Export	-0.026
	(0.03)
Observations	624

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Sector and year dummies are included in all regressions. TFP_NP is the estimates of TFP where the motion equation for TFP is a cubic polynomial of TFP and export status.

Table 2.17 – Propensity Score Matching – Treatment is Access to Overdraft in 1995

	(1) Export Status in 1995 b/se	(2) Exports to African countries in 1995 (% of output) b/se	(3) Exports to countries outside Africa in 1995(% of output) b/se	(4) Export Intensity in 1995 (% of output) b/se
ATT				
	0.194*	1.500	7.667*	9.166**
	(0.09)	(0.79)	(3.05)	(3.09)
Observations	135	135	135	135

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. ATT is average treatment effects on the treated. Matching Covariates are lagged export status, capital, firm age, and number of bank officials who are in the firm's network in year 1994.

Table 2.18.1 – Checking Whether Credit Constraint Affects TFP – Regression of TFP According to a Fitted Evolution Equation of TFP where Credit Access is Included in the Motion Equation of TFP

	(1) TFP_CC b/se
Lag of TFP_CC	2.064***
	(0.22)
Lag of TFP_CC squared	-0.192***
	(0.05)
Lag of TFP_CC cubed	0.008**
	(0.00)
Lag of Overdraft-Loan Dummy	30.542
	(43.48)
Lag of TFP_CC* Lag of Overdraft-Loan	-10.860
	(14.00)
Lag of TFP_CC squared*Lag of Overdraft-Loan	1.243
	(1.49)
Lag of TFP_CC cubed*Lag of Overdraft-Loan	-0.046
	(0.05)
Observations	624

Notes: $^{*} p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$. Sector and year dummies are included in all regressions. TFP_CC is the estimates of TFP where the motion equation for TFP is a cubic polynomial of TFP and the Overdraft-Loan indicator.

Table 2.18.2 – Correlation between TFP Estimates

	TFP	TFP_NP	TFP_CC
TFP	1		
TFP_NP	0.6691	1	
TFP_CC	0.8566	0.8848	1

Notes: TFP is calculated using Levinsohn-Petrin (2003) method. TFP_NP is calculated using De Loecker (2013) approach by modeling the motion equation for TFP as a cubic polynomial of lagged TFP and lagged export status. TFP_CC is calculated by modeling the motion equation for TFP as a cubic polynomial of lagged TFP and lagged Overdraft-Loan.

Table 2.19 – Average Partial Effects (APEs) for the Dynamic Probit Regression of Export Status

	(1) APE b/se	(2) APE b/se
Lagged Export	0.158*	0.161*
	(0.067)	(0.072)
Loan Constraint	0.014	0.013
	(0.027)	(0.025)
Overdraft	0.076*	0.093*
	(0.033)	(0.037)
Capital	-0.012	-0.016
	(0.033)	(0.026)
Observations	737	740

Notes: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. Capital is in logarithm, and lagged. Column 1 is estimation of the dynamic probit regression that includes lagged Export, Loan Constraint, Overdraft, Capital, TFP, Firm Age, and Management Education. Column 2 is estimation of the dynamic probit regression that includes lagged Export, Loan Constraint, Overdraft, and Capital. Reported standard errors are panel bootstrap standard errors with 500 replications.

Figure 2.1 – Exporting Decision as a Function of Firm's Productivity and Liquidity
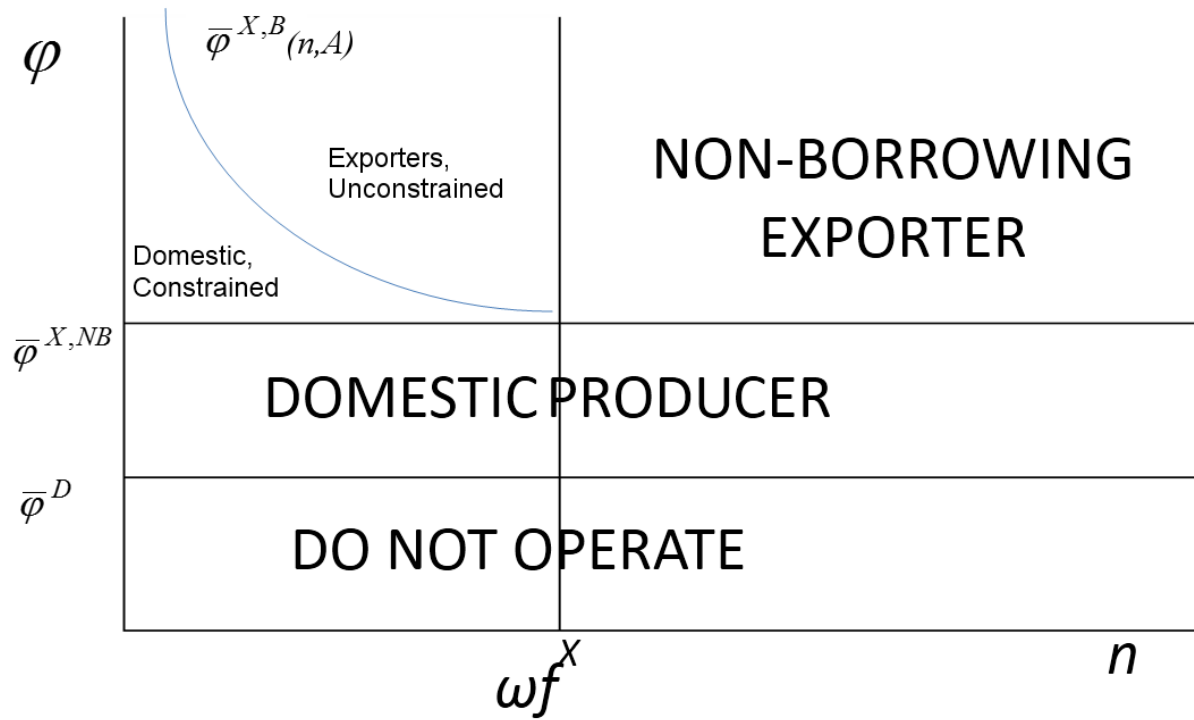
CHAPTER 3

Innovation and Credit Constraints – Evidence from a Survey of Vietnamese Small and Medium Enterprises

I.   Introduction

Innovation in the private sector has been an area of high interest both for policy makers and for the business community in developing countries. At the macro level, several studies have pointed out the importance of cross-country differences in TFP in explaining the difference in the growth rates of GDP per capita across countries. For example, Klenow and Rodriguez-Clare (1997) and Easterly and Levine (2002) find that growth in TFP accounts for about 90% of the cross-country growth differences. At the micro level, innovation has been considered as one of the important factors that affect the growth in firms' productivity. Since rising productivity in the private sector is one of the factors that drive the growth of the economy, it is important to understand what factors hinder a firm's innovation and consequently, the improvement in its productivity levels.

This paper looks at one of the potential obstacles to firms' innovation: the credit constraint that innovating firms face. Innovating firms may face tighter credit constraint for various reasons. First, the fixed costs of innovation are often so high that many firms need to obtain external financing to fund their innovative activities. The need for external financing of innovative activities is likely to be even higher in developing countries, where firms are more

likely to lack sufficient internal funds needed to finance innovative projects. Secondly, among the various activities of firms that may need external financing, innovation is one that has more acute problems of adverse selection and moral hazard. There is a larger gap between a firm's knowledge and the lender's knowledge of the likelihood of success of a firm's innovation project. In addition, it is more difficult for lenders to monitor effectively the firm's research projects since a large portion of investment in innovation goes into intangible assets such as the specialized knowledge of the firm's researchers and skilled workforce. Thirdly, innovation is a risky activity that involves a high level of uncertainty. Finally, the costs of innovative projects must be covered upfront, while the returns on these investments may take a long time to be realized.

To highlight the tighter credit constraints that innovating firms face, I build a theoretical model that extends the Melitz (2003) model of heterogeneous firms by adding the bank's lending decision and focuses on firms' innovation decisions. In addition, my model features two explanations for why innovating firms may face tighter credit-constraint than non-innovating firms: the longer time innovation projects take to become profitable and the higher risk of these projects. To test the theoretical predictions, empirical estimations are conducted using a panel data set of Vietnamese small and medium enterprises.

Two key assumptions about the bank's lending process are made in my theoretical model. First, the bank cannot observe a firm's productivity. Secondly, the bank cannot verify whether the firm will use the loan for innovation or for other activities. These assumptions are realistic in the context of the Vietnamese economy. As the stock market and credit rating agencies are not

well developed in Vietnam[50] and the business environment is still immature and rapidly

changing, banks face a much more acute problem of asymmetric information where it is a

challenge for the banks to determine the true profitability of the firm that applies for a loan.[51]

Moral hazard is still prevalent due to little regulatory oversight, and the "absence of a well-

established legal infrastructure, contracting and property norms" (Nguyen et al. 2006).

Under these two key assumptions, my model predicts that more productive firms have higher

interest payments on formal loans and that innovating firms are more credit constrained. These

predictions are supported by the empirical testing on panel data of Vietnamese small and

medium enterprises (SMEs). The study of the impact of credit constraint on Vietnamese SMEs'

innovation is of particular interest because of the rapid growth of the Vietnamese economy and

the important role of the Vietnamese SMEs in driving that growth. Since 2000, the Vietnamese

private sector has grown rapidly. Between 2000 and 2002, 55,793 new enterprises were

established compared to less than 45,000 "in the nine-year period preceding 2000" (Nguyen et al.

2006). However, the Vietnamese banking sector is still relatively underdeveloped,[52] and

Vietnamese SMEs still cite financing and insufficient access to land as major obstacles (Nguyen

et al. 2006). Since small and medium scale enterprises comprise the majority of Vietnamese

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[50] Descriptive statistics on Vietnam's stock market in 2003 yields market capitalization/GDP of 0.4% and market liquidity of 0.08% (Malesky and Taussig 2008).

[51] Nguyen et al. (2006) surveyed bank officials in Vietnam about how they made their lending decisions. Their interview results highlight significant uncertainties that Vietnamese banks face when lending to private businesses. According to the authors, in the context of the Vietnamese economy, "data on private firms and the general business environment in which they function tend to be unavailable or unreliable. Furthermore, most banks and firms are newly established, and they have little history of working with each other. Thus, conventional risk management techniques (for banks), such as credit scoring or pricing for risks, are of limited use."

[52] According to Nguyen et al. (2006), up to 2006, "there are five state-owned commercial banks, 34 private (or joint stock) banks, four joint venture banks, and 28 branches of foreign banks operating in Vietnam."

private firms, studying how credit constraint affects innovation and ultimately, the competitiveness of SMEs is important for Vietnamese economic growth.

In the empirical application, I estimate a baseline regression equation derived from the theoretical model and obtain estimation results that support the predictions of the theoretical model that credit constraint has a negative impact on firms' revenues and profits and that innovating firms face tighter credit constraints. In addition to the estimation of the baseline regression, endogenous switching models, matching and a regression in the reverse direction are also estimated to account for the endogeneity of the interest payments per worker and the innovation indicator, and to check for possible reverse causation. The estimation results from these robustness checks also confirm a statistically significant and negative impact of credit constraint on firms' revenues and profits.

II.   Literature Review

The literature of the importance of financing constraint on firm investment, research and development expenditure (R&D), and recently, on firm's innovation has been more abundant regarding to firms in developed countries than to firms in developing countries. In the context of firms in developed countries, there has been a large empirical literature testing the impact of liquidity constraint on firms' investment and performance. There are two traditional approaches in this branch of the literature. The first approach is to test whether a firm's investment decision is sensitive to its cash flow. One of the pioneer studies in this literature is Fazzari et al. (1988). Studies using this approach usually add cash flow and the firm's marginal (or average) Q value to the regression of the firm's investment. The Q value is used as a proxy for the firm's investment opportunities. The cash flow is added to test for the presence of the financing

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constraint. The logic behind this approach is that if the credit market is perfect, cash flow should not affect firms' investment decisions. However, if problems of asymmetric information or contract enforcement exist, the costs of external financing will be higher than of internal financing. In this case, a firm's cash flow is expected to affect its investment decision. The second approach involves estimating an Euler equation, as by Bond and Meghir (1994). The majority of studies using the two approaches above have found that most types of firms face significant financial constraints.

There are methodological issues with these two approaches. For the first approach, a well-known critique is that a firm's cash flow may be endogenous "since it is likely to be related to unobserved investment opportunities or profitability of the firm" (Schiantarelli, 1996). To deal with this problem, Fazzari et al. (1988) propose to split the sample into firms that are likely to be more financially constrained and firms that are likely to be less constrained based on a prior characteristic such as age. While this approach alleviates the endogeneity problem of the regressor cash flow, it is difficult in empirical applications to find a prior characteristic that is also not correlated with the error term in the investment equation. Both of the approaches mentioned are usually not applicable to most firm-level data from developing countries since information on firm's Q value and cash flow often is not available in these data sets. Furthermore, estimates of the Euler equation are of poor quality when the sample size is small or the panel is short, which is the case for most firm-level data sets in developing countries.

In the context of combining firms' investment decisions and financing constraints, there are two notable theoretical papers that combine the literature on firms' dynamic investment decision with the literature on firms' financing constraints. Both papers have models calibrated to the U.S. firm data. Cooley and Quadrini (2001) model financial frictions via a cost per unit of new equity

through shares. They also model costly borrowing where the loan interest rate is higher than the risk-free interest rate. By incorporating financial friction into a model of firm behavior, they are able to explain why firm growth, job creation/destruction, and exit are negatively related to the size (age) of firms, conditional on age (size). Gomes (2001) builds a general equilibrium model with financial frictions where the frictions are modeled as a fixed cost of borrowing plus a per unit cost of new equity. He shows that results from standard investment regressions are questionable, partly due to the measurement error in marginal Q when it is approximated by average Q.

Regarding the effect of financial frictions on firms' R&D in OECD countries, Hall (2005) reports evidence for the presence of liquidity constraints in a number of studies of R&D investment by firms. Herrera and Minetti (2007) conclude that the length of a bank's relationship with a firm is positively associated with more R&D by the firm.

While there are many studies on financing constraints for firms in developed countries, few studies have been done on financing constraints for firms in developing countries using firm-level panel data sets until recently. At the macro level, some authors have noted the abnormally low investment rates despite high marginal returns to capital in developing countries such as some African economies, and have cited financial constraints as one of the main hypotheses that explain this abnormality (Bigsten 2000, Tybout 2000 at the macro level). Among papers using country-level data, there is a diverse empirical literature on the causal effect of a country's financial intermediary development on economic growth and growth of aggregate TFP (see Levine, 2001 for a summary of this literature). However, at the micro level, studies on firm-level financing constraint have been rare until recently. In fact, older studies on credit constraints in developing economies are concerned with credit constraints for household or household firms

such as credits for household's consumption smoothing or for farm household's production (Besley (1995), Rosenzweig and Wolpin (1993)). Paulson and Townsend (2001) studied financing constraints for firms but focused on the impact of these constraints in the start-up of a firm.

As data on firms in developing countries become more available, an emerging literature on the impacts of financial constraint on firms in developing countries is taking shape. Regarding to the literature on the existence of financial constraint or the impact of financial constraint on firms' fixed or R&D investment and productivity in developing and transition countries, Bigsten (2000) finds that for his sample of African manufacturing firms, small and unproductive firms are most likely to be constrained. A drawback of his approach is that it relies on strong assumptions about what types of reasons for not applying for loans are signs of credit constraint. For example, if a firm did not apply for a loan because the "interest rate is too high", it is not clear whether the firm is constrained or simply so unproductive that the prevailing market interest rate renders obtaining the loan unprofitable for the firm. Reyes et al (2012) find that formal credit constraint has negative impact on fixed investments undertaken by market-oriented farmers in Central Chile. They use direct evidence of credit constraint by coding an indicator based on the farmer's perceptions of credit constraint, and address potential endogeneity of this variable by using a discrete switching endogenous model. [53] Banerjee and Duflo (2001) exploit a

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[53] The endogeneity problem of credit constraint arises where there are several unobserved characteristics that may affect both firm investment and the likelihood the firm is credit constraint. For example, very innovative farmers that are unknown to banks may both face credit constraint but also have higher investment levels. In this case, unable to account for the endogeneity of firm-level credit constraint leads to underestimation of the negative effect of the credit constraint as the positive impact of innovation partly offsets the negative effect of credit constraint on farmer's investment level. On the other hand, farmers with poor entrepreneurial ability (an unobserved characteristic) who likely have lower need for investments are more likely to be credit constrained. If this is the case, ignoring the endogeneity of credit constraint will lead to an overestimation of the effect of credit constraint on farmers' investments.

change in government policy about loan allocation rules to examine whether firms would like to obtain more credit at the going interest rate than they actually obtain. They find a greater than proportional increase in profits in response to an increase in working capital and interpret the results as evidence for the existence of credit constraint at the firm level. They argue that the results indicate that credit constraint leads to significant productivity losses. Gatti and Love (2008) estimate the impacts of access to credit on firm productivity in Bulgaria and find a strong association between firm productivity and access to credit.

While most of the studies on financial constraint for firms in developing countries are static, Schündeln (2005) estimates a dynamic model of Ghanaian firm-level investment and obtains a quantitative estimate of the cost of financing constraints by estimating how much of the observed dynamic firm behavior is explained by financing constraints. His counterfactual analyses indicate that removing the constraints would result in an economically significant increase in investment and consumption levels.

Another more recent strand of literature studies the role of financial frictions on measures of innovation output in developing countries instead of measures of innovation inputs into such as R&D spending. One of the reasons for the switch of focus on direct measure of innovation is a practical consideration. Reliable data on firms' R&D expenditure are hard to find. In addition, many firms in developing countries do not engage in R&D activities but they still engage in incremental innovative activities. Ayyagari et al. (2011) finds a positive correlation between external finance and the extent of innovation. Gorodnichenko and Schnitzer (2010) study the impact of financial constraints on developing countries' innovation. Using direct measures of innovation indicators available from the BEEPS (Business Environment and Enterprise

Performance Survey) firm-level data they conclude that financial constraints restrain domestically owned firms from innovating.

It is important to note that testing for the presence of financing constraint or finding a good measure of firm-level financial constraint is not a trivial problem. This is even more challenging for studies using developing countries' firm-level data, since data on these firms' investment expenditures are not available or are unreliable. In the firm-level financial constraint literature, the presence of firm financing constraints has been found through estimating a model of credit demand, using indirect evidence from firm balance sheet information (interest payment, leverage, financial asset, debt, coverage ratio, etc.), or using direct evidence from the firm surveys based on the replies from firms' owners (managers) on questions about loan application and/or financial obstacles. For example, Bigsten (2000) estimates the determinants of demand for bank loans using a selection model based on firms' answers regarding the reasons why firms do not apply for credit.

It is important to also highlight the literature on the differential credit constraints that SMEs face to see why financial constraint is an even greater concern for this population of firms. Guiso et al. (2004a) list a number of possible explanations why small and medium firms are more likely to be financially constrained. Firstly, small firms tend to be more opaque and thus, face more problems with asymmetric information in the credit market. Secondly, given the relatively small loan size, banks may not be willing to spend time acquiring information about the small firms or monitoring the loans to these firms. Thirdly, if borrowing requires collateral, small firms have fewer tangible assets that can be used as collateral and thus are in a disadvantage. Support for the hypothesis of the tighter credit constraints that small firms face have been voiced in a number of empirical studies. Benfratello et al. (2008) find evidence of stronger positive effects of regional

banking development on innovative activities for small firms in Italy. Sharma (2007) concludes that in countries at higher levels of financial development, small firms are more likely to undertake R&D and spend more on R&D projects.

The recent global financial crisis has motivated a number of studies on the differential impact of the crisis on financially constrained firms and less financially constrained firms. Campello et al. (2010) show that the global financial crisis of 2008/09 caused deeper cuts in employment, technology and capital spending among financially constrained firms in U.S., Europe, and Asia. They also note that constrained firms drew more heavily on lines of credit in fear of restricted access to credit in the future. Savignac (2008), Aghion et al. (2012) and others find strong evidence that financial constraints have a negative effect on R&D and innovation. Badia and Slootmaekers (2009) conclude that financial constraints had a large negative impact on productivity in Estonia.

My paper fits in with the recent literature on the impact of the financing constraint on firm innovation. On the theoretical side, I develop a model of bank's lending decisions that features tighter credit constraint for innovating firms caused by the longer time to completion and the higher risks of the innovating projects. My theoretical model is similar to the theoretical framework in Feenstra et al. (2011) but I model credit constraint for innovation activities while Feenstra et al. model credit constraint for Chinese exporters. In the empirical application, I analyze a data set of Vietnamese small and medium enterprises (SMEs). My empirical results provide firm-level evidence of the presence of credit constraint, especially for innovating firms from Vietnam, a developing country that is less studied.

III.   Theoretical Model

The following theoretical model features firms heterogeneous in productivity and a banking sector. To focus on the impact of credit constraint on innovation, I model a closed economy and thus abstract from export decisions.

1.   Consumers

There are two sectors in the economy: a sector that produces a homogeneous good and a differentiated sector that produces different varieties of a differentiated good. Each consumer is endowed with one unit of labor. The utility function of the representative consumer is:

$$U = q_0^{1-\mu} \left(\int_{\omega \in \Omega} q(\omega)^{\frac{\sigma-1}{\sigma}} d\omega \right)^{\frac{\sigma}{\sigma-1}\mu}$$

where ω denotes a variety, Ω is the set of varieties available in the differentiated sector, σ is the constant elasticity of substitutions between each variety, μ is the share of the expenditure on the differentiated sector, q_0 is the output of the homogenous good, and $q(\omega)$ is the output of a variety in the differentiated sector.

The aggregate price in the differentiated sector is:

$$P = \left(\int_{\omega \in \Omega} p(\omega)^{1-\sigma} d\omega \right)^{\frac{1}{1-\sigma}}$$

where $p(\omega)$ is the price of a variety ω.

The demand for each variety in the differentiated sector is:

$$q(\omega) = \frac{Y}{P}\left(\frac{p(\omega)}{P}\right)^{-\sigma}$$

(3.1)

where $Y = \mu w L$ is the total expenditure on the differentiated good in the home country, and w denotes the wages. It is a well-known result that under this set-up, more productive firms charge a lower price and produce more than less productive firms.

2.   Firm Decisions

For simplicity, it is assumed that firms in the homogeneous good sector do not face borrowing constraints but firms in the differentiated good sector do. The following sections outline the decisions for firms in the differentiated sector and the bank's lending decisions to firms in this sector.

The distribution of firm productivity $f(x)$ in the differentiated good sector is common knowledge. Labor is the only production factor. Let the subscripts N denote non-innovating firms and I denotes innovating firms. Production involves fixed costs C_N for non-innovating firms and C_I for innovating firms. Since innovation often involves high fixed costs, it is assumed that $C_I > C_N$.

In the differentiated sector, firms need to borrow to finance a fraction δ of their total costs of production. This fraction is assumed to be equal across all firms in the model. Firms either produce without engaging in innovation activities, or produce and innovate.

There is a single, monopolistic bank that firms borrow from. Let i be the opportunity cost of loans. Assume that loans for non-innovating projects are paid back after τ_N periods while loans for innovating projects are paid back after τ_I periods. Since innovation is often a long process

compared to just producing without engaging in any innovation activities, it is assumed that $\tau_I > \tau_N$.

A firm can choose to innovate or not. If the firm does not engage in innovation, its productivity level stays the same. If a firm with productivity level x engages in innovation activities and the innovation project is successful, the firm's productivity level is raised to $(1 + \Delta z)x$. For simplicity, Δz is assumed to be common across firms.

All firms face some project risks. Non-innovating firms face a project risk s_N. For these firms, with probability s_N, their sales are successful and the firm receives the sales revenue. With probability $1 - s_N$, the project fails and the firm's revenue will be zero. Likewise, innovating firms face the project risk s_I. With probability s_I, a firm's innovative project is successful and the firm enjoys higher revenue that comes from a greater productivity level compared to when it does not innovate.[54] Because innovation often involves high uncertainty about the outcome, it is assumed that innovating firms have higher project risks, i.e. $s_I < s_N$.

In addition to project risks, for borrowing firms, there is a default risk where a firm fails to pay back the loan and interest payment. Innovating firms pay back their loans and interest payments with probability ρ_I while non-innovating firms pay back with the probability ρ_N. There are several reasons why firms might default such as project failure, lack of financial contractibility, or lack of contract enforcement. To account for the extra uncertainties of

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[54] While one may assume that if an innovation project fails, the firm still remains its productivity level before innovation and receives sales revenue accordingly to that productivity level, I assume that if the firm's innovation project fails, the firm's revenue will be zero. This happens if innovation is irreversible.

repayment in additional to project risks, it is assumed that $\rho_I \leq s_I$ and $\rho_N \leq s_N$. It is also

assumed that $\rho_I \geq \rho_N$ to capture the higher riskiness of innovation activities.

It is assumed that because of incomplete information, the bank cannot observe a firm's

productivity. This assumption is realistic for the SMEs data set used in this paper for three

reasons. First, the Vietnam's economy has gone through rapid growth and firms are constantly

presented with new opportunities so it is more difficult for banks to predict firms' productivity

and profitability correctly. Secondly, the Vietnamese financial system is still not very developed.

The stock market is in early stage of development and plays a much less important role than in

developed countries. In addition, there is no credit rating agency. For this reason, public

information that reveals Vietnamese firms' productivity levels is hard to find. Thirdly, the data

set surveys small and medium enterprises, whose productivity levels are arguably not as easy for

banks to observe as in the case of much larger firms since small firms are much less likely to be

mentioned in the news and many of the smaller firms do not keep a formal accounting book in

accordance with regulations.[55]

2.1. Non-innovating Firms' Decisions

As specified above, the bank does not observe firms' productivity level. Let x' be the

announced productivity level of a firm with productivity x that comes to the bank for a loan. The

bank will design a schedule of loan $M_N(x')$ and interest payment $I_N(x')$ contingent on the

firm's announced productivity level x'. If the firm defaults, the bank can collect the collateral

amount K_N.

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[55] 61.55% firms in the final regression sample do not keep a formal accounting book in accordance with regulations.

The revelation principle guarantees that for any Bayesian Nash equilibrium of a game of incomplete information, there exists a payoff-equivalent revelation mechanism that has equilibrium where the players truthfully report their types. Therefore, without loss of generality, I will focus on an equilibrium where firms truthfully reveal their productivity levels to the bank. In this equilibrium, the best solution for the bank is to design a loan-interest payment schedule that induces a firm to reveal its true productivity. [56] In this setup, a non-innovating firm chooses its announced productivity level x' and output level q_N that maximizes its profits under the incentive compatibility constraint induced by the loan design. The firm's expected profit is its expected sales revenue minus both the fraction $(1-\delta)$ of total costs that the firm pays itself and the expected costs of borrowing, where the expected costs of borrowing consists of the expected loan payment if the firm pays back the loan and the collateral being seized by the bank if the firm defaults.

$$\max_{x',q_N} E\left(\pi_N(x,x')\right) = s_N p_N q_N - (1-\delta)\left(\frac{q_N w}{x} + C_N\right) - \rho_N\left(M_N(x') + I_N(x')\right) - (1-\rho_N)K_N \quad (3.2)$$

$$
\begin{aligned}
& E\left(\pi_N(x,x)\right) \geq E\left(\pi_N(x,x')\right) \\
& E\left(\pi_N(x,x)\right) \geq 0 \\
\text{s.t.} \quad & M_N(x') \geq \delta\left(\frac{q_N w}{x} + C_N\right) \\
& q_N = \frac{Y}{P}\left(\frac{p(x)}{P}\right)^{-\sigma}
\end{aligned}
$$

The first constraint in the non-innovating firm profit maximization problem is the incentive compatibility constraint. This constraint ensures that in equilibrium, firms find it in their best

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[56] For more information on the revelation principle, see Myerson (1979), Baron and Myerson (1982).

interest to announce their true productivity level when applying for a loan from the banks. The second constraint specifies that firms only produce when their expected profits are non-negative. The third constraint ensures that the amount of loan is adequate to cover the fraction δ of total production costs. The fourth constraint is the firm's demand function as derived earlier.

In equilibrium, the third constraint is binding and thus:

$$q_N = \left(\frac{M_N(x')}{\delta} - C_N \right) \frac{x}{w} \tag{3.3}$$

Assuming that the functions for the loan and interest payment schedules are differentiable in x', then the incentive compatibility constraint implies that

$$\frac{\partial E\left(\pi_N(x,x') \right)}{\partial x'} \bigg|_{x'=x} = 0 \tag{3.4}$$

Solving the firm profit-maximization problem and then taking the derivative as in (3.4) gives us the following condition in equilibrium:

$$\left(\Phi_N(x, M_N(x)) + \delta(1 - \rho_N) - 1 \right) \frac{M'_N(x)}{\delta} = \rho_N I'_N(x) \tag{3.5}$$

where the apostrophe denotes a derivative and

$$\Phi_N(x, M_N(x)) \equiv \left[\frac{\sigma - 1}{\sigma} s_N p_N \right] / \frac{w}{x}$$

$$= s_N \frac{\sigma - 1}{\sigma} \left(\frac{M_N(x)}{\delta} - C_N \right)^{-1/\sigma} \left(\frac{xP}{w} \right)^{\frac{\sigma - 1}{\sigma}} Y^{1/\sigma} \tag{3.6}$$

As can be seen from the first line of (3.6), Φ_N is the ratio of expected marginal revenue to marginal cost. The expression in the second line of (3.6) can be obtained by rewriting the first line using (3.3) and (3.1).

In the special case that a firm does not need to borrow, the firm's profit function can be written as:

$$\max_{q_N} E\left(\pi_N(x, x')\right) = s_N p_N q_N - \left(\frac{q_N w}{x} + C_N\right)$$

and profit-maximization condition implies the following standard result of the equalization of marginal revenue and marginal costs:

$$\frac{\sigma - 1}{\sigma} s_N p_N = \frac{w}{x} \text{ , or } \Phi_N = \left[\frac{\sigma - 1}{\sigma} s_N p_N\right] / \frac{w}{x} = 1$$

In other words, a non-innovating firm with no credit constraint has $\Phi_N = 1$ and produces at the first-best output level where marginal revenue equals marginal costs.

Let $q_N^0(x)$ and $q_I^0(x)$ denote the output level of non-innovating firms and innovating firms if there is still project risk but no need for credit, i.e. when $\Phi_N = 1$. Then, from (3.6):

$$q_N^0(x) = \left(\frac{1}{s_N} \frac{\sigma}{\sigma - 1} \frac{w}{x}\right)^{-\sigma} \frac{Y}{P^{1-\sigma}}$$

$$q_N(x) = q_N^0(x)(\overline{\Phi}_N)^{-\sigma}$$

Since Φ_N is greater than one, $q_N(x)$ is less than $q_N^0(x)$. In other words, compared to firms that do not have to borrow, borrowing firms produce where $\Phi_N > 1$ with output levels less than the first-best level. Therefore, Φ_N can be regarded as a measure of a non-innovating firm's credit constraint. The greater the value of Φ_N is, the higher the credit constraint a firm faces and the less the firm produces.

Intuitively, the credit constraint comes from the asymmetric information problem where the bank cannot observe the firm's true productivity and has to design loans based on the firm's announced productivity. In this setup, a firm would have only a second-order loss in profits from announcing a slightly smaller productivity compared to its true productivity and would produce slightly less, but would have a first-order gain in profits from the reduced interest payments (since $I_N'(x) > 0$). So without a credit constraint imposed by the bank, a firm would understate its productivity. Therefore, to ensure incentive compatibility, the bank will need to impose a credit constraint, hence making $\Phi_N > 1$. Because of this, credit constraint still exists even when there is no loan default risk (i.e. $\rho_N = 1$), as can be seen in (3.6).

2.2. Innovating Firms' Decisions

I assume that the bank can determine whether a firm that applies for a loan plans to innovate. I believe this assumption is reasonable since firms usually have to provide a business plan to banks when applying for loans and thus, a bank may be able to detect a firm's innovation intention. Denote the loan and interest payment schedule of a firm with announced productivity x' that plans to innovate as $M_I(x')$ and $I_I(x')$.

The constraints of the innovating firm's profit maximization problem are similar to the constraints for a non-innovating firm, except for the inclusion of an additional constraint that ensures the firm's expected profits from innovation is higher than from no innovation so that innovation is a profit-maximizing decision.

$$\max{}_{x',q_I} E\left(\pi_I(x(1+\Delta z), x')\right) = s_I p_I q_I - (1-\delta)\left(\frac{q_I w}{x(1+\Delta z)} + C_I\right) - \rho_I\left(M_I(x') + I_I(x')\right) - (1-\rho_I)K_I$$

$$
\text{s.t.} \quad
\begin{aligned}
&E\left(\pi_I(x(1+\Delta z), x(1+\Delta z))\right) \geq E\left(\pi_I(x(1+\Delta z), x')\right)\\
&E\left(\pi_I(x(1+\Delta z), x(1+\Delta z))\right) \geq 0\\
&M_I(x') \geq \delta\left(\frac{q_I w}{x(1+\Delta z)} + C_I\right)\\
&q_I = \frac{Y}{P}\left(\frac{p_I(x(1+\Delta z))}{P}\right)^{-\sigma}\\
&E\left(\pi_I(x(1+\Delta z), x(1+\Delta z))\right) \geq E\left(\pi_N(x, x)\right)
\end{aligned}
$$

In equilibrium, the third constraint is binding:

$$q_I = \left(\frac{M_I(x')}{\delta} - C_I\right)\frac{x(1+\Delta z)}{w}$$

The incentive-compatibility condition requires that:

$$\frac{\partial E\left(\pi_I(x, x'')\right)}{\partial x'}\bigg|_{x'=x(1+\Delta z)} = 0$$

An analogous measure of credit constraint for innovating firms, Φ_I, can be readily obtained following the same solution steps as in the case with non-innovating firms:

$$\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) \equiv \left[\frac{\sigma-1}{\sigma} s_I p_I\right] / \frac{w}{x(1+\Delta z)}$$

$$= s_I \frac{\sigma-1}{\sigma}\left(\frac{M_I(x(1+\Delta z))}{\delta} - C_I\right)^{-1/\sigma}\left(\frac{x(1+\Delta z)P}{w}\right)^{\frac{\sigma-1}{\sigma}} Y^{1/\sigma} \tag{3.7}$$

and in equilibrium, the following equality holds:

$$\left(\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z)))\right) + \delta(1-\rho_N)-1)\frac{M_I'(x(1+\Delta z))}{\delta} = \rho_I I_I'(x(1+\Delta z)) \tag{3.8}$$

2.3. Bank's Decision

Since the loans are designed to be incentive-compatible, the firm's expected profits

$E(\pi_N(x,x))$ and $E(\pi_I(\bar{x}_I(1+\Delta z), \bar{x}_I(1+\Delta z)))$ are non-decreasing in firm productivity level, x.[57]

In Appendix D it is proved that only more productive firms find it profitable to innovate.

Together, these imply that there is a cutoff level $\bar{x}_N$ such that firms with productivity below this

cutoff do not produce and firms with productivity above this cutoff operates. Similarly, there is a

productivity cutoff $\bar{x}_I$ where only firms with productivity levels above this cutoff decide to

innovate. These productivity cutoffs satisfy the zero-profit conditions:

$$E(\pi_N(\bar{x}_N, \bar{x}_N)) = 0$$
$$E(\pi_N(\bar{x}_I, \bar{x}_I)) = E(\pi_I(\bar{x}_I(1+\Delta z), \bar{x}_I(1+\Delta z)))$$

The monopolistic bank chooses the bank loan schedules subject to the incentive compatibility

conditions to maximize its profits:

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[57] According to Feenstra et al. (2011), this property of firm profits under any incentive-compatibility policy is established "in Baron and Myerson (1982) and subsequent literature". (Feenstra et al. 2011, footnote 7, p10)

$$\text{Max}_{M,I} \int_{\bar{x}_N}^{\bar{x}_I} \rho_N I_N(x) - (1-\rho_N)(M_N(x) - K_N) - i\tau_N M_N(x)) f(x) dx$$

$$+ \int_{\bar{x}_I}^{\infty} \rho_I I_I(x(1+\Delta z)) - (1-\rho_I)(M_I(x(1+\Delta z)) - K_I) - i\tau_I M_I(x(1+\Delta z))) f(x) dx$$

s.t. (5) if $x \in [\bar{x}_N, \bar{x}_I)$ and s.t. (8) if $x \in [\bar{x}_I, \infty)$

The bank's maximization problem is solved in two steps. First, the loan schedule that maximizes the bank's profit is derived. Secondly, the initial level of interest payments for the cutoff non-innovating and innovating firms are determined and then used to solve for the productivity cutoffs $\bar{x}_N$ and $\bar{x}_I$. Solutions for the optimal loan amount and interest payments are derived below (Section 2.3.1).

2.3.1. The Loan Schedule

It is shown in Appendix D that the optimal loan schedules for the bank satisfy the following conditions:

$$\Phi_N(x, M_N(x)) \equiv \overline{\Phi}_N = (1+i\delta\tau_N)\left[1 - \left(\frac{\sigma-1}{\sigma}\right)\frac{1-F(x)}{xf(x)}\right]^{-1}$$

$$\Phi_I(x, M_N(x)) \equiv \overline{\Phi}_I = (1+i\delta\tau_I)\left[1 - \left(\frac{\sigma-1}{\sigma}\right)\frac{1-F(x)}{xf(x)}\right]$$

(3.9)

where the bars over Φ_N and Φ_I indicate the equilibrium values of Φ_N and Φ_I. If we assume that firm productivity levels follow a Pareto distribution with the shape parameter θ:

$F(x) = 1 - (1/x)^\theta$, $x \geq 1$, then a further simplified solution for the credit constraints and the loan schedules can be obtained:

$$\overline{\Phi}_N = (1+i\tau_N)\left[1-\left(\frac{\sigma-1}{\sigma}\right)\frac{(1/x)^{\theta}}{\theta x(1/x)^{\theta-1}(1/x^2)}\right]^{-1} = (1+i\delta\tau_N)\left(1-\frac{\sigma-1}{\sigma\theta}\right)^{-1}$$

$$\overline{\Phi}_I = (1+i\delta\tau_I)\left(1-\frac{\sigma-1}{\sigma\theta}\right)^{-1}$$

(3.10)

$$\frac{M_N(x)}{\delta} = \left[\frac{\sigma-1}{\sigma}\left(\frac{xP}{w}\right)^{\frac{\sigma-1}{\sigma}}Y^{1/\sigma}\right]^{\sigma}\left[\frac{\overline{\Phi}_N}{s_N}\right]^{-\sigma} + C_N$$

$$\frac{M_I(x(1+\Delta z))}{\delta} = \left[\frac{\sigma-1}{\sigma}\left(\frac{x(1+\Delta z)P}{w}\right)^{\frac{\sigma-1}{\sigma}}Y^{1/\sigma}\right]^{\sigma}\left[\frac{\overline{\Phi}_I}{s_I}\right]^{-\sigma} + C_I$$

(3.11)

Equation (10) indicates that if the firm productivity distribution is Pareto, the value of the credit constraint parameter does not depend on the firm productivity but only depends on the opportunity cost of making loans, the fraction of costs that the firm has to borrow to cover, the length of time the firm holds the loan, and the rate of substitution between varieties of the differentiated good. It can readily be seen that both $\overline{\Phi}_I$ and $\overline{\Phi}_N$ are increasing in the parameters that determine the opportunity cost of making loans: i, τ_N and τ_I. The higher this opportunity cost, the stricter the borrowing constraint becomes. Furthermore, $\overline{\Phi}_I$ and $\overline{\Phi}_N$ are decreasing in θ, which implies that the more dispersed the distribution of firm productivity is (i.e. a lower value of θ), the higher the borrowing constraints are. Intuitively, when costs of lending are higher, such as when the opportunity costs of making loans increase or when the asymmetric information problem worsens due to increased dispersion in firm productivity distribution, the bank responds by restricting the loan supply making credit constraint more severe. Using the same reasoning, it follows that if firms need to borrow a higher fraction of production costs, the credit constraint would be tighter.

Furthermore, if it is assumed that $\theta > \dfrac{\sigma-1}{\sigma}$, then $\overline{\Phi}_N > 1$ and $\overline{\Phi}_I > 1$, which implies the

existence of credit constraint. It is easy to prove that $\overline{\Phi}_N$ and $\overline{\Phi}_I$ are greater than one even when

$i=0$. In other words, firms will be under credit constraint even when the bank incurs zero

opportunity cost in making a loan. Also, since it is assumed that innovation projects take longer

time, i.e., $\tau_I > \tau_N$, it can be proved that $\overline{\Phi}_I > \overline{\Phi}_N$. In other words, the model implies that

innovating firms face more severe credit constraint than non-innovating firms.

The solutions for the interest payment schedules for non-innovating firms and innovating

firms are derived in Appendix D, and are as follows:

$$\rho_N I_N(x) = \left[\overline{\Phi}_N + \delta(1-\rho_N) - 1\right]\frac{M_N(x)}{\delta} - (1-\rho_N)K_N, \quad \forall x \in [\bar{x}_N, \bar{x}_I) \tag{3.12}$$

$$\rho_I I_I(x(1+\Delta z)) = \left(\overline{\Phi}_I + \delta(1-\rho_I) - 1\right)\frac{M_I(x(1+\Delta z))}{\delta} + \Psi, \quad \forall x \in [\bar{x}_I, \infty)$$

where

$$\Psi = \left\{\frac{\overline{\Phi}_I \sigma}{\sigma-1} + \delta(1-\rho_I) - \frac{\overline{\Phi}_N}{\sigma-1}(1+\Delta z)^{1-\sigma}\left[\frac{\overline{\Phi}_N}{\overline{\Phi}_I} \cdot \frac{s_I}{s_N}\right]^{-\sigma}\right\}\Pi\left[(1+\delta i\tau_N)C_N - (1+\delta i\tau_I)C_I\right]$$
$$- (1-\rho_I)K_I + \overline{\Phi}_N C_N + \delta(1-\rho_I)C_I$$

and under Pareto distribution of firm productivity:

$$\Pi = \frac{-1}{\sigma-1}(1+i\delta\tau_I) - (1+\Delta z)^{1-\sigma}\left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)} \cdot \frac{s_I}{s_N}\right]^{-\sigma}\left[\frac{\sigma}{\sigma-1}(1+i\delta\tau_N) + (1+i\delta\tau_I)\right]$$

2.3.2. The Cutoff Productivity Levels

Recall that $\bar{x}_N$ is the productivity cutoff for non-innovating firms or the cutoff productivity for production. If a firm's productivity level is below this cutoff, the firm will exit the market. Similarly, $\bar{x}_I$ denotes the productivity cutoff for undertaking the innovation activity: only firms with productivity above this cutoff innovate.

As proved in Appendix D, the productivity cutoff for production is:

$$\bar{x}_N = w\left(\frac{\sigma}{\sigma-1}\left(\frac{(\sigma-1)C_N}{s_N^\sigma Y P^{\sigma-1}}\right)^{1/\sigma}\overline{\Phi}_N\right)^{\sigma/(\sigma-1)} \tag{3.13}$$

Since $\overline{\Phi}_N > 1$, the productivity cutoff for production is greater than the cutoff in Melitz (2003) where there is no credit constraint. This implies that credit constraint not only reduces firms' intensive margin but also reduces the extensive margin.

Similarly, the productivity cutoff for innovation can be obtained as follows:

$$\bar{x}_I = w\left(\frac{\sigma}{\sigma-1}\left(\frac{(\Pi[(1+\delta i \tau_N)C_N - (1+\delta i \tau_I)C_I]}{s_I^\sigma Y(1+\Delta z)^{\sigma-1}P^{\sigma-1}}\right)^{1/\sigma}\overline{\Phi}_I\right)^{\sigma/(\sigma-1)} \tag{3.14}$$

Under the model's assumptions that $\tau_N < \tau_I$ and $C_N < C_I$, it can be proved that $\bar{x}_I$ is increasing in i. As the opportunity cost of making loans increases, the credit constraint for innovating firms becomes tighter, making it more costly to pursue innovation projects and further reduces the extensive margin of innovation.

In summary, the theoretical model leads to two predictions. The first prediction is that credit constraint negatively affects firms' output and revenue. In the model, this is represented by the result that $\overline{\Phi}_N$ and $\overline{\Phi}_I$ are both greater than one. Given that these are the ratios of marginal

revenue to marginal costs for non-innovating and innovating firms, this implies that credit

constraint results in both types of firms producing less than the first best output level, where

marginal revenue equals marginal costs. The second prediction is that innovating firms face

tighter credit constraint, resulting in an even larger gap between the actual output and the first-

best output level, represented by the result that $\overline{\Phi}_I > \overline{\Phi}_N$. In the next section, Empirical Testing,

I will derive an estimating equation from the theoretical model that captures these two

predictions, and describe the data set used for the empirical estimation.

IV.   Empirical Testing

1.   Background of the Vietnamese Economy

Economic reform ("Doi Moi") in Vietnam started in 1986 with the goal of transforming the

Vietnamese economy from a centrally planned to a more market-oriented one. Since then, the

Vietnamese economy has become more industrialized. Industries and construction share 41

percent of GDP, followed by services (39 percent of GDP), and agriculture, forestry and fishery

(20 percent of GDP). The agricultural sector remains important, and 65 percent of the population

still lives and works in rural areas. The domestic private sector grew significantly during the

reforms: by 2009, it accounted for 46 percent of GDP and was responsible for creating 90

percent of new employment (Doanh 2009). In the period of 2000-2007, Vietnam experienced

high growth rates, with GDP growth averaging 7.6 per cent per year (Abbot and Tarp, 2011).

Vietnam has participated in several bilateral and regional trade agreements, such as joining the

Association of Southeast Asian Nations (ASEAN) in 1995, and signing a bilateral trade

agreement with the U.S. in 2001. As a result, Vietnam's economy has become much more open

for international trade, and highly dependent on foreign direct investments as well as indirect

financial investments. Vietnamese exports increased by 440%, from 14.5 billion U.S. dollars in

2000 to 64 billion in 2009, and export value accounted for 70 percent of GDP. However, the value-added share for export goods of Vietnam was still small.

In January 2007, after 11 years of negotiations, Vietnam became a WTO member, which increased the flow of foreign capital to Vietnam significantly that year. However, because of this large increase in capital inflow, a boom in commodities, and increases in rice and other food prices, in the first three quarters of 2008, Vietnam faced high inflation in addition to high current-account and budget deficits (Harvard Vietnam Program 2008, Doanh 2009). The inflation rate based on the consumer price index for 2008 was estimated by the World Bank to be at 23% (Table 3.1.1). In response to the overheating of the domestic economy and high inflation rate, in March 2008, the Vietnamese government adopted a stabilization package aimed at bringing down the inflation rate, and the State Bank of Vietnam adopted a tight monetary policy. On May 16 2008, the State Bank of Vietnam (SBV) issued Decision No. 6/2008/QD-NHNN, which raised the base interest rate and prohibited credit institutions from setting the mobilizing and lending interest rate over 150% of the base interest rate announced by the SBV for a particular period (Cao 2013). The tight monetary policy led to a sharp decline in credit growth and "raised concerns of a credit crunch in June and July of 2008" (Doanh 2009). The 2007-2008 global financial crisis hit Vietnam in late 2008, around the fourth quarter. Vietnam's annual GDP growth rate in 2008 was 6.2 percent, the lowest since 2000.

Vietnam provides an interesting case to study the impact of credit constraint on firm innovation. While the period 2005-2007 saw a large increase in investment as share of GDP which contributed to Vietnam's rapid growth, there is concern that "growth is due to capital accumulation rather than technical innovation" (Abbot and Tarp 2011, page 7). Despite its high rate of growth and increase in capital flow during the 2005-2007 period, Vietnam still ranked

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low in financial development, below many countries in the region, including Singapore, China, and Thailand.[58] Vietnam's stock market was still underdeveloped with low market capitalization (see Table 3.1.1). Professional credit rating systems were not common in the period 2005-2008. There was no private credit bureau coverage and very low public credit registry coverage (see Table 3.1.1). The only official source for credit information was the Credit Information Center (CIC) which was supervised by the State Bank of Vietnam. However, the CIC only had the credit history of state lending institutitions, such as state-owned commercial banks. Furthermore, banks were reluctant to share their customers' credit information due to concern about privacy protection. Therefore, the quality of credit information from the CIC was often very poor and inadequate (To 2013). At the same time, the extent of disclosure among businesses was low, although it improved significantly after Vietnam joined the WTO in 2007 (Table 3.1.1). This situation implied that there was severe asymmetric information for bank lending in Vietnam during the studied period.

There is also ample evidence that Vietnamese firms in the private sector, especially SMEs, still faced high credit constraint during the period of 2005-2008. For example, most surveys of private company owners in Vietnam cited the difficulty of accessing credit as one of the leading obstacles to private sector development (see Malesky and Taussig 2008 for a summary of the information from these surveys). Compared to other countries, Vietnam still had a higher share of firms that found "insufficient access to finance a "severe" or "major" constraint to their development" (World Bank 2005).

Credit constraint is likely to be higher for the group of firms studied in this chapter, small and medium enterprises (SMEs). Many empirical studies have documented a tighter credit constraint

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[58] Source: World Economic Forum. http://www.weforum.org/pdf/FinancialDevelopmentReport/Rankings.pdf.

and more severe asymmetric problem in access to bank financing for small firms. For example, Beck et al. (2009) find that small firms face more severe financial obstacles and that financial developments have a positive effect for all firms but benefit small firms the most (Beck et al. 2008, and Beck et al. 2009).[59] The crowding out of credits by state-owned enterprises (SOEs) in Vietnam further increased the credit constraint that SMEs in Vietnam faced. Banks, especially state-owned commercial banks, preferred lending to SOEs because of policy-lending, long-standing relationships between the banks and SOEs, and their perception of SOEs as having low risk of default due to "implicit government guarantees" (Hakkala and Kokko 2007).

In terms of lending interest rate, the nominal interest rate was kept unchanged during the period 2001-2007 despite increases in the money supply, as the Vietnamese government's priority in this period was economic growth (Table 3.1.1. of this chapter; Doanh 2009, Table 6).[60] The real interest rate was positive during the period in my empirical analysis, except for the year 2008. However, given the high inflation in 2008, the nominal rate was actually lower than the inflation rate, leading to a negative interest rate.[61]

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[59] Beck et al. (2008) presents cross-country and cross-industry empirical evidence that the financial development increases (1) the growth of small-firm industries more than that of large-firm industries, and (2) the level of output accounted for by small-firm industries. Specifically, they find a positive coefficient estimate of the interaction between the share of small firms (less than 20 employees) in an industry and financial development in a regression of industry-level growth rates. They interpret the finding as consistent with the hypothesis that small firms have difficulty in access to financing due to asymmetric and transaction cost problems, since as financial development decreases these problems, it should benefit small firms disproportionately. This result is consistent with this chapter's model assumption of an asymmetric problem in lending/borrowing.

[60] According to Table 6 in Doanh (2009), the average 1-year lending annual interest rate was 11.8% for each month between January 2006 and February 2008. The lending interest rate then increased to 16-18% for April to June, 2008, and then to a peak of around 22% in July and August 2008, and then steadily decreased. The lending rate in November and December of 2008 came down to 14.1% and 11.5%, respectively.

[61] In response to the global financial crisis, Vietnamese government adopted an interest rate subsidy program. The program, which started in April 2009, subsidized 4 percent of the interest payments "imposed on medium and long-term loans for two years" (Nguyen et al. 2011)

In recent years, non-performing loans have emerged as a serious problem. The ratio of non-performing loans over total loans (in terms of value) doubled in October 2008 from the value at the end of 2007 (see Table 3.1.1).[62] A high percentage of non-performing loans are loans to unprofitable state-owned enterprises.[63] A high rate of non-performing loans can potentially lead to a "credit crunch" and further increase credit rationing (Hou 2007). Although non-performing loans have the potential to be a big problem for the health of the Vietnamese banking system, the size of the problem is not clear for the period analyzed in this chapter (2005-2008) since the problem emerged in 2008 and the rate of non-performing loans in Vietnam for 2005-2008 was less than that of some other countries in the area such as Thailand, Singapore, and China (see Table 3.1.1). More importantly, for the period studied, the Vietnamese banking system still had adequate capital, as indicated by the statistics of non-performing loans net of provisions to capital (see Table 3.1.1).[64] However, since the statistics reported by Vietnam used a more lenient definition of NPLs, it is also probable that the actual rate of NPLs was already high before 2008 and started affecting the availability of credit to firms. If this is the case, it would imply even more severe credit rationing for SMEs in Vietnam.

2. Data

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[62] The number reported is official number reported by the State Bank of Vietnam (SBV). Since Vietnam uses a more lenient definition of non-performing loans, it is believed that the actual rate of non-performing loan is much higher (KPMG 2013). According to Reuters, the SBV acknowledged in its statement in 2013 that "Several banks did not comply with the regulations about debt classification, recording non-performing loans below the actual figure to reduce their provisions." (Source: http://in.reuters.com/article/2012/07/12/vietnam-bank-loans-idINL3E8IC2H220120712)

[63] According to the State Bank of Vietnam, 60% of non-performing loans in 2010 were from state-owned enterprises.

[64] According to IMF documentation, the non-performing loans net of provisions to capital "is a capital adequacy ratio and is an important indicator of the capacity of bank capital to withstand losses from non-performing loans." (Source: http://fsi.imf.org/misc/FSI%20Concepts%20and%20Definitions.pdf).

For the empirical application, I analyzed a panel data set of Vietnamese private, small and medium enterprises (SMEs) in the manufacturing sector. Given that the Vietnamese economy is predominantly SMEs, the data set I use provides an opportunity to understand how credit constraint affects the innovation decision of this significant component of the private sector in Vietnam. While it may be argued that there is less innovation among small firms, with the recent rapid change in the Vietnamese economy, Vietnamese SMEs have to innovate constantly and adapt their products to meet changing demands. Thus, while these SMEs may not undertake large-scale R&D projects, it is very likely that they need to undertake small innovations in order to stay competitive. Therefore, innovation is likely to play an important role in the survival and growth of Vietnamese SMEs.

The data come from a survey project of private SMEs in Vietnam. The survey project was designed and carried out by the Department of Economics of the University of Copenhagen in collaboration with several Vietnamese government ministries.[65] The firms surveyed come from random sampling of firms that satisfied the following criteria: (1) firm employment is supposed to be no more than 300 employees,[66] and (2) the enterprise is non-state in the sense that the state has less than 50% of the ownership share of the firm. Approximately 2800 firms in the selected 10 provinces in Vietnam were surveyed in the initial survey wave in 2005. The selected provinces covered around 30 percent of the manufacturing enterprises in Vietnam. Efforts were made to track these firms in subsequent waves. In 2009, exit firms were randomly replaced based

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[65] The survey project was started as collaboration between the Institute of Labour Studies and Social Affairs (ILSSA) in the Ministry of Labour, Invalids and Social Affairs (MOLISA), the Stockholm School of Economics (SSE) and Department of Economics, University of Copenhagen with funding from SIDA and DANIDA.

[66] This criterion was adhered to with some flexibility. If, in the course of the interview, it was discovered that the firm employed more than 300 (but fewer than 400) workers, the interviewer may still include the firm.

on two criteria: (i) a constant level of household firms based on the information in GSO (2004), and (ii) the new 2009 population of firms registered under the Enterprise Law obtained from the Vietnam's Government Statistics Office (GSO).

Increased funding resulted in significant improvement in the data quality of the three most recent survey waves, 2005, 2007, and 2009. However, since the format of some of the survey questions of interest to this paper changed after the 2005 wave, I will only use data from the last two waves 2007 and 2009 to ensure consistency. In addition, since some of my analyses use lagged variables, restricting to the last two waves of data allow me to keep the various data analyses comparable.

In each survey wave, questions were asked about the firms' activities in the two years between the time of the previous survey and the current survey. Most variables are yearly such as revenues, costs, physical capital and employment. A few variables are only for the year before the survey year such as the formal interest payments. A few other variables are for the two years between survey waves such as variables regarding innovation and loan application status. Therefore, when I estimated the regression, I use a two-year interval time period, and use the average over two years for yearly variables.

The data set has relatively comprehensive information about a firm's activities, revenues, and costs. It also includes questions on whether a firm engaged in different innovation activities: modification of an existing product, creation of a new product, and implementation of a new process. There are detailed questions on firms' borrowing such as formal interest payments, whether the firm applied for a loan in the past two years, and if applicable, the reasons a firm did not apply for a loan. In addition, the questionnaire includes some questions about firms'

networks and the firms' expectation (or perception) of the impact of Vietnam's recent WTO membership, either on the firms themselves or on the macroeconomic condition.

After data cleaning, the final data set contains 5007 observations across the two survey waves of 2007 and 2009.[67] Some overview information of the Vietnamese economies during 2005-2008 and of the firms in the data set is provided in Table 3.1.1 to Table 3.1.4. Tables 3.2.1 and 3.2.2 present basic descriptive statistics and correlations of the key regression variables. Since the main regression results come from a fixed-effect estimation method, in the majority of the regression results, the regression sample is restricted to the sample of firms that was in both survey waves.

3.   Estimating Equations

Recall that under a Pareto distribution of firm productivity:

$$\overline{\Phi}_N = \left[\frac{\sigma-1}{\sigma}s_N p_N\right]/\frac{w}{x}$$

$$q_N = \left(\frac{M_N(x)}{\delta} - C_N\right)\frac{x}{w}$$

$$\rho_N I_N(x) = \left[\overline{\Phi}_N + \delta(1-\rho_N) - 1\right]\frac{M_N(x)}{\delta} - (1-\rho_N)K_N \qquad \forall x \in [\bar{x}_N, \bar{x}_I]$$

Combining the three expressions above, the expected revenue for a non-innovating firm can be rewritten as:

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[67] Firms that are joint ventures with foreign capital or local state-owned enterprises are dropped in the data cleaning process since they have very different characteristics from private firms. This does not affect the analysis because there is only 1 joint venture and 2 state-owned enterprises in the data set for the survey wave 2007 and 2009.

$$s_N p_N q_N = \frac{\sigma}{\sigma-1} \frac{w}{x} \overline{\Phi}_N q_N = \frac{\sigma}{\sigma-1} \frac{w}{x} \overline{\Phi}_N \left(\frac{M_N(x)}{\delta} - C_N \right) \frac{x}{w} = \frac{\sigma}{\sigma-1} \overline{\Phi}_N \left(\frac{M_N(x)}{\delta} - C_N \right)$$

$$= \frac{\sigma}{\sigma-1} \overline{\Phi}_N \left(\frac{\rho_N I_N(x) + (1-\rho_N)K_N}{\overline{\Phi}_N + \delta(1-\rho_N) - 1} - C_N \right)$$

Similarly, the expected revenue for innovating firms can be expressed as follows:

$$s_I p_I q_I = \frac{\sigma}{\sigma-1} \frac{w}{x(1+\Delta z)} \overline{\Phi}_I q_I = \frac{\sigma}{\sigma-1} \frac{w}{x(1+\Delta z)} \overline{\Phi}_I \left(\frac{M_I(x(1+\Delta z))}{\delta} - C_N \right) \frac{x(1+\Delta z)}{w}$$

$$= \frac{\sigma}{\sigma-1} \overline{\Phi}_I \left(\frac{M_I(x(1+\Delta z))}{\delta} - C_I \right)$$

$$= \frac{\sigma}{\sigma-1} \overline{\Phi}_I \left(\frac{\rho_I I_I(x(1+\Delta z)) - \Psi}{\overline{\Phi}_I + \delta(1-\rho_I) - 1} - C_I \right)$$

where, as defined earlier:

$$\Psi = \left\{ \frac{\overline{\Phi}_I \sigma}{\sigma-1} + \delta(1-\rho_I) - \frac{\overline{\Phi}_N}{\sigma-1}(1+\Delta z)^{1-\sigma} \left[\frac{\overline{\Phi}_N}{\overline{\Phi}_I} \cdot \frac{s_I}{s_N} \right]^{-\sigma} \right\} \Pi \left[(1+\delta \tau_N)C_N - (1+\delta \tau_I)C_I \right]$$

$$- (1-\rho_I)K_I + \overline{\Phi}_N C_N + \delta(1-\rho_I)C_I$$

and

$$\Pi = \frac{-1}{\sigma-1}(1+i\delta\tau_I) - (1+\Delta z)^{1-\sigma} \left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)} \cdot \frac{s_I}{s_N} \right]^{-\sigma} \left[\frac{\sigma}{\sigma-1}(1+i\delta\tau_N) + (1+i\delta\tau_I) \right]$$

To simplify the presentation of these relationships, the following notations for the formal interest payment, expected revenue, fixed costs of operation, and an innovation indicator for an operating firm will be used:

$$E(I(x)) = \begin{cases} \rho_N I_N(x) + (1-\rho_N)K_N & \text{if } x \in [\bar{x}_N, \bar{x}_I) \\ \rho_I I_I(x(1+\Delta z)) + (1-\rho_I)K_I & \text{if } x \in [\bar{x}_I, \infty) \end{cases}$$

$$E(r(x)) = \begin{cases} s_N p_N q_N & \text{if } x \in [\bar{x}_N, \bar{x}_I) \\ s_I p_I q_I & \text{if } x \in [\bar{x}_I, \infty) \end{cases}$$

$$C = \begin{cases} C_N & \text{if } x \in [\bar{x}_N, \bar{x}_I) \\ C_I + C_N & \text{if } x \in [\bar{x}_I, \infty) \end{cases}$$

$$1_{\{x \geq \bar{x}_I\}} = \begin{cases} 0 & \text{if } x \notin [\bar{x}_I, \infty) \\ 1 & \text{if } x \in [\bar{x}_I, \infty) \end{cases}$$

Using the notations above, a firm's expected revenue can be expressed as a linear function of interest payment for firm j in year t:

$$E_{jt}(r(x)) = \beta_0 1_{\{x \geq \bar{x}_I\}} + \beta_1 C + \beta_2 C 1_{\{x \geq \bar{x}_I\}} + \beta_3 E_{jt}(I(x)) + \beta_4 E_{jt}(I(x))1_{\{x \geq \bar{x}_I\}}$$
$$= \beta_1 C + (\beta_0 + \beta_2 C)1_{\{x \geq \bar{x}_I\}} + \beta_3 E_{jt}(I(x)) + \beta_4 E_{jt}(I(x))1_{\{x \geq \bar{x}_I\}}$$

where the coefficients are:

$$\beta_0 = -\frac{\sigma}{\sigma-1}\left[\overline{\Phi}_I \frac{\Psi + (1-\rho_I)K_I}{\overline{\Phi}_I + \delta(1-\rho_I)-1}\right]$$

$$\beta_1 = -\frac{\sigma}{\sigma-1}\overline{\Phi}_N < 0$$

$$\beta_2 = -\frac{\sigma}{\sigma-1}(\overline{\Phi}_I - \overline{\Phi}_N) < 0$$

$$\beta_3 = \frac{\sigma}{\sigma-1}\left(\frac{\overline{\Phi}_N}{\overline{\Phi}_N + \delta(1-\rho_N)-1}\right) > 0$$

$$\beta_4 = \frac{\sigma}{\sigma-1}\left(\frac{\overline{\Phi}_I}{\overline{\Phi}_I + \delta(1-\rho_I)-1} - \frac{\overline{\Phi}_N}{\overline{\Phi}_N + \delta(1-\rho_N)-1}\right) < 0$$

The sign of β_0 is undetermined since the sign of Ψ may be either positive or negative depending on different values of the model parameters. Therefore, the sign of the coefficient on the innovation indicator, $\beta_0 + \beta_2 C$, is undetermined. It is clear from the derivation earlier that

$\Phi_N > 1$ and $\Phi_I > \Phi_N$, which implies that β_1 and β_2 are both negative, and β_3 is positive. Since it is assumed that innovation has higher or equal default risk as producing without innovation ($\rho_I \geq \rho_N$), it follows that $\beta_4 < 0$.

In estimating the regression equation above, I add two transformations. First, I scale all continuous regression variables by the firm's employment. This helps me to control for the scale effect where a large firm tends to have both large revenues and high interest payments simply because it operates on a larger scale. In addition, I take the natural logarithm of all the scaled continuous variables to smooth out the distribution and for the purpose of comparison, to also obtain a regression that is more similar to the traditional production function. Secondly, I also include additional control variables that may affect a firm's revenues or profits. Specifically, while not in the estimating equation derived from the theoretical model, the logarithm of capital intensity and employment are included to control for the roles of production factors. I also include sector and time dummies to control for differences between sectors and changes in the macroeconomic environment. Thus, the baseline regression equation to be estimated using the Vietnamese SME data set is as follows:

$$
\begin{aligned}
\ln\left(\frac{y_{it}}{L_{it}}\right) = \alpha_0 + \alpha_1 \frac{\text{InterestPayment}_{it}}{L_{it}} + \alpha_2 \text{Innovation}_{it} \\
+ \alpha_3 \text{Innovation}_{it} * \frac{\text{InterestPayment}_{it}}{L_{it}} + \alpha_4 \ln\left(\frac{K_{it}}{L_{it}}\right) + \alpha_5 \ln(L_{it}) \\
+ \alpha_6 S_{it} + \alpha_7 T_t + \eta_i + \varepsilon_{it}
\end{aligned}
\tag{3.15}
$$

In the regression specification above, the subscripts i and t denote firm and time subscripts respectively. The regressand is either the natural logarithm of a firm's revenues or the natural logarithm of a firm's gross profits per worker. *Interest Payment* is the firm's formal interest

payment, *K* and *L* are the firm's capital and labor, and *Innovation* is the innovation indicator. The subscript *i* and *t* are firm and time subscripts. Thus, in effect, the estimating equation is an augmented scaled production function. While the estimating equation is an identity, an error term is included in the regression equation. The error term of the estimating equation includes two components: a time-invariant firm-specific effect η_i and an idiosyncratic error term ε_{it} that follows a normal distribution $(0, \sigma_\varepsilon^2)$.

It follows from the discussion above that in the above regression equation of the firm's revenue, the coefficient on the interest payment per worker is positive while the coefficient on the interaction term between the interest payment per worker and the innovation indicator is negative. The model does not provide a conclusive prediction on the sign of the coefficient on the innovation indicator. However, I expect that the sign of this coefficient is positive as innovation tends to increase a firm's performance. The coefficient of the logarithm of capital-labor ratio is expected to be positive since capital is expected to have a positive impact on firm's revenues. The coefficient on the logarithm of labor would be positive (negative) if the production function exhibits increasing (decreasing) returns to scale.

The survey includes information on whether the firm engages in each of three types of innovation activities in the time period between previous and the current survey waves: (1) introducing new products (a different ISIC 4-digit code), (2) making major improvements on the same product or changing specification (within an ISIC 4-digit code), and (3) introducing a new production process or new technology. I constructed the innovation indicator based on whether the firm engaged in activity (2), hereafter called innovation of an existing product. While this definition of innovation does not measure the introduction of radically new product or new

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technology, it is nonetheless more relevant to small and medium firms in developing countries such as Vietnam whose technology is behind the technology frontier.

While the regression equation is derived directly from the theoretical model, for empirical considerations, one may raise concerns about the choice of interest payment per worker as a proxy for credit access. In the theoretical model, there is credit rationing where firms can only obtain a loan amount that is smaller than they need. Therefore, larger debt and interest payment implies that a firm is less credit constrained. However, it is possible that in empirical setting, there is a non-monotonic relationship between a firm's debt (interest payment) and its degree of credit constraint. For example, while high formal interest payments may signal higher credit availability to the firm, a firm with a too high interest payment per worker may actually be in financial distress and thus, face tight credit constraint. I would argue that this concern is raised in the context of firms in developed countries and does not apply to the data set I am using. The firms in my data are small and medium enterprises (SMEs); it has been well-documented in the empirical finance literature that these small firms face higher credit constraint than larger firms. In addition, case studies and interviews have shown that banks in Vietnam are very risk-averse and reluctant to lend to small firms (Malesky and Taussig 2008). Because of this context, I believe that in the case of my data, higher values of formal interest payment per worker are unambiguously positively associated with lower degrees of credit constraint.

The second concern is the problem of distinguishing high interest payments that are due to a large loan amount from those that are due to high loan interest rates. The first group of firms is less likely to be credit constrained since they can borrow a large amount while the second group is more likely to be credit constrained due to the high costs of borrowing. This concern is only valid if there is a large variation in the loan interest rate among firms that borrow or if the real

interest rate is very high. As can be seen in Table 3.1.1 and Table 3.2.3, real interest rate is very

low in Vietnam during the period of 2005-2008. This suggests that high costs of borrowing (as in

high real interest rate) was not an issue in this time period. Furthermore, it seems that the real

interest rate did not vary much for firms in the data set I analyze as can be seen in the summary

statistics of the interest rate for the most important current formal loans for firms in the data set

(see Table 3.2.3 and Figure 3.1).[68] Table 3.2.4 provides regression results of the determinants of

the interest rate for the most important current formal loans. The estimation results indicate that

the interest rate for the current most important formal loan does not vary across firm size

categories and other firm characteristics such as age, ownership forms, and whether the firm has

land ownership, etc.[69] This further confirms that there was little variance in the loan interest rate

across firms in the data. This result is expected since 67% of the firms in the data set indicate that

their most important formal loans (in terms of values) are from state-owned commercial banks.

Because state-owned banks are more likely to follow lending regulations, I believe that a large

proportion of loans for firms in the Vietnam's SME data set has a loan interest rate that is very

similar. The statistics of the lending interest rate in Vietnam for the period 2005-2008 also

confirms that there is little change in the lending rate as argued in Rand (2009) and indicated in

the World Development Indicator's statistics of nominal lending rate (see Table 3.1.1). While the

State Bank of Vietnam (SBV) did change the lending interest rate significantly in 2008, during

the period of May 2008 to the end of 2008, the SBV also required that banks must not set lending

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[68] The data set I use in this paper does not have comprehensive information on banks' loan interest rate. However, it does have information on monthly interest rate for the most important (in terms of value) current formal loans. I calculated the nominal interest rate for firms in the data set based on this information.

[69] In fact, the regression results indicate that loan interest rate only depends on location and year. The loan interest rate, on average, is higher in wave 2, which agrees with the macroeconomic statistics of the increase in nominal lending rate in 2008.

interest rates over 150% of the base interest rate announced by the SBV. This implied that there was small variation in the formal loan interest rate across firms during this period.

Furthermore, to allow for the effect that changing credit conditions caused by joining the WTO in 2007 and by the global financial crisis in 2008 changed the interest rate or affect the credit constraint, I also estimate the specification where an interaction term between the interest payment per worker and the time dummy is added to the baseline regression equation.[70] The result of this regression is presented in column 3 and 4 of Table 3.3.

To estimate the baseline regression, i.e., equation (15), I use a fixed-effect OLS estimation for panel data with the standard error corrected for clustering at the firm level. This allows me to control for time-invariant unobservables. However, an important estimation issue with equation (15) is the possible endogeneity of the interest payment per worker and the innovation indicator. For example, there may be unobserved factors that affect both a firm's revenues (profits) and its interest payments. This could be an unobserved shock to the firm's revenue that also negatively affects the firm's interest payments, or unobserved time-varying firm characteristics that may influence both the firm's credit access and its revenue. Similarly, unobserved firm characteristics or shocks may affect both the firm's revenue (profits) and its innovation activities.

It should be noted that the fixed-effect method has eliminated time-invariant unobserved heterogeneity. Therefore, the fixed-effect estimation results for the baseline regression are only biased if there is some unobserved time-variant factor that affect both firms' revenues (or profits)

---

[70] While I would like to also add the interaction term between the interest payment per worker, the innovation indicator, and the time dummy to see whether the differential credit constraint between innovating and non-innovating firms was changed by the change in the credit situation, this interaction term is highly correlated with other regressors and causes the estimation to be imprecise when added to the regression specification. For this reason, I choose to add only the interaction between interest payment per worker and time dummy.

and interest payment or innovation. I believe that the endogeneity problem is less serious for

interest payments since they include interest payment on loans from previous periods and thus,

are mostly pre-determined. In addition, the number of firms in the sample that had failed to

service its debts on time is very small. This suggests that it is unlikely that unobserved negative

shocks to firm production affected the values of interest payments for the firms in the data.

To address the endogeneity issue, I estimated two endogenous switching regressions where

the endogenous switching variable is either a constructed credit constraint indicator or the

innovation indicator defined above. As explained earlier, I believe that the relationship between

the formal interest payments per worker and the degree of credit constraint for a firm is

monotonic. Therefore, for firms in my data set, I believe the higher the formal interest payment

per worker, the lower the degree of credit constraint is for a firm. Thus, I constructed a credit

constraint indicator such that the indicator takes a value of one if the firm's formal interest

payment per worker is greater than the 80th percentile of the variable in the same sector and the

same survey wave.[71]

The endogenous switching regression accounts for self-selection into credit constraint or

innovation. By explicitly modeling the credit constraint status, the switching regression method

is more coherent in methodology. Because the switching regression method does not treat each

observation as definitely in the credit constrained or the unconstrained group, intuitively, its

results should be "more robust than the results from the sample splitting method that directly use

a proxy for the credit constraint status" and thus, may generate more power in statistical tests

(Guo 2009). The latter method may suffer from "sensitivity caused by arbitrarily choosing and

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[71] Defining by sector and year allows me to control for possible different financial needs across sectors and different financial environment in the Vietnamese economy across years.

shifting a threshold value" (Guo 2009). Another advantage of the switching regression method is that multiple variables can be used to predict whether firms are credit constrained or unconstrained in the selection equation. In contrast, the method of splitting the sample according to a priori characteristics is based on one characteristic at a time.

With that being said, one disadvantage of the switching regression is that there is a danger of misspecification error because the model requires making additional parametric distribution assumptions. Within this paper's context, another disadvantage of the switching regression approach is that the model's set-up does not allow for exploring the impact of the interaction term between the endogenous switching variable and another regressor. This means that the interaction between the credit constraint indicator (or interest payments per worker) and the innovation indicator cannot be examined using the endogenous switching regression framework.

The specification of the endogenous switching regression with the endogenous switching variable being the credit constraint status, hereafter called the credit constraint endogenous switching regression, is as follows:

$$\ln\left(\frac{y_{it}}{L_{it}}\right) = \alpha_1 + \alpha_2 \ln\left(\frac{K_{it}}{L_{it}}\right) + \alpha_3 \ln(L_{it}) + \alpha_4 CC_{it} + \alpha_5 Innovation_{it}$$
$$+ \alpha_6 S_{it} + \alpha_7 T_t + \mu_{1i} + \varepsilon_{1it}$$

(3.16)

$$CC_{it}^* = Z_{it}' \beta + \mu_{2i} + \varepsilon_{2it}$$

with

$$CC_{it} = 1 \text{ if } CC_{it}^* \geq 0$$
$$CC_{it} = 0 \text{ if } CC_{it}^* < 0$$

where μ_{1i} and μ_{2i} are unobserved firm heterogeneities, ε_{1it} and ε_{2it} are idiosyncratic error terms and are assumed to follow a bivariate normal distribution with means zero. S and T are sector and time dummies. CC is the credit constraint status and CC^* is its latent variable. As described above, the credit constraint indicator is defined to take value of one if the firm's formal interest payment per worker is less than the 80th percentile in its sector and survey wave, and take value of zero otherwise. If credit constraint has negative impact on firm's revenues and profits even after controlling for self-selection, one would expect the estimate for the coefficient of the credit constraint indicator to be statistically significant and negative.

In panel data setting, it is very likely that the unobserved heterogeneities, μ_{1i} and μ_{2i} , are correlated with the regressors, and thus, would lead to inconsistent estimates. To address this issue, I model the unobserved time-invariant heterogeneity as a function of the initial value of the regressand, defined as the value from survey wave 2005, and the averages across the time of each regressor. In other words, I assume the following:

$$
\begin{aligned}
\mu_{1i} &= \gamma_1 + \alpha_1 y_{i0} + \overline{X}_i \delta_1 + a_{1i} \\
\mu_{2i} &= \gamma_2 + \alpha_2 CC_{i0} + \overline{z}_i \delta_2 + a_{2i}
\end{aligned}
\tag{3.17}
$$

The error terms a_{1i} and a_{2i} are assumed to follow a bivariate normal distribution with means zero and covariance matrix Ω, and are assumed to be independent of all the regressors. γ_1 and γ_2 are intercept terms. $\overline{X}_i$ and $\overline{z}_i$ are vectors of averages over time of the regressors for firm i in the main regression and the credit constraint equation, i.e. $\overline{X}_i = \left(\sum_{t=1}^{T} X_{it} \right)/T$ and

$\overline{Z}_i = \left(\sum_{t=1}^{T} Z_{it} \right)/T$. y_{i0} and CC_{i0} are values of the main dependent variable y (the natural

logarithm of revenues or gross profits per worker) and the credit constraint status in period $t=0$, which is defined as the survey wave in 2005.

Substituting (3.17) into equation (3.16) yields the credit constraint endogenous switching regression equation to be estimated:

$$
\ln\left(\frac{y_{it}}{L_{it}}\right) = (\alpha_1 + \gamma_1) + \alpha_2 \ln\left(\frac{K_{it}}{L_{it}}\right) + \alpha_3 \ln(L_{it}) + \alpha_4 Innovation_{it} + \alpha_5 CC_{it} + \alpha_1 y_{i0}
$$
$$
+ \overline{X}_i \delta_1 + (a_{1i} + \varepsilon_{1it}) \tag{3.18}
$$
$$
CC_{it}^* = (\theta + \gamma_2) + Z_{it}' \beta + \alpha_2 CC_{i0} + \overline{Z}_i \delta_2 + (a_{2i} + \varepsilon_{2it})
$$

with

$$
CC_{it} = 1 \text{ if } CC_{it}^* \geq 0
$$
$$
CC_{it} = 0 \text{ if } CC_{it}^* < 0
$$

The endogenous switching regressions are estimated using the maximum likelihood method with the standard errors clustered by firm. Since the new error terms are now uncorrelated with the regressors, estimation of the above regression yields consistent estimates. Note that in this approach, the effects of time-constant regressors are indistinguishable from the effect of the unobserved heterogeneities. For this reason, even though time-constant regressors can be included, I can only obtain estimates of the effects of time-varying regressors. Furthermore, this approach requires a balanced panel and initial values from survey wave 2005 so the regression sample is restricted to a subsample of firms that were in all of three survey waves 2005, 2007 and 2009.

The set of regressors in the selection equation into credit constraint, Z, includes an intercept term and all the regressors in the main regression of revenue or profit per worker. Specifically,

capital intensity is used to capture whether firms using different technologies may have different levels of ease in access to credit. The natural logarithm of employment captures the effect of firm size on access to credit. The innovation indicator captures whether credit constraint is different for innovating firms. Sector and time dummies are included to control for sector and time fixed effects. In addition, Z incorporates a number of financial variables to account for different channels in which financing frictions may be present: the ratio of formal short-term debts to physical capital, the ratio of formal long-term debts to physical capital, and trade credit dummies (an indicator of whether the firm had an outstanding balance owed to its customers, and an indicator of whether the firm had an outstanding balance owed by its customers). To control for the possibility that firms of different ownership forms may have different levels of ease of credit access, Z also includes firms' ownership forms such as household enterprise, and limited liability companies. Finally, two measures of a firm's network that may influence its credit access are included: the number of bank officials and the number of politicians and civil servants in its network. The latter network variable is included because politics may influence banks' lending decisions.

Following the same approach, the endogenous switching regression with the switching variable being the innovation indicator, hereafter called the innovation endogenous switching regression, is specified as follows:

$$\ln\left(\frac{y_{it}}{L_{it}}\right) = \beta_1 + \beta_2 \ln\left(\frac{K_{it}}{L_{it}}\right) + \beta_3 \ln(L_{it}) + \beta_4 \frac{IP_{it}}{L_{it}} + \beta_5 Innovation_{it} + \beta_6 S_{it} + \beta_7 T_t$$

$$+ \beta_8 \ln\left(\frac{y_{i0}}{L_{i0}}\right) + \bar{X}_i \eta_1 + (b_{1i} + \varepsilon_{1it}) \tag{3.19}$$

$$Innovation_{it}^* = \lambda_1 + z_{it}' \gamma + \lambda_2 Innovation_{i0} + \bar{z}_i \eta_2 + (b_{2i} + \varepsilon_{2it})$$

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with

$$Innovation_{it} = 1 \text{ if } Innovation_{it}^* \geq 0$$
$$Innovation_{it} = 0 \text{ if } Innovation_{it}^* < 0$$

In the specification above, y denotes either revenues or gross profits. K, L, and IP denote a firm's physical capital stock, employment, and formal interest payments respectively. S and T are sector and time dummies. b_{1i} and b_{2i} are unobserved firm heterogeneities that are uncorrelated with the regressors, ε_{1it} and ε_{2it} are idiosyncratic error terms that are assumed to follow a bivariate normal distribution with means zero. *Innovation* is the innovation indicator and *Innovation** is its latent variable.

The set of variables that explains selection into innovation (z) includes all the regressors in the main regression, except for innovation. The natural logarithm of employment is included to capture the size effect on innovation. Capital intensity is included as a proxy for the impact of different production technology on the innovation propensity. Formal interest payment per worker is included to capture possible effect of credit constraint on the innovation propensity. Time and sector dummies are included to control for time and sector's fixed-effects.

In addition to the regressors of the main regression, firms' ages are included to capture the possible effect of age on innovation. Additional variables that capture competitive pressures and firm's expectation of the impact of future trade liberalizations in the next one to three years are included in the selection equation to capture the effect of current competitive pressures and anticipated future competition on the innovation propensity. The four competition indicators indicate whether firms perceived that they faced competition from state enterprises, non-state enterprises, legal imports, and smuggling respectively. The expectation indicators show whether

firms expected that future trade liberalization would lead to increased labor costs, higher demand for the firm's products, higher competition with Vietnamese small and medium enterprises, increase in the firm's exports, more competition from increased imports, easier access to credit and capital, and/or easier access to modern technologies. An indicator of membership in a business association is included to capture the effect of idea sharing within a business association that may lead to innovation. Dummies of ownership forms are also included to control for different propensities to innovate among enterprises of different forms of ownership.

In summary, three regressions will be estimated: a baseline regression using the fixed effect method, the credit constraint endogenous switching regression, and the innovation endogenous switching regression. These estimation results are presented in Section 4 (*Empirical Results*). As argued above, the endogeneity of the innovation indicator is probably more severe than that of the interest payments or the credit constraint indicator. Therefore, I consider the estimation results from the innovation endogenous switching regression to be the main result as it accounts for the endogeneity of innovation.

4. Empirical Results

4.1. Suggestive Direct Evidence for Credit Constraint

The survey has some questions that provide suggestive direct evidence of the existence of a firm financing constraint. 31% of the firms in the regression sample (or equivalently, 38% of the firms that indicate facing some constraints to growth) considered shortage of capital/credit as the most important constraint to their growth. Indeed, shortage of capital/credit outnumbers other constraints to growth (see Table 3.1.3).

4.2.   Estimation Results

Table 3.3 presents the fixed-effect estimation results of the baseline regression. All of the coefficients have the expected signs and statistical significance. Capital and employment both have significant effect on firm's revenue or profits. The negative sign on the natural logarithm of employment indicates that the production function for the firms in the sample exhibits decreasing returns to scale. Innovating firms, on average, have higher revenue and profits. An increase in interest payments per worker is associated with a positive and statistically significant increase in revenues and profits per worker. This result suggests that firms in the data set, on average, faced a binding credit constraint. The estimate of the coefficient on the interaction term between the interest payment per worker and innovation is statistically significant and negative, which is in line with the theoretical model's predictions that credit constraint is, on average, tighter for innovating firms. The coefficient on the interaction between the interest payment per worker and time dummy is insignificant, and the magnitude of the coefficient estimates are very similar between when this interaction was included and when it was excluded. These two results suggest that the credit constraint for Vietnamese SMEs, on average, did not change between 2005/2006 and 2007/2008. This could be that regulations on lending rate made the impact channel through changing loan interest rate insignificant. On the other hand, it could be that the effect of credit growth in 2007 and increased credit constraint in 2008 cancelled each other and led to a significant net effect.[72]

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[72] It should be noted that as part of its response to the 2008/2009 global financial crisis, the Vietnamese government implemented a subsidized bank loan interest rate for selected enterprises. However, this scheme only started to be implemented in 2009, past the time period that the data set used in this chapter covers.

Table 3.4.1 presents the estimation results of the credit constraint endogenous switching regression. The estimation results indicate that initial revenue (profits) is positively correlated to current revenue (profits). Innovation of existing products is associated with higher revenues and profits. Both capital and labor have significant and positive impact on firms' revenue and profits, and the production function is decreasing returns to scale. Firms that are credit constrained have lower revenue and profits per worker and this difference is statistically significant.

In terms of selection into credit constraint, capital intensity, the number of bank officials in the firm's network, the ratio of (long-term or short-term) debts over total assets are all negatively correlated with the likelihood a firm is credit constrained. These are all expected results suggesting the importance of collateral and network with bank officials in reducing firms' credit constraint. In addition, firms that had outstanding debts from their clients are less credit constrained. While this result may seem surprising at first, it is consistent with the story that firms that did not face tight credit constraint were in a position to extend trade credits to their clients. Credit constraint status is persistent as shown by the significant and positive estimate of the coefficient on the initial credit constraint status.

Table 3.4.2 provides results of the robustness checks when the credit constraint endogenous switching regression was re-estimated using different cutoffs of the interest payment per worker (by sector and survey wave) other than the 80th percentile to construct the credit constraint indicator. The estimation results all point to a negative impact of credit constraint on firms' revenues and profits per worker. Furthermore, the magnitude of the effect of credit constraint monotonically increases with the percentile cutoff. Therefore, the estimation results in Table 3.4.2 support the assumption adopted in the empirical estimation that the degree of credit constraint is monotonically decreasing in the value of interest payment per worker.

Table 3.4.3 presents the estimation results of the innovation endogenous switching regression. Again, the estimation results indicate that an increase in interest payment on formal loans is associated with an increase in revenue and profits per worker. This result points to the positive effect of relaxing credit constraint, through increased bank financing, on firms' revenues and profits. Innovation of existing product is associated with an increase in revenues and profits. As expected, capital and labor has significant effect on firms' revenue and profits, and the production function also exhibits decreasing returns to scale. Revenues and profits per worker are persistent since their current-period values are found to be significantly correlated with their initial values.

In terms of selection into innovation, initial engagement in innovation is associated with higher propensity to innovate. This is consistent with the story of the persistence of innovation due to the large sunk costs of undertaking innovative activities. Larger as well as younger firms are more likely to innovate. Limited liability firms also have higher innovation propensity. Furthermore, membership in a business association increases the likelihood of innovation. This suggests the presence of sharing of knowledge and ideas among members between members of a business association. The sharing of information is likely to give firms' managers more innovative ideas and thus, increases the likelihood of innovation. Furthermore, firms that expected that trade liberalization would bring increased access to capital and credit were more likely to innovate, suggesting that credit constraint may have a negative impact on firm's innovation decision. Furthermore, interest payment per worker is positively related to the innovation propensity in the selection equation of the endogenous switching regression of firm's revenue per worker but is statistically insignificant for the endogenous switching regression of firm's profits per worker. This result also indicates that there may be some negative effect of

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credit constraint on the innovation propensity. In the selection equation of the endogenous switching regression of profits per worker, firms' expectation of increased competition from imports following trade liberalization is associated with higher innovation propensity. This suggests that anticipated competitive pressure may push firms to innovate. An unexpected result is that a firm's perception of the existence of (current) competition from legal imports is associated with lower innovation propensity. This may seem counterintuitive at first but it is consistent with the story that fierce competition from imports can result in a steep decline in the firm's financial resources, which makes it more difficult for these firms to fund their innovative projects.

In summary, the estimation results from the three regressions above all point to a negative impact of credit constraint on a firm's revenue and profits per worker. In addition, the estimation results from the baseline regression indicates that innovating firms are more credit constrained, and the results from the innovation endogenous switching regression suggest that credit constraint has a negative impact on a firm's propensity to innovate.

5. Robustness Checks

5.1. Addressing the Reverse Causation Concern by Estimating a Regression in the Reverse Causation Direction

There is a valid concern about the possibility of reverse causation where the causation runs from firm's revenues (or profits) to interest payment rather than in the other direction as hypothesized in this paper. Since application for formal loans usually take a long time and the interest payments are made on debts that already existed, it is more likely that lagged revenue (instead of current period's revenue) would be correlated with the interest payment if the

causation is in the reverse direction. To explore whether this reverse causation exists in the Vietnamese SME data set, I estimate the following regression:

$$\frac{IP_{it}}{L_{it}} = \beta_0 + \beta_1 \ln\left(\frac{y_{i,t-1}}{L_{i,t}-1}\right) + \beta_3 S_{it} + \beta_4 T_t + \mu_i + \varepsilon_{it}$$

The regression above examines whether a firm's lagged revenues or profits per worker affect its form interest payment per worker controlling for sector and time fixed-effects, *S* and *T* respectively. The error term of the regression equation consists of a time-invariant firm's fixed effect μ_i and an idiosyncratic error ε_{it}.

The fixed-effect estimation results of the regression equation above suggest that the lag of revenues (profits) per worker has insignificant impact on the interest payments per worker (see Table 3.5). This gives some confidence that reverse causation may not be a serious problem in the data set used in this paper.

5.2. Controlling for Self-Selection into Credit Constraint Status using Matching Approach

Ideally, we would like to compare the outcomes (revenues and profits per worker) for a firm when it is credit constrained versus when it is not. However, in reality, we just observe the outcome for only one credit constraint status. Matching provides the counterfactual of firms that are "close enough" to the credit-constrained firms and thus, allows the comparison of the impact of credit constraint among firms with similar observable characteristics.[73] For this reason, matching helps to eliminate (or at least alleviate) the self-selection problem and makes it more

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[73] The matching model to estimate treatment effects was originally applied to evaluate the effect of a medical treatment or program participation. However, as pointed out in Wooldridge (2003), matching is always applicable when the explanatory variable of interest is binary.

credible to interpret the remaining difference in the outcomes after matching as being caused by credit constraint. In addition, matching does not require making an assumption about the functional form of selection into credit constraint, or about the functional form of the outcome. The matching estimator also allows for heterogeneous effects of the matching covariates, i.e. observable characteristics that matching is based on, on the outcome variables.

To avoid the dimensionality problem of matching over a large set of covariates, I used propensity score matching. The average treatment effect I focus on is the average treatment effects on the treated (ATT) since this average treatment effects gives an estimate of the effect of credit constraint for credit constrained firms. The ATTs of interest are the estimates for the firm's revenues per worker or profits per worker and the change in these variables, where the latter approach is essentially combining matching with difference-in-difference. It should be noted that if the firm's unobserved heterogeneity are time-invariant or if the unobservable only affects either the treatment assignment or the outcomes, matching with difference-in-difference will be unbiased.[74] The set of covariates used in matching will be presented in Section 4.4.2.1.

5.2.1. Matching Covariates

For the matching estimator to be unbiased, two assumptions need to be satisfied. The first assumption is the unconfoundedness assumption which requires that there is no difference in the unobservable between the treated and control group. For the matching with difference-in-difference approach, the equivalence of this assumption is that there is no unobservable that affects both the treatment assignment and the growth rate of the outcome variables. The second

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[74] In the context of this paper, an example where this assumption holds is if we believe that banks do not make lending decisions based on the firm's productivity and thus, firms' productivity levels only affect their revenue or profit but do not affect whether the firms are credit constrained.

assumption is the common support assumption which requires that the distributions of the treated and matched control overlap. While the first assumption cannot be tested, I choose the set of matching covariates to best control for possible heterogeneity between the treated and control group that is not caused by the treatment so that the unconfoundedness assumption is less likely to be violated. To examine whether the second assumption holds, I ensure that the propensity scores used in the matching satisfied the balancing test.

Table 3.6 provides the list of the covariates used in matching. The matching covariates are variables from survey wave 2007. The credit constraint indicator as well as the outcome variables are from wave 2009. This timing ensures that the matching covariates are not intermediate outcomes that were affected by the treatment. It should be noted that because of this timing, only firms that existed in both survey waves 2007 and 2009 were included in the matching.

I choose to include lagged outcomes, i.e. the lag of revenues per worker or lag of profits per worker, in the set of matching covariates to further control for the case where the unobservable may be serially correlated. Therefore, including lagged outcomes as matching covariates makes it more likely that the unconfoundedness assumption holds. For example, if productivity is not observed and less productive firms are also less likely to obtain loans, including the lagged revenue or profits would control for part of the difference among firms in the unobserved productivity levels. In addition, by including these lagged outcomes as matching covariates, I also partially address the concern of reverse causation where large revenue leads to higher interest payment instead of the other way around. If large revenue does lead to higher interest payments because of the scale effect where large firms also borrow more, including pre-treatment revenue and employment in the set of matching covariates should control for most of

this effect. Therefore, if the average treatment effects after this matching indicate significant differences in the performance of credit constrained and unconstrained firms, it is then more plausible to interpret this difference as being caused by credit constraint.

5.2.2. Matching Results

The matching and estimation of the average treatment effect on the treated (ATTs) are conducted using the new command *teffects* available in Stata 13. This command yields consistent standard errors for the estimates of the average treatment effects. For details on how to obtain these consistent standard errors, see Abadie and Imbens (2008, 2011). A logistic model was used to calculate the propensity scores used in the matching. Although not reported, the test results indicated that the estimated propensity scores satisfy the balancing test.

Table 3.7 presents the results from the logistic regression that estimates firms' credit constraint propensity. The credit constraint indicator was coded based on information from the 2009 survey wave while the regressors are all lags, and are information from the 2007 survey wave. Although the adjusted R-squared value of the logistic regression is not high ($R^2=0.16$), it is in the range of many other studies using propensity score matching. In addition, it has been argued in the literature that the logit (probit) regression used in calculating the propensity scores for matching is not a determinant model so its test statistics and adjusted R^2 are not informative and may be misleading (Khandker et al. 2010, p58).

The results in Table 3.7 indicate that lags of revenue per worker and employment were negatively associated with the likelihood that a firm was credit constrained. A firm that had extended credits to clients were less likely to be credit constrained. Firms with more bank officials in the firm's network or had have previous relationship with the main creditor were also

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less likely to be credit constrained. Firms in rural areas tended to be less constrained. This may be due to the fact that Vietnamese government had some preferential lending programs for firms in rural areas. Finally, firms that had expected that future trade liberalization would lead to increased credit access were less likely to be credit constrained.

Table 3.8 presents the estimates of the average treatment effects on the treated (ATTs), including the estimates of the ATTs for important pre-treatment variables (variables with names ending in 1). Any statistically significant difference between the treated and control group in these statistics would suggest that the self-selection problem may not be controlled for completely. In addition, if the lagged outcome affects current outcomes, any difference in the lagged outcome will further bias the matching estimator. The estimation results suggest that credit constraint has a negative impact on the change as well as post-treatment values of the firm's revenue (profits) per worker. The ATTs for all of the pre-treatment variables are insignificant. This increases my confidence that the estimated ATTs are not simply caused by unobserved firm heterogeneity that had a persistent effect on the firm's revenue (profits) per worker.

V.   Conclusion

Innovation is an important channel through which developing countries can grow and catch up with developed countries. In this paper, I ask the question of whether firms in developing countries face binding credit constraint, and whether innovating firms face higher credit constraint. To answer this question, I build a theoretical model where asymmetric information results in credit constraint for firms. Constrained access to bank loans leads to a lower output level compared to the first-best solution. The asymmetric problem is higher for innovating firms

because of the higher risks in their projects. Therefore, my model also implies that, other things being equal, innovating firms face tighter credit constraint than firms that do not innovate. An estimating equation derived from the theoretical model predicts a positive relationship between a firm's formal interest payment per worker and its revenues (profits) per worker. Furthermore, the estimating equation predicts a significant and negative coefficient on the interaction term between the interest payment per worker and the innovation indicator. The empirical estimation confirms these predictions. To address the issues of endogeneity and reverse causation, I estimated endogenous switching regressions where the switching variable is either a constructed credit constraint indicator or an innovation indicator. In addition, I conducted several robustness checks, including estimating the regression in the reverse direction and estimating the average treatment effects using the matching approach. The estimation results from these robustness checks confirm a significant and negative impact of credit constraint on firms' revenues and profits per worker.

Overall, this paper's empirical results suggest that in developing countries, financial institutional development is important for increasing innovation through lowering credit constraint for firms that choose to implement innovative projects. Since innovating firms face significantly higher credit constraint due to the nature of innovative activities, this paper's results also suggest that it may be beneficial for financial institutions to customize lending practices for innovative projects. Several future extensions of the paper are possible. For example, future work could include extending the theoretical model to a dynamic model. Availability of more and better quality data would allow for a quantitative estimation of the credit gap, and for testing whether this credit gap is higher for innovating firms.

Table 3.1.1 – Some Macroeconomic and Credit Indicators for the Vietnamese Economy during 2005-2008

	2005	2006	2007	2008
Domestic credit to private sector by banks (% of GDP)	60.47	65.36	85.64	82.87
Listed domestic companies, total	33	102	121	171
Market capitalization of listed companies (% of GDP)	0.80	13.70	25.24	9.67
Inflation, consumer prices (annual %)	8.28	7.39	8.30	23.12
Lending interest rate (%)	11.03	11.18	11.18	15.78
Real interest rate (%)	1.67	2.40	1.41	-5.62
Business extent of disclosure index (0=less disclosure to 10=more disclosure)	3	3	6	6
Credit depth of information index (0=low to 6=high)	3	3	3	4
Private credit bureau coverage (% of adults)	0	0	0	0
Public credit registry coverage (% of adults)	1.1	2.7	9.2	13.4
Strength of legal rights index (0=weak to 10=strong)	6	6	8	8
Time to resolve insolvency (years)	5	5	5	5
Nonperforming loans (NPLs) to total loans (%)		2.6	1.5	3.0
NPLs net of provisions to capital		12.4	-1.5	3.9

Notes: Data are from the World Bank's World Development Indicators Database, except for the last two rows, which are from: Vietnam's Key Financial Soundness Indicators. Statistics for 2008 are estimates from the end of October 2008. http://www.imf.org/external/pubs/ft/scr/2009/cr09110.pdf

Table 3.1.2 – Innovation Activities of Enterprises

	Yes	No
Product Innovation	192	4815
Innovation of an Existing Product	2156	2851
Process Innovation	730	4277
Innovation (engaging in at least any of the 3 innovation activities above)	2339	2668

Notes: N=5007. Source is author's own calculation from the Vietnamese Medium and Small Enterprises administered by the Department of Economics of the University of Copenhagen. Product Innovation is introduction of a new product (a different ISIC 4-digit code). Innovation of an Existing Product is defined as making major improvements on the same product or changing specification (within an ISIC 4-digit code). Process Innovation is defined as introduction of a new production process or new technology. All innovation measures are for the past two years.

Table 3.1.3 – Number of Enterprises by Province

Province	Frequency	Percent
Ha Noi	561	11.2
Phu Tho	500	9.99
Ha Tay	750	14.98
Hai Phong	403	8.05
Nghe An	705	14.08
Quang Nam	302	6.03
Khanh Hoa	181	3.61
Lam Dong	150	3
Ho Chi Minh City	1,212	24.21
Long An	243	4.85
Total	5,007	100

Notes: Source is author's own calculation from the Vietnamese Medium and Small Enterprises administered by the Department of Economics of the University of Copenhagen.

Table 3.1.4 – Most Important Constraint to Firm Growth

Most Important Constraint to Growth	Frequency	Percent
Shortage of capital/credit	1,546	30.88
Cannot afford to hire wage labor	32	0.64
Lack of skilled workers at the local job	141	2.82
Lack of technical know-how	63	1.26
Current products have limited demand	719	14.36
Too much competition/unfair competition	563	11.24
Lack of marketing or transport facilities	122	2.44
Lack of modern machinery/equipment	129	2.58
Lack of raw material	129	2.58
Lack of energy (power, fuel)	10	0.2
Inadequate premises/land	417	8.33
Too much interference by local authorities	17	0.34
Uncertain government policies	78	1.56
Difficult to get licenses/permissions	11	0.22
Other constraints	69	1.38
No constraint to growth	958	19.13
Missing information	3	0.04
Total	5,007	100

Notes: Source is author's own calculation from the Vietnamese Medium and Small Enterprises administered by the Department of Economics of the University of Copenhagen.

Table 3.2.1 – Summary Statistics (2005-2008)

Variable	Mean	Std. Dev.	Min	Max
Employment	17.4283	80.87406	1	5007.5
Physical Capital	1263.259	5270.966	0.306311	282951.5
Revenue	1358.131	6496.925	1.914833	229417.4
Gross Profits	212.4165	1364.322	-93.461	80711.73
TFP	11.31746	14.60451	0.280424	543.1218
Formal Interest Payments	19.33891	276.8149	0	15609.17

Notes: Source is author's own calculation from the data set of Vietnamese Medium and Small Enterprises administered by the Department of Economics of the University of Copenhagen. N=5007. Revenue, costs, TFP, and interest payment are in million 1994 VND. TFP values are calculated from the regression of firms' value added using Levinsohn-Petrin method to account for unobserved production shocks.

Table 3.2.2 – Correlation of Key Variables

	ln(Rev/L)	ln(K/L)	ln(L)	IP/L	CC	resid2	I
ln(Rev/L)	1						
ln(K/L)	0.42	1					
ln(L)	0.25	0.11	1				
IP/L	0.14	0.07	0.07	1			
CC	-0.24	-0.13	-0.39	-0.15	1		
resid2	0.14	0.07	0.07	1	-0.15	1	
I	0.15	0.09	0.29	0.03	-0.14	0.03	1

Notes: Source is author's own calculation from the data set of Vietnamese Medium and Small Enterprises administered by the Department of Economics of the University of Copenhagen. N=5007. Rev denotes firm's revenues, P denotes gross profits, K denotes physical capital stock, L denotes employment, IP denotes firm's formal interest payment, resid2 is the residual from the regression of (IP/L) against ln(K/L) and ln(L), and I is an indicator of innovation on existing products. CC is the credit constraint indicator based on the 80th percentile of formal interest payment per worker in each sector and in each survey wave, CC=0 if the firm's formal interest payment is greater than or equal to this 80th percentile, CC=1 otherwise.

Table 3.2.3 – Interest Rate of the Current Most Important Formal Loan

	p10	p25	Median	Mean	p75	p90	sd
Nominal Interest Rate in 2006	8.08	12.42	14.03	13.19	14.71	16.08	2.83
Nominal Interest Rate in 2008	8.08	10.69	12.82	13.61	15.39	19.56	6.79
Change in Nominal Interest Rate	-4.96	-3.07	0	0.40	3.37	7.71	4.76
Real Interest Rate in 2006	1.00	1.04	1.05	1.04	1.06	1.07	0.03
Real Interest Rate in 2008	0.88	0.90	0.92	0.93	0.94	0.97	0.06
Change in Real Interest Rate	-0.16	-0.15	-0.12	-0.12	-0.09	-0.06	0.04

Notes: Source is author's own calculation from the data set of Vietnamese Medium and Small Enterprises administered by the Department of Economics of the University of Copenhagen. The data set only has information on loan interest rate in 2006 and 2008 for the period 2005-2008, and only for the most important loan. Interest rates are annual and in percentage. The change in interest rate is by firm, i.e., the difference in the interest rate of the most important formal loan between 2008 and 2006 for the same firm. Real interest rate is calculated from nominal interest rate using GDP deflator and Fisher formula. sd stands for standard deviation. p10, p25, p75, p90 denote the 10th, 25th, 75th, 90th percentiles respectively.

Table 3.2.4 – Regression of the Interest Rate of the Current Most Important Formal Loan

	(1) Loan Interest Rate b/se	(2) Loan Interest Rate b/se
Micro Firm	0.372	0.129
	(0.33)	(0.31)
Medium Firm	-0.120	-0.452
	(0.30)	(0.46)
Wave 2	0.407[*]	0.664
	(0.20)	(0.46)
Firm Age		-0.005
		(0.01)
TFP		0.003
		(0.01)
Ha Noi		1.165
		(0.93)
Phu Tho		1.435[***]
		(0.43)
Ha Tay		1.602[**]
		(0.55)
Hai Phong		-0.163
		(0.57)
Nghe An		0.100
		(0.43)
Quang Nam		-0.487
		(0.46)
Khanh Hoa		-0.730
		(0.71)
Lam Dong		1.571[**]
		(0.57)
Ho Chi Minh City		0.013
		(0.45)
constant		.
		.
Observations	1805	1803

Notes: Standard errors are clustered by firm. [*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$. Loan interest rate is the annual interest rate for the current most important formal loan (in terms of loan value). There are 3 firm size categories: micro (1-9 workers), small (10-49 workers), and medium (at least 50 workers). Since the data set only includes small and medium enterprises, there are no large firms in the data set. Provincial dummies are Ha Noi, Phu Tho, Ha Tay, Hai Phong, Nghe An, Quang Nam, Khanh Hoa, Lam Dong, Ho Chi Minh City. Excluded province is Long An. TFP is firm's total factor productivity obtained using Levinsohn-Petrin (2003) method. The regression in column 2 also includes the following regressions that have statistically insignificant coefficient estimates: household firm dummy, an indicator of whether the firm is a limited liability company, an indicator of whether the firms does not have a land user rights Certificate of Land Use Rights, an indicator of whether the firm has an outstanding balance owed to suppliers, an indicator of whether the firm has an outstanding balance due from its customers, the firm's network (number of bank officials, and number of politicians and civil servants that are in the firm's network).

Table 3.3 – Fixed Effect Estimation of the Baseline Regression

	(1) log of revenue per worker	(2) log of gross profit per worker	(3) log of revenue per worker	(4) log of gross profit per worker
	b/se	b/se	b/se	b/se
Wave 2	0.234***	0.179***	0.237***	0.180***
	(0.02)	(0.02)	(0.02)	(0.02)
Interest Payment per Worker	0.035***	0.052**	0.041**	0.054*
	(0.01)	(0.02)	(0.01)	(0.02)
Interest Payment per Worker * Innovation Indicator	-0.024*	-0.037*	-0.024*	-0.037*
	(0.01)	(0.02)	(0.01)	(0.02)
Innovation Indicator	0.164***	0.131***	0.162***	0.131***
	(0.03)	(0.04)	(0.03)	(0.03)
Log of Capital-Labor Ratio	0.119***	0.101***	0.119***	0.101***
	(0.02)	(0.02)	(0.02)	(0.02)
Log of Employment	-0.349***	-0.415***	-0.348***	-0.415***
	(0.04)	(0.04)	(0.04)	(0.04)
Interest Payment per Worker * Wave 2			-0.007	-0.002
			(0.01)	(0.01)
constant	2.824***	2.767***	2.820***	2.767***
	(0.31)	(0.66)	(0.31)	(0.66)
Observations	5007	4996	5007	4996

Notes: Standard errors are clustered by firm. Although not shown in the table, sector dummies were included in the estimation.

$^{*} p < 0.05,$ $^{**} p < 0.01,$ $^{***} p < 0.001$

Table 3.4.1 – Endogenous Switching Regression - Switching Variable is Credit Constraint Indicator

	(1) log of revenue per worker b/se	(2) log of gross profits per worker b/se
Main Regression		
Wave 2	0.261***	0.184***
	(0.02)	(0.02)
revenuepe0	0.332***	0.228***
	(0.02)	(0.02)
Innovation Indicator	0.129***	0.097*
	(0.03)	(0.04)
log of K/L	0.118***	0.096***
	(0.02)	(0.02)
log of L	-0.322***	-0.380***
	(0.04)	(0.04)
Credit Constraint Indicator (CC)	-0.439***	-0.339***
	(0.07)	(0.07)
Constant	2.073***	0.958***
	(0.42)	(0.25)
Selection Regression: Credit Constraint Indicator (CC)		
CC0	0.610***	0.604***
	(0.08)	(0.08)
Innovation Indicator	-0.101	-0.092
	(0.09)	(0.09)
log of K/L	-0.294***	-0.304***
	(0.05)	(0.05)
log of L	0.026	0.018
	(0.10)	(0.11)
Network size: Bank officials	-0.180***	-0.189***
	(0.05)	(0.05)
Network size: Politicians and civil servants	-0.002	0.010
	(0.05)	(0.05)
customercredit_dummy	-0.320*	-0.306*
	(0.13)	(0.13)
suppliercredit_dummy	-0.059	-0.056
	(0.10)	(0.11)
ownershipform=Household	-0.011	-0.047
	(0.11)	(0.11)
ownershipform=Limited liability company	-0.162	-0.186
	(0.12)	(0.12)

formal short-term debts over total assets		-2.509**	-2.572***
		(0.77)	(0.78)
formal long-term debts over total assets		-3.328***	-3.405***
		(0.67)	(0.67)
wave 2		0.354***	0.351***
		(0.10)	(0.10)
		(0.14)	(0.14)
constant		2.528***	2.586***
		(0.61)	(0.62)
Observations		3471	3464

Notes: In the main regression, the averages (across years) of the innovation indicator, $\ln(K/L)$, $\ln(L)$ are also included. The selection regression also includes the averages (across years) of the innovation indicator, $\ln(K/L)$, $\ln(L)$, network_bankofficial (network size: bank officials), network_politicians (network size: politicians and civil servants), suppliercredit_dummy, customercredit_dummy, indicator of ownership forms (household, limited liability), and ratio of formal long-term and of formal short-term debts over total assets. Standard errors are clustered at firm level.

$^* p < 0.05$, $^{**} p < 0.01$, $^{***} p < 0.001$

Table 3.4.2 – Endogenous Switching Regression - Switching Variable is Credit Constraint Indicator When Varying the Percentile Cutoff of Interest Payment per Worker

	(1) Log of Revenue per Worker	(2) Log of Gross Profits per Worker
CC_70	-0.294***	-0.266***
CC_75	-0.383***	-0.291***
CC_80	-0.439***	-0.339***
CC_85	-0.453***	-0.406***
CC_90	-0.576***	-0.592***
Observations	3471	3464

Notes: CC_70 is the credit constraint indicator based on the 70th percentile of formal interest payment per worker in each sector and each survey wave. CC_70 takes a value of one if the firm has a formal interest payment per worker less than the 70th percentile. The coefficient estimate of CC_70 is the coefficient of the credit constraint indicator when a similar regression as the regression in Table 3.4.1 is estimated but using CC_70 instead of CC_80 as the credit constraint indicator. Similar notations are applied for CC_75, CC_80, CC_85, and CC_90. Although already included in Table 3.4.1, the estimates for the coefficient of CC_80 are included for comparison.

Table 3.4.3 – Endogenous Switching Regression - Switching Variable is the Innovation Indicator

	(1) log of revenue per worker b/se	(2) log of gross profits per worker b/se
Main Regression		
revenuepe0	0.342***	0.235***
	(0.02)	(0.02)
wave 2	0.266***	0.192***
	(0.02)	(0.03)
formal interest payments per worker	0.010***	0.015***
	(0.00)	(0.00)
log of K/L	0.132***	0.116***
	(0.02)	(0.02)
log of L	-0.372***	-0.406***
	(0.05)	(0.05)
innovation indicator	0.730***	0.576***
	(0.13)	(0.17)
constant	1.928***	0.746**
	(0.44)	(0.29)
Selection Regression: Innovation Indicator		
Innovation Indicator0	0.342***	0.370***
	(0.06)	(0.07)
log of K/L	-0.027	-0.032
	(0.04)	(0.04)
log of L	0.234**	0.220*
	(0.09)	(0.09)
age	-0.015***	-0.013***
	(0.00)	(0.00)
Trade liberalization will make access to credit and capital easier	0.147*	0.152*
	(0.07)	(0.08)
Trade liberalization will increase competition due to increased imports	0.128	0.181*
	(0.08)	(0.08)
competition from state enterprises	-0.018	-0.007
	(0.04)	(0.04)
competition from non-state enterprises	-0.062	-0.041
	(0.04)	(0.04)
competition from legal imports/foreign competition	-0.102*	-0.119*
	(0.05)	(0.05)

competition from smuggling	0.006	0.045
	(0.05)	(0.05)
interest payment per worker	0.049**	0.036
	(0.02)	(0.02)
Member of a business association	0.246**	0.287**
	(0.09)	(0.09)
Ownership form=Household	0.026	0.091
	(0.08)	(0.09)
Ownership form=Limited liability company	0.194*	0.287**
	(0.09)	(0.10)
wave 2	-0.130	-0.105
	(0.09)	(0.09)
Constant	-1.736**	-1.758**
	(0.64)	(0.62)
Observations	3047	3040

Notes: In the main regression, the averages (across years) of formal interest payment per worker, ln(K/L), ln(L) were also included. The selection regression also included the averages (across time) of all regressors. To save space, I do not report the following regressors which are included in the selection regression and have insignificant coefficient estimates: indicators that the firms expected future further opening of the market/trade liberalization will lead to (1) higher demand for firm products, (2) higher competition to SMEs, (3) increasing firm's exports, (4) easier access to modern technology, and (5) increased labor costs due to higher labor standards. Standard errors are clustered at firm level.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.5 – Regression of Interest Payment per Worker against Lag of Log of Revenue per Worker or Against Lag of Log of Gross Profits per Worker

	(1) Formal Interest Payment per Worker b/se	(2) Formal Interest Payment per Worker b/se
Wave 2	0.509	0.816
	(0.40)	(0.65)
Lag of log of Revenue per worker	-1.707	
	(1.45)	
Lag of log of Gross Profits per worker		-1.567
		(1.32)
constant	3.582	0.954
	(2.66)	(1.27)
Observations	4167	4132

Notes: Standard errors are clustered by firm. Although not shown in the table, sector dummies are included in the regression.

$^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$

Table 3.6 – Matching Covariates for Matching when the Treatment is the Credit Constraint Indicator

Variable	Definition
revenues per worker1	Revenue per worker
profitgrosspc1	Gross profits per worker
innovation_existing1	Indicator of whether the firm innovated its existing products
TFP1	Total factor productivity (TFP)
templanduserights14	Indicator of whether the firm rented the land
suppliercredit_dummy1	Indicator of whether the firm has positive outstanding balance owed to its suppliers
customercredit_dummy1	Indicator of whether the firm has positive outstanding balance due from its customers
loan_appproblem1	Indicator of whether the firm indicated it had problems in applying for bank loans
loandeniednumber_shortterm1	Number of short-term loans were denied from the firm
loandeniednumber_longterm1	Number of long-term loans were denied from the firm
loan_informal1	Indicator of whether the firm borrowed from informal sources
creditor_lentbyfirm1	Indicator of whether the firm had lent to the creditor before
creditor_lentbefore1	Indicator of whether the creditor had lent to the firm before
input_inventorydays1	Number of days (on average) of the most important input the firm had
informalpayment1	Whether the firm made informal communication (bribe) payment
emplog1	Natural logarithm of a firm's employment
network_bankofficial1	Number of bank officials in the firm's network
network_fractionsupplier1	Fraction of suppliers in the firm's network
network_fractioncustomer1	Fraction of customers in the firm's network
age1	Firm's age
rural1	Indicator of whether the firm was located in rural areas
WTO_higherdemand1	Indicator of whether the firm expected future trade liberalization (during the next 1-3 years) would lead to greater demand for the firm's products
WTO_highercompetitiontoSME1	Indicator of whether the firm expected future trade liberalization (during the next 1-3 years) would lead to more competition to small and medium enterprises (SMEs)
WTOaffected_exportincrease1	Indicator of whether the firm expected future trade liberalization would lead to increase in the firm's exports in the next 1-3 years
WTOaffected_techaccess1	Indicator of whether the firm expected future trade liberalization would make access to modern technology easier for the firm in the next 1-3 years
WTOaffected_creditincrease1	Indicator of whether the firm expected future trade liberalization would make access to credit and capital easier

	for the firm in the next 1-3 years
WTOaffected_importcompetition1	Indicator of whether the firm expected future trade liberalization increase competition from imports for the firm in the next 1-3 years
WTOaffected_wageincrease1	Indicator of whether the firm expected future trade liberalization would increase labor costs for the firm in the next 1-3 years due to higher labor standards
WTOfirm_inputcostfall1	Indicator of whether the firm dealt with increasing international competition by reducing production costs
WTOfirm_newtech1	Indicator of whether the firm dealt with increasing international competition by introducing new technology
WTOfirm_laborupgrade1	Indicator of whether the firm dealt with increasing international competition by upgrading its labor force (training)
WTOfirm_newmarket1	Indicator of whether the firm dealt with increasing international competition by identifying new market outlets
WTOfirm_newproduct1	Indicator of whether the firm dealt with increasing international competition by creating new products or improving existing products

Notes: The numeric ending 1 indicates that the variable is from survey wave 2007, and is averages of values in 2005 and 2006. The numeric ending 2 indicates that the variable is from survey wave 2009, and is averages of values in 2007 and 2008. The ending "diff" denotes the difference in the variable between survey wave 2009 and survey wave 2007.

Table 3.7 – Logistic Regression Results for the Propensity Scores

	Credit Constraint Indicator b/se
revenue per worker1	-0.003**
	(0.00)
log of employment1	-0.380***
	(0.07)
suppliercredit_dummy1	0.148
	(0.21)
customercredit_dummy1	-0.671***
	(0.20)
creditor_loanedbyfirm1	0.079
	(0.17)
creditor_lentbefore1	-0.480**
	(0.15)
network_bankofficial1	-0.674**
	(0.22)
age1	-0.002
	(0.01)
rural1	-0.598***
	(0.15)
WTOaffected_creditincrease1	-0.338*
	(0.16)
Constant	5.084***
	(0.49)
Observations	1871

Notes: Adjusted R^2=0.16. To save space, the following regressors with insignificant coefficient estimates are not presented in the table: innovation_existing1, network_fractionsupplier1, network_fractioncustomer1, landuserights1==Rented/Leased, loan_appproblemdummy1, loandeniednumber_shortterm1, loandeniednumber_longterm1, loan_informal1, input_inventorydays1, informalpayment1, WTOaffected_exportincrease1, WTOaffected_techaccess1, WTOaffected_importcompetition1, and WTOaffected_wageincrease1.
 * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3.8 – Propensity Score Matching Results

	(1) revenue pcdiff b/se	(2) profitgro sspcdiff b/se	(3) revenue pc2 b/se	(4) profitgro sspc2 b/se	(5) revenue 1 b/se	(6) emplog1 b/se	(7) revenue pc1 b/se	(8) profitgr osspc1 b/se
ATT								
	-41.756*	-9.688*	-45.794*	-10.257*	65.749	0.024	-4.038	-0.569
	(18.29)	(4.75)	(19.03)	(4.85)	(67.09)	(0.05)	(3.94)	(0.53)
Observat ions	1871	1871	1871	1871	1871	1871	1871	1871

Notes: To save space, only the ATTs of pre-treatment values of the key variables are presented here. While not presented in the table, the ATTs for other pre-treatment variables that were used as matching covariates are all insignificant. Standard errors are robust standard errors calculated using the formula in Abadie and Imbens (2008).
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 3.1 – Histogram of the Change in the Nominal Interest Rate of the Current Most Important Formal Loan between 2006 and 2008
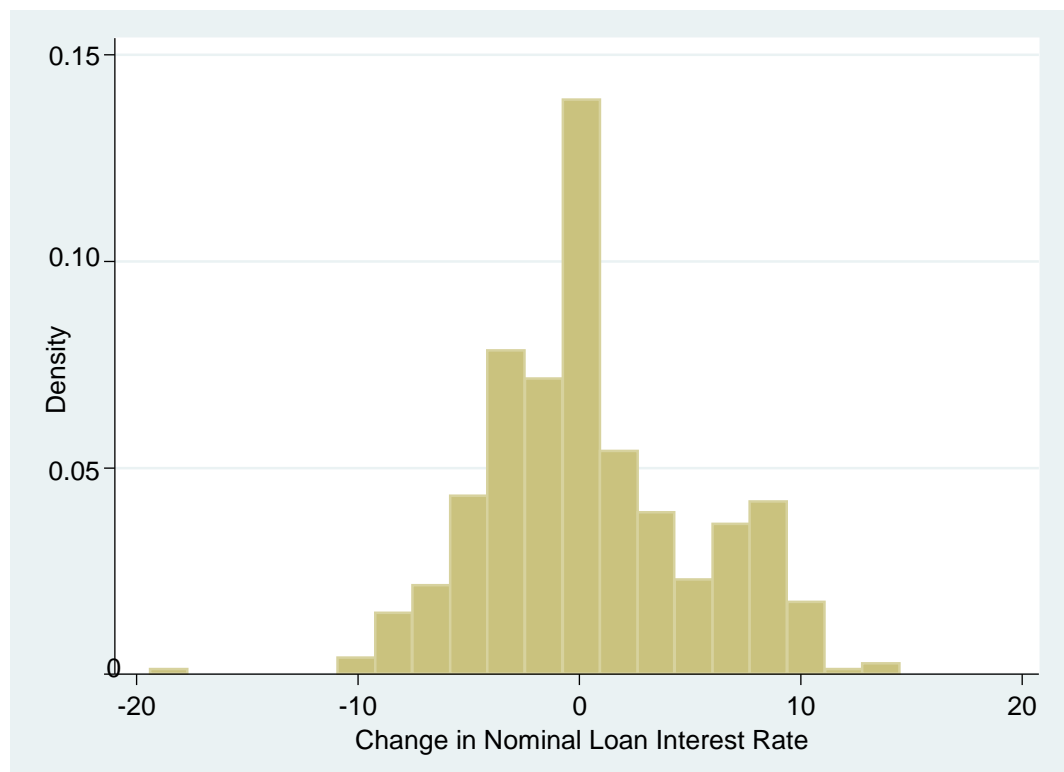
Notes: Source: author's own calculation from the data set of Vietnamese Medium and Small Enterprises administered by the Department of Economics of the University of Copenhagen. Interest rates are annual and in percentage. The change in interest rate is by firm, i.e., the difference in the interest rate of the most important formal loan between 2008 and 2006 for the same firm. As illustrated in this Figure, 46% firms experienced a decrease, 44% firms experienced an increase, and 10% of the firms experienced no change in the nominal interest rate for the most important formal loan.

Appendix A – Estimation Issues and Solutions for the Dynamic Probit Regression

Several estimation issues need to be addressed in estimating the dynamic probit regression outlined above. First, the inclusion of the lagged value of the dependent variable as a regressor leads to the "initial condition problem", where the likelihood function of a dynamic probit is conditional on the initial value of the dependent variable at time t=0, denoted as y_{i0} and the first period in the data sample does not coincide with the initial period of the dynamic process. To obtain consistent estimates from maximizing the likelihood function requires making a decision on how the initial observations y_{i0} will be treated.

Secondly, even though I have included industry and time dummies as well as controlling for some firm characteristics such as firm size, age, TFP and the education of the firm's management, it is very likely that there still exist unobserved firm-specific characteristics that affect its export decisions. These characteristics are likely to persist over time. This unobserved heterogeneity component is denoted as η_i in the regression equation in the chapter. In order to obtain consistent estimates, one needs to integrate the firm's unobserved heterogeneity out of the likelihood function. If the strong assumption that the initial conditions are exogenous holds, i.e., that η_i is independent of y_{i0}, then estimates from a standard random-effects probit estimation command such as *xtprobit* in *Stata* will be consistent. However, in the context of this chapter, η_i is likely to be correlated to y_{i0} since firm's unobserved heterogeneity are likely to affect the firm's propensity to export in the first survey period. If we ignore this correlation, the estimates obtained will be inconsistent.

To deal with the initial condition problem in the presence of unobserved heterogeneity, i.e. the first and second estimation issue, I use the estimation method proposed by Wooldridge (2005),

which models the unobserved time-invariant heterogeneity as a function of the initial value of the dependent variable and time-averages of all exogenous regressors.[75] This method also addresses the fourth estimation issue since it accounts for the correlation between the regressors and the time-invariant unobserved heterogeneity η_i by modeling η_i as a function of the initial value of the dependent variable and the time-averages of all exogenous regressors.

The strength of the estimator proposed by Wooldridge (2005) is that it leads to a straightforward regression equation that can be estimated by any standard software and thus, is much less time- and computing-intensive. It solves the problem of unobserved heterogeneity and the problem of initial condition and yields consistent estimates. In addition, the method does not require exclusion variables (for the initial period) outside of the regression equation for the following periods. Given that these exclusion variables must satisfy the condition that they correlate with the value of the dependent variable in the first period, but are not correlated to subsequent values of the dependent variables in the following periods, it is often very hard to find convincing exclusion variables in practice.

On the other hand, the Wooldridge (2005) method cannot yield estimates for time-invariant regressors (since the value of these regressors are the same as their time-averages) and requires strict exogeneity of the regressors.[76] It also does not allow for the feedback of current value of

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[75] Wooldridge (2005) specifies a more general function form for the time-invariant unobserved firm heterogeneity as a function of the initial value of the dependent variable and all the past, and future values of all exogenous regressors (see Appendix A for more detailed explanation). However, this specification would place too much demand on the data for the Ghanaian data set so I choose to model the time-invariant unobserved heterogeneity as a special case of the Wooldridge's proposal: as a function of the initial value of the dependent variable and time-averages of all exogenous regressors. This is also the approach that is used in many empirial studies using the Wooldridge (2005) method.

[76] Although the Wooldridge (2005) method cannot yield estimates for time-variant regressors, including these regressors where relevant will improve the quality of the estimates.

the dependent variable to the future values of the explanatory variables. These assumptions may be violated in the context of this chapter if a firm's current export activity affects its access to credit in the future.

Compared to another method proposed by Heckman (1981) for estimating dynamic probit by modeling the initial value of the the dependent variable, the Wooldridge (2005) method imposes a slightly stricter assumption on the unobserved firm fixed effect. However, the Heckman (1981) method is more computational intensive and requires exclusion variables for the initial period(s). In practice, it is hard to find convincing exclusion variables that affect export participation in the initial period, but do not affect export participation in the following periods. Furthermore, several studies that compare different methods used to estimate a dynamic probit model conclude that the Wooldridge (2005) method is as good as the Heckman (1981) method when the time length of the panel data is moderately long or long, i.e. when $T \geq 5$ (see for example, Akay 2009). The data set I have has 6 time periods so estimation using the Wooldridge method is a reasonable choice. Because of the reasons above, I choose to use the Wooldridge (2005) method.[77]

Dating the observations starting at t=0 so that $Export_{i0}$ is the first observation on firm export status. For t=1, …, T, the regression equation can be rewritten as:

$$Export_{it} = \beta_1 Export_{i,t-1} + X_{it}\delta + \eta_i + \varepsilon_{it}$$

and the probability of firm's participation in exporting can be written as:

$$P(Export_{it} = 1 \mid Export_{i,t-1}, Export_{i,t-2}, ..., Export_{i0}, X_i, \eta_i) = G(\beta_1 Export_{i,t-1} + X_{it}\delta + \eta_i)$$

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[77] The data set is actually from 1991-2002 but the surveys after 1997 is carried out every three years instead of every two years and there are many changes in the questionnaire for the years 1998-2002.

where G is the probit function. X_{it} is a vector of contemporaneous explanatory variables, and $X_i = (X_{i1}, X_{i2},..., X_{iT})$

Note that the specification above allows for the probability of exporting to depend on the export status in t-1 and on unobserved heterogeneity η_i. The above model requires that conditional on firm's time-invariant fixed effect η_i, X_{it} must satisfy a strict exogeneity assumption.

The likelihood function can be written as:

$$f(y_1, y_2,..., y_T \mid y_0, X, c; \beta) = \prod_{t=1}^{T} f(y_t \mid y_{t-1},..., y_1, y_0, X_t, \eta; \beta)$$

$$= \prod_{t=1}^{T} G(\beta_1 Export_{t-1} + X_i\delta + \eta)^{y_t} \left[1 - G(\beta_1 Export_{t-1} + X_i\delta + \eta)\right]^{1-y_t}$$

To obtain a consistent estimator, it is necessary that the unobserved heterogeity is integrated out of the likelihood function above since if we just treat this unobserved heterogeneity as a paramenter to be estimated, the estimators of β_1 and δ will be inconsistent.

When integrating the unobserved heterogeneity out of the distribution, we have to deal with the initial conditions problems, i.e. how to treat the initial observation of the dependent variable $Export_{i0}$.

Wooldridge (2005) proposes to model the unobserved heterogeneity as follows

$$\eta_i = \psi + \xi_0 Export_{i0} + X_i\xi + a_i$$

where $a_i \sim \text{Normal}(0, \sigma_a^2)$ and independent of (y_{i0}, X_i). Given this assumption of the conditional distribution of firm's unobserved heterogeneity, we can write

$$Export_{it} = 1(\psi + \beta_1 Export_{i,t-1} + X_{it}\delta + \xi_0 Export_{i0} + X_i\xi + a_i + e_{it} > 0)$$

and thus, the regression can now be estimated with standard random-effect probit software by simply expanding the list of regressors to include $Export_{i0}$, and X_i in each time period.

Because of the limited number of observations in the data set, including all the history of the regressors in the regression exhausts degrees of freedom. Therefore, I choose to adopt a more specific assumption of the initial condition that has been used by many authors in estimating a dynamic probit using Wooldridge (2005) method. In particular, I assume that

$$\eta_i = \psi + \xi_0 Export_{i0} + \overline{X}\lambda + a_i$$

where $\overline{X}$ denotes time-average of the exogenous regressors.[78]

This leads to the following regression equation:

$$Export_{it} = 1(\psi + \beta_1 Export_{i,t-1} + X_{it}\delta + \xi_0 Export_{i0} + \overline{X}\lambda + a_i + e_{it} > 0)$$

The regression can now be estimated with standard random-effect probit software by simply expanding the list of regressors to include $Export_{i0}$, and the time-average values of each exogenous regressor.

To calculate the average effect, I use the following approach outlined in Wooldridge (2010) by first, averaging out the initial condition. Denote Φ and ϕ as the c.d.f and p.d.f of a standard normal random variable. Then the Average Structural Function (ASF)

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[78] Examples of empirical studies that use time-averages of exogenous regressors (instead of values of their entire history) are Akay (2009), and Buddelmeyer et al. (2010).

$$ASF = E\left[\Phi(\psi_a + \beta_{1a} Export_{i,t-1} + X_{it}\delta_a + \xi_{0a} Export_{i0} + \overline{X}\lambda_a)\right]$$

can be consistently estimated as

$$A\hat{S}F = \frac{1}{N}\sum_{i=1}^{N}\Phi\left(\hat{\psi}_a + \hat{\beta}_{1a} Export_{i,t-1} + X_{it}\hat{\delta}_a + \hat{\xi}_{0a} Export_{i0} + \overline{X}\hat{\lambda}_a\right)$$

where $\hat{\psi}$, $\hat{\beta}_1$, $\hat{\delta}$, $\hat{\xi}_0$ $\hat{\lambda}$ are the original coefficient estimates reported by Stata for the random

effects probit including $Export_{i0}$, and the time-average values of each exogenous regressor. The

subscript a on $\hat{\psi}$, $\hat{\beta}_1$, $\hat{\delta}$, $\hat{\xi}_0$ $\hat{\lambda}$ denotes the values where the original coefficient estimates

have been multiplied by $(1 + \hat{\sigma}_a^2)^{-1/2}$ with the value of $\hat{\sigma}_a^2$ obtained from Stata regression output.

Let X_1 be an indicator variable that is one of the regressors. To calculate the APE (average

partial effects) for X_1, we can estimate the difference in the $A\hat{S}F$ when $X_1 = 1$ and the $A\hat{S}F$

when $X_1 = 0$. To obtain a single APE, this difference is then averaged out over time periods. For

example, to obtain the APE of the lagged export, we calculate

$$\Phi\left(\hat{\psi}_a + \hat{\beta}_{1a} + X_{it}\hat{\delta}_a + \hat{\xi}_{0a} Export_{i0} + \overline{X}\hat{\lambda}_a\right) - \Phi\left(\hat{\psi}_a + X_{it}\hat{\delta}_a + \hat{\xi}_{0a} Export_{i0} + \overline{X}\hat{\lambda}_a\right)$$

for each observation, then average this value across all firms and all time periods.

For continuous regressors, the APE can be obtained by taking derivatives of the $A\hat{S}F$ with

respect to the regressor we are interested in. For example, if X_2 is a continuous regressor and $\hat{\delta}_{a1}$

is its re-scaled coefficient estimate then the APE for X_2 is the average across all firms and all

time periods of $\hat{\delta}_{a1}\phi\left(\hat{\psi}_a + \hat{\beta}_{1a} + X_{it}\hat{\delta}_a + \hat{\xi}_{0a} Export_{i0} + \overline{X}\hat{\lambda}_a\right)$

Appendix B – Levinsohn-Petrin (2003) method for obtaining firm's unobserved productivity

I use the Levinsohn-Petrin (2003) method that accounts for unobservable input shock in estimating the production function to obtain the estimates of TFP. Levinsohn and Petrin specify the firm's production function in logs as:

$$y_{it} = \beta_0 + \beta_1 l_{it} + \beta_2 k_{it} + \omega_{it} + \eta_{it}$$

where y is a measure of firm's output such as deflated value added or revenue, l and k are labor and capital. The error term of the production function comprises of two components: a transmitted component ω_{it} and an i.i.d component η_{it}. As Levinsohn and Petrin (2003) state, ω_{it} is a state variable and influences the firm's decisions while η_{it} has no impact on the firm's decision. The TFP values I use are estimates of ω_{it} using the Levinsohn-Petrin (2003) method. Under the assumption that ω_{it} is stochastically increasing in past values, Levinsohn and Petrin (2003) argue that a firm's demand for intermediate inputs is monotonically increasing in ω_{it} and can be written as:

$$m_{it} = m_{it}(\omega_{it}, k_{it})$$

where the variable m denotes the quantity of an intermediate input. Since the function m_{it} is monotonically increasing in ω_{it}, the input demand function can be inverted as $\omega_{it} = \omega_{it}(k_{it}, M_{it})$ and consistent estimates for the coefficients of capital and labor can be obtained. After that, consistent estimates of ω_{it} can be obtained.

The following steps for estimating TFPs come directly from Levinsohn and Petrin (2003), page 340.

Stage one:

1. Run a locally weighted least square regression of y_t on m_t and k_t to obtain an estimate of the function $E(y_t|m_t,k_t)$.

2. Run a regression of l_t on m_t and k_t to obtain an estimate of the function $E(l_t|m_t,k_t)$.

3. Construct $Y_t = y_t - E(y_t|m_t,k_t)$ using the estimate of the conditional expectation from the regression in step 1. This is the dependent variable in step 4. Similarly, difference out the predicted mean for each of the explanatory variables, and use these differences as explanatory variables for the regression in step 4.

4. Run no-intercept OLS regressing the constructed dependent variable Y on the vector of constructed independent variables. The key estimated parameters from this stage are the production function parameters on all the variable inputs except the intermediate proxy, raw materials.

Stage two:

1. Compute the estimate of $\phi_t(m_t,k_t)$. To do so use the appropriate observations and (some form of) regression to predict $y_t - \beta_l l_t = \phi_t + \eta_t$ using (m_t, k_t) as explanatory variables. Save the estimate $\hat{\phi}_t$.

2. Choose a candidate value for (β_m, β_k), say (β_m^*, β_k^*). A good starting value might be the OLS value from a Cobb-Douglas production function.

3. Compute $\omega_t \,\hat{+}\, \eta_t = y_t - \beta_l l_y - \beta_m^* m_t - \beta_k^* k_t$. Call the variable just computed "A".

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4. Compute $\hat{\omega}_{t-1} = \hat{\phi}_{t-1} - \beta_m^* m_{t-1} - \beta_k^* k_{t-1}$. Call this variable *"B"*.

5. Regress *A* on *B* using use locally weighted least squares. Call the predicted values "C". "C" is an estimate of $E(\omega_t | \omega_{t-1})$.

6. Compute $(\xi_t \hat{+} \eta_t)$ by substituting *C* in for $E(\omega_t | \omega_{t-1})$ to obtain

$$\xi_t \hat{+} \eta_t (\beta_m^*, \beta_k^*) = y_t - \beta_l l_y - \beta_m^* m_t - \beta_k^* k_t - E(\omega_t | \omega_{t-1})$$

This is the residual that enters the moment equation. Use it to construct the sample analogues to the population moment conditions.

7. Using a minimization routine, choose $(\hat{\beta}_m, \hat{\beta}_k)$ to minimize the following GMM objective function:

$$Q(\beta_m^*, \beta_k^*) = Min_{\beta_m^*, \beta_k^*} \sum_{h=1}^{h=5} \left(\sum_i \sum_{t=T_{i0}}^{t=T_{il}} \left(\xi_t \hat{+} \eta_{it} (\beta_m^*, \beta_k^*) Z_{i,ht} \right) \right)^2$$

where $Z_t = (k_t, m_{t-1}, l_{t-1}, k_{t-1}, m_{t-2})$.

This will involve iterations over the previous six steps.

Appendix C – Proofs for Chapter 2

1.   Solving firm's decision whether to borrow for export or to produce only

domestically

$$V_t^{X,B}(n,\varphi,r_{it}) = \frac{1}{1-\beta(1-p)(1-\Phi^{X,B})}\left[\pi^D + p^X y^X - \frac{\omega\tau * y^X}{\varphi} - (1+r_{it})\omega f^X + (1+r_0)n\right] - f^{ex}$$

$$V_t^D(n,\varphi) = \frac{1}{1-\beta(1-p)}\left[\pi^D + (1+r_0)n\right]$$

where f^{ex} is the sunk cost of entry into the foreign market and

$$\pi^D = p^D(\varphi)y^D(\varphi,\overline{\varphi}^D) - \frac{\omega * y^D(\varphi,\overline{\varphi}^D)}{\varphi} - \omega f^D$$

To simplify, in the following part of this section, Φ refers to $\Phi^{X,B}$, the probability of default

for a borrowing exporter.

A firm decides to borrow for export if $V_t^{X,B}(n,\varphi,r_{it}) \geq V_t^D(n,\varphi)$. Otherwise, the firm decides

to produce only for the domestic market. Using algebra:

$$V_t^{X,B}(n,\varphi,r_{it}) - V_t^D(n,\varphi)$$
$$= \frac{-\Phi\beta(1-p)\{\pi^D + (1+r_0)n\} + [1-\beta(1-p)]\pi^{X,B} - [1-\beta(1-p)(1-\Phi)][1-\beta(1-p)]f^{ex}}{\{1-\beta(1-p)(1-\Phi)\}\{1-\beta(1-p)\}}$$

where

$$\pi^{X,B} = p^X y^X - \frac{\omega\tau * y^X}{\varphi} - (1+r_{it})\omega f^X = \frac{r^{X,B}}{\mu} - (1+r_{it})\omega f^X$$

So $V_t^{X,B} \geq V_t^D$ if and only if:

$$D = -\Phi\beta(1-p)\left\{\pi^D + (1+r_0)n\right\} + \left[1 - \beta(1-p)\right]\pi^{X,B} - \left[1 - \beta(1-p)(1-\Phi)\right]\left[1 - \beta(1-p)\right]f^{ex} \geq 0$$

Note that

$$\frac{\partial \pi^{X,B}}{\partial \varphi} = \frac{\partial\left(\dfrac{r^{X,B}}{\mu} - (1+r_{it})\omega f^{x}\right)}{\partial \varphi} = \frac{1}{\mu}\frac{\partial r^{X,B}}{\partial \varphi} - \omega f^{X}\frac{\partial r_{it}}{\partial \varphi}$$

where $r^{X,B}$ is the revenue from exporting by borrowing.

Similarly, let r^D be the revenue from selling to the domestic market then:

$$\frac{\partial \pi^D}{\partial \varphi} = \frac{\partial\left(\dfrac{r^D}{\mu} - \omega f^{D}\right)}{\partial \varphi} = \frac{1}{\mu}\frac{\partial r^D}{\partial \varphi}$$

We also know that:

$$r^{X,B} = \tau^{1-\mu}r^D$$

so $$\frac{\partial r^{X,B}}{\partial \varphi} = \tau^{1-\mu}\frac{\partial r^D}{\partial \varphi}$$

Using the above formula to take derivative of D with respect to φ:

$$\frac{\partial D}{\partial \varphi} = -\Phi\beta(1-p)\frac{\partial \pi^D}{\partial \varphi} - \beta(1-p)\left\{\pi^D + (1+r_0)n\right\}\frac{\partial \Phi}{\partial \varphi} + \left[1 - \beta(1-p)\right]\frac{\partial \pi^{X,B}}{\partial \varphi}$$

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$$\frac{\partial D}{\partial \varphi} = \frac{-\Phi\beta(1-p)}{\mu}\frac{\partial r^D}{\partial \varphi} - \beta(1-p)\{\pi^D + (1+r_0)n\}\frac{\partial \Phi}{\partial \varphi} + [1-\beta(1-p)]\left[\frac{1}{\mu}\tau^{1-\mu}\frac{\partial r^D}{\partial \varphi} - \omega f^X\frac{\partial r_{it}}{\partial \varphi}\right]$$

$$\frac{\partial D}{\partial \varphi} = \frac{1}{\mu}\{-\Phi\beta(1-p)+[1-\beta(1-p)]\tau^{1-\mu}\}\frac{\partial r^D}{\partial \varphi} - \beta(1-p)\{\pi^D + (1+r_0)n\}\frac{\partial \Phi}{\partial \varphi}$$

$$- [1-\beta(1-p)]\omega f^X\frac{\partial r_{it}}{\partial \varphi}$$

Since $\frac{\partial \Phi}{\partial \varphi}<0$ and $\frac{\partial r_{it}}{\partial \varphi}<0$, $-\beta(1-p)\{\pi^D + (1+r_0)n\}\frac{\partial \Phi}{\partial \varphi}>0$ and $-[1-\beta(1-p)]\omega f^X\frac{\partial r_{it}}{\partial \varphi}>0$.

In addition, $\frac{\partial r^D}{\partial \varphi}>0$. Therefore if

$$-\Phi\beta(1-p)+[1-\beta(1-p)]\tau^{1-\mu}>0$$

or equivalently:

$$\Phi < \frac{[1-\beta(1-p)]\tau^{1-\mu}}{\beta(1-p)}$$

then $\frac{\partial D}{\partial \varphi}>0$ which implies that among financially-constrained firms with $\varphi \geq \overline{\varphi}^{X,B}$ and $n<\omega f^X$,

the more productive the firm is, the more likely it will borrow to export.

The derivative of D with respect to n is:

$$\frac{\partial D}{\partial n} = -\beta(1-p)\{\pi^D + (1+r_0)n\}\frac{\partial \Phi}{\partial n} - \Phi\beta(1-p)(1+r_0)$$

$$\frac{\partial D}{\partial n} = \frac{\beta(1-p)\{\pi^D + (1+r_0)n\}\phi(1+r_0)}{p^X y^X \sigma} - \Phi\beta(1-p)(1+r_0)$$

where ϕ represents the density function of the standard normal distribution.

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If $\dfrac{\Phi}{\phi} < \dfrac{\left\{ \pi^D + (1 + r_0)n \right\}}{p^X y^X \sigma}$, then $\dfrac{\partial D}{\partial n} > 0$

2. Proofs that the default probability is decreasing in firm productivity and liquidity level.

Suppose the export income shock z_{it} follows a truncated normal distribution $N(1, \sigma^2)$ which is left-truncated at zero. Using the c.d.f for truncated normal distribution, the probability of default for a borrowing exporter is:

$$\Phi^{X,B} \equiv \text{Probability}\left(z_{it} \leq \frac{(1 + r)\omega f^X - (1 + r_0)n + (\omega\tau * y^X / \varphi) - \pi^D}{p^X y^X} \right)$$

$$= \frac{1}{1 - F(-1/\sigma)}\left[F\left[\frac{(1 + r)\omega f^X - (1 + r_0)n + (\omega\tau * y^X / \varphi) - \pi^D - 1}{\sigma p^X y^X} \right] - F(-1/\sigma) \right]$$

where F is the c.d.f of the standard normal distribution. Since z_{it} follows a truncated normal distribution $N(1, \sigma^2)$ which is left-truncated at zero:

$$\frac{(1 + r)\omega f^X - (1 + r_0)n + (\omega\tau * y^X / \varphi) - \pi^D}{p^X y^X} > 0$$

or

$$(1 + r)\omega f^X - (1 + r_0)n + (\omega\tau * y^X / \varphi) - \pi^D > 0$$

Taking derivative of the default probability with respect to firm productivity:

$$\frac{\partial \Phi^{X,B}}{\partial \varphi} = \frac{1}{1 - F(-1/\sigma)} f\left[\frac{(1 + r)\omega f^X - (1 + r_0)n + (\omega\tau * y^X / \varphi) - \pi^D - 1}{\sigma p^X y^X} \right] \frac{\partial B}{\partial \varphi}$$

Where f denotes the probability density function of the standard normal distribution and

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$$B = \left[\frac{(1+r)\omega f^X - (1+r_0)n + (\omega\tau * y^X / \varphi) - \pi^D - 1}{\sigma p^X y^X} \right]$$

$$= \frac{(1+r)\omega f^X - (1+r_0)n - \pi^D - 1}{\sigma p^X y^X} + \frac{(\omega\tau y^X / \varphi)}{\sigma y^X \frac{\tau\omega}{\rho\varphi}}$$

$$= \frac{(1+r)\omega f^X - (1+r_0)n - \pi^D - 1}{\sigma p^X y^X} + \frac{\rho}{\sigma}$$

$$\frac{\partial A}{\partial \varphi} = \frac{(1+r)\omega f^X - (1+r_0)n - \pi^D - 1}{\sigma} \frac{\partial \left(p^X y^X \right)^{-1}}{\partial \varphi} + \frac{1}{\sigma p^X y^X} \left[\omega f^X \frac{\partial r}{\partial \varphi} - \frac{\partial \pi^D}{\partial \varphi} \right]$$

Since $\dfrac{\partial \left(p^X y^X \right)^{-1}}{\partial \varphi} < 0$, $\dfrac{\partial r}{\partial \varphi} < 0$ and $\dfrac{\partial \pi^D}{\partial \varphi} > 0$, $\dfrac{\partial B}{\partial \varphi} < 0$ when

$$(1+r)\omega f^X - (1+r_0)n - \pi^D - 1 \geq 0$$

In other words, the probability of default on loan is decreasing with productivity when

$(1+r)\omega f^X - (1+r_0)n - \pi^D - 1 \geq 0$.

Taking derivative of the default probability with respect to firm liquidity:

$$\frac{\partial \Phi^{X,B}}{\partial n} = \frac{1}{1 - F(-1/\sigma)} f \left[\frac{(1+r)\omega f^X - (1+r_0)n + (\omega\tau * y^X / \varphi) - \pi^D - 1}{\sigma p^X y^X} \right] \left[\omega f^X \frac{\partial r}{\partial n} - \frac{1+r_0}{\sigma p^X y^X} \right]$$

Since $\dfrac{\partial r}{\partial n} < 0$, $\dfrac{\partial \Phi^{X,B}}{\partial n} < 0$, which means that the probability of defaulting on loan is

decreasing with the firm's liquidity stock.

3. **Proof that** $E_t\left[I^{X,B}(\varphi^B,n)|default\right]$ **is increasing in firm productivity and liquidity level**

Recall that

$$E_t\left[I^{X,B}(\varphi^B,n)|default\right]=\int_{z_{it}^{B,Min}}^{z_{it}^{B,Default}}\left[\pi^D+z_{it}\,p^X\,y^X-\frac{\omega\tau*y^X}{\mu}+(1+r_0)n\right]l(z)dz$$

where $z_{it}^{B,Default}$ solves:

$$I^{X,B}(z_{it},\varphi^B,n)=\pi^D+z_{it}\,p^X\,y^X-\frac{\omega\tau*y^X}{\mu}+(1+r_0)n-(1+r_{it})\omega f^X=0$$

and $z_{it}^{B,Min}$ solves:

$$I^{X,B}(z_{it},\varphi^B,n)=\pi^D+z_{it}\,p^X\,y^X-\frac{\omega\tau*y^X}{\mu}+(1+r_0)n=0$$

with r_{it} being the interest rate on the loan.

Using Differentiation under the Integral Sign rule:

$$\frac{\partial E_t\left[I^{X,B}(\varphi^B,n)|default\right]}{\partial\varphi}=\int_{z_{it}^{B,Min}}^{z_{it}^{B,Default}}\frac{\partial\left[\pi^D+z_{it}\,p^X\,y^X-\frac{\omega\tau*y^X}{\mu}+(1+r_0)n\right]}{\partial\varphi}l(z)dz$$

Thus,

$$\frac{\partial E_t\left[I^{X,B}(\varphi^B,n)|default\right]}{\partial\varphi}>0\text{ since }\frac{\partial\left[\pi^D+z_{it}\,p^X\,y^X-\frac{\omega\tau*y^X}{\mu}+(1+r_0)n\right]}{\partial\varphi}>0$$

Taking derivative of the expected net worth of the firm that the banks can collect in case the

firm defaults with respect to firm liquidity level:

$$\frac{\partial E_t\left[I^{X,B}(\varphi^B,n)\middle|default\right]}{\partial n}=\int_{z_{it}^{B,Min}}^{z_{it}^{B,Default}}\frac{\partial\left[\pi^D+z_{it}p^Xy^X-\dfrac{\omega\tau*y^X}{\mu}+(1+r_0)n\right]}{\partial n}l(z)dz$$

$$\frac{\partial E_t\left[I^{X,B}(\varphi^B,n)\middle|default\right]}{\partial n}=\int_{z_{it}^{B,Min}}^{z_{it}^{B,Default}}(1+r_0)l(z)dz$$

Thus, $\dfrac{\partial E_t\left[I^{X,B}(\varphi^B,n)\middle|default\right]}{\partial n}>0$

Appendix D – Proofs for Chapter 3

I.   Solving for the Optimal Loan Schedule

The bank's optimization problem can be solved using the Euler-Lagrange method as follows.

Using the incentive-compatibility for non-innovating firms, i.e. firms with productivity within

$[\bar{x}_N, \bar{x}_I]$, the Lagrangian function for the bank's maximization problem can be written as:

$$L = \rho_N I_N(x) - (1 - \rho_N)(M_N(x) - K_N) - i\tau_N M_N(x))f(x)$$
$$+ \lambda(x)\left[\left(\Phi_N + \delta(1 - \rho_N) - 1\right)\frac{M_N'(x)}{\delta} - \rho_N I_N'(x)\right]$$

The solution to the bank's maximization problem for non-innovating firms must satisfy the

following conditions:

$$\frac{\partial L}{\partial I_N} - \frac{d}{dx}\frac{\partial L}{\partial I_N'} = 0$$

and $$\frac{\partial L}{\partial M_N} - \frac{d}{dx}\frac{\partial L}{\partial M_N'} = 0$$

or:

$$f(x) + \lambda'(x) = 0$$
$$(1 - \rho_N + i\tau_N)f(x) - \lambda(x)\frac{\partial \Phi_N}{\partial M_N}\frac{M_N'(x)}{\delta} + \left(\Phi_N + \delta(1 - \rho_N) - 1\right)\frac{\lambda'(x)}{\delta} + \frac{\lambda(x)}{\delta}\frac{d\Phi_N}{dx} = 0$$

Let $t = x(1 + \Delta z)$. For innovating firms, i.e. firms with productivity levels within $[\bar{x}_I, \infty)$, the

Lagrangian function is:

$$L = \rho_I I_I(t) - (1 - \rho_I)(M_I(t) - K_I) - i\tau_I M_I(t))f\left(\frac{t}{1 + \Delta z}\right)$$

$$+ \lambda(t)\left[\left(\Phi_I(t, M_I(t)) + \delta(1 - \rho_I) - 1\right)\frac{M'_I(t)}{\delta} - \rho_I I'_I(t)\right]$$

and the Euler-Lagrange equations are:

$$f\left(\frac{t}{1 + \Delta z}\right) + \lambda'(t) = 0$$

$$(1 - \rho_I + i\tau_I)f\left(\frac{t}{1 + \Delta z}\right) - \lambda(t)\frac{\partial \Phi_I}{\partial M_I}\frac{M'_I(t)}{\delta} + \left(\Phi_I + \delta(1 - \rho_I) - 1\right)\frac{\lambda'(t)}{\delta} + \frac{\lambda(t)}{\delta}\frac{d\Phi_I}{dt} = 0$$

Since $\Phi_N \equiv \Phi_N(x, M_N(x))$ and $\Phi_I \equiv \Phi_I(x(1 + \Delta z), M_I(x(1 + \Delta z)))$, we have:

$$\frac{d\Phi_N}{dx} = \frac{\partial \Phi_N}{\partial x} + \frac{\partial \Phi_N}{\partial M_N}M'_N(x)$$

and

$$\frac{d\Phi_I}{dt} = \frac{\partial \Phi_I}{\partial t} + \frac{\partial \Phi_I}{\partial M_I}M'_I(t)$$

Substituting these expressions into the second Euler-Lagrange equations for non-innovating and innovating firms, we have:

$$(1 - \rho_N + i\tau_N)f(x) + \left(\Phi_N + \delta(1 - \rho_N) - 1\right)\frac{\lambda'(x)}{\delta} + \frac{\lambda(x)}{\delta}\frac{\partial \Phi_N}{\partial x} = 0$$

and

$$(1 - \rho_I + i\tau_I)f\left(\frac{t}{1 + \Delta z}\right) + \left(\Phi_I + \delta(1 - \rho_I) - 1\right)\frac{\lambda'(t)}{\delta} + \frac{\lambda(t)}{\delta}\frac{\partial \Phi_I}{\partial t} = 0$$

The transversality condition on the bank's maximization problem implies that $\lambda(\infty) = 0$.

Combining this condition with the first Euler-Lagrange equation gives us:

From the innovating firm's first Euler-Lagrange equation, we have:

$$-\int_{\bar{x}_I(1+\Delta z)}^{\infty} \lambda'(t)dt = \int_{\bar{x}_I(1+\Delta z)}^{\infty} f\left(\frac{t}{1+\Delta z}\right)dt$$

or $\quad -\lambda(\infty) + \lambda(\bar{x}_I(1+\Delta z)) = (1+\Delta z)(1 - F(\bar{x}_I))$

or $\quad \lambda(\bar{x}_I(1+\Delta z)) = (1+\Delta z)(1 - F(\bar{x}_I))$

Similarly, it can be proved that $\lambda(t) = (1+\Delta z)(1 - F(x))$ and thus,

$$\lambda'(t) = (1+\Delta z)\frac{d(1-F(x))}{dx} \cdot \frac{dx}{dt} = -f(x) \text{ for } x \in [\bar{x}_I, \infty)$$

Similarly, taking integral of the non-innovating firm's first Euler-Lagrange equation, we have:

$$-\int_x^{\bar{x}_I} \lambda'(x)dx = \int_x^{\bar{x}_I} f(x)dx$$

or $\quad \lambda(x) = 1 - F(\bar{x}_I) + F(\bar{x}_I) - F(x) = 1 - F(x)$

and thus, $\lambda'(x) = -f(x) \qquad$ for $x \in [\bar{x}_D, \bar{x}_I]$

Also notice that $\dfrac{\partial \Phi_N}{\partial x} = \dfrac{\sigma-1}{\sigma}\dfrac{\Phi_N}{x}$ and $\dfrac{\partial \Phi_I}{\partial t} = \dfrac{\sigma-1}{\sigma}\dfrac{\Phi_I}{t}$

Substituting these expressions for $\lambda(x)$ into the second Euler-Lagrange equations for non-innovating firms, we have:

$$(1 - \rho_N + i\tau_N)f(x) + \left(\Phi_N + \delta(1-\rho_N) - 1\right)\frac{-f(x)}{\delta} + \frac{1-F(x)}{\delta}\frac{\sigma-1}{\sigma}\frac{\Phi_N}{x} = 0$$

or $\quad \Phi_N(x, M_N(x)) = (1 + i\delta\tau_N)\left[1 - \left(\frac{\sigma-1}{\sigma}\right)\frac{1-F(x)}{xf(x)}\right]^{-1}$

Similarly, we can solve for the loan schedule for non-innovating firms:

$$(1 - \rho_I + i\tau_I)f(x) + (\Phi_I + \delta(1-\rho_I) - 1)\frac{-f(x)}{\delta} + \frac{(1+\Delta z)(1-F(x))}{\delta}\frac{\sigma-1}{\sigma}\frac{\Phi_I}{x(1+\Delta z)} = 0$$

or $\quad \Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) = (1 + i\delta\tau_I)\left[1 - \left(\frac{\sigma-1}{\sigma}\right)\frac{1-F(x)}{xf(x)}\right]^{-1}$

Assume that firm productivity follows a Pareto distribution with the shape parameter θ:

$F(x) = 1 - (1/x)^\theta$, $x \geq 1$, then the credit constraints become:

$$\Phi_N(x, M_N(x)) = (1 + i\delta\tau_N)\left[1 - \left(\frac{\sigma-1}{\sigma}\right)\frac{(1/x)^\theta}{\theta x(1/x)^{\theta-1}(1/x^2)}\right]^{-1}$$

$$= (1 + i\delta\tau_N)\left(1 - \frac{\sigma-1}{\sigma\theta}\right)^{-1} \equiv \overline{\Phi}_N \tag{A1}$$

$$\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) = (1 + i\delta\tau_I)\left(1 - \frac{\sigma-1}{\sigma\theta}\right)^{-1} \equiv \overline{\Phi}_I \tag{A2}$$

Assuming that $\theta > (1+\Delta z)\frac{\sigma-1}{\sigma}$, then $\overline{\Phi}_N \geq 1$ and $\overline{\Phi}_I \geq 1$.

Under Pareto distribution of firm productivity levels, direct solutions of the loan schedules are:

$$\frac{M_N(x)}{\delta} = \left[\frac{\sigma-1}{\sigma}\left(\frac{xP}{w}\right)^{\frac{\sigma-1}{\sigma}}Y^{1/\sigma}\right]^\sigma\left[\frac{\overline{\Phi}_N}{s_N}\right]^{-\sigma} + C_N \tag{A3}$$

$$\frac{M_I(x(1+\Delta z))}{\delta} = \left[\frac{\sigma-1}{\sigma}\left(\frac{x(1+\Delta z)P}{w}\right)^{\frac{\sigma-1}{\sigma}}Y^{1/\sigma}\right]^\sigma \left[\frac{\overline{\Phi}_I}{s_I}\right]^{-\sigma} + C_I \tag{A4}$$

II. Solving for the Cutoff Productivity Levels

These derivations are obtained under the assumption of Pareto distribution of firm productivity. Taking integral of the incentive-compatibility condition for non-innovating firms, we have:

$$\int_{\bar{x}_N}^x \left(\overline{\Phi}_N + \delta(1-\rho_N)-1\right)\frac{M'_N(x)}{\delta}dx = \int_{\bar{x}_N}^x \rho_N I'_N(x)dx$$

or

$$\left(\overline{\Phi}_N + \delta(1-\rho_N)-1\right)\frac{M_N(x)-M_N(\bar{x}_N)}{\delta} + \rho_N I_N(\bar{x}_N) = \rho_N I_N(x)$$

A similar expression can be obtained for innovating firms:

$$\rho_I I_I(x(1+\Delta z)) = \left(\overline{\Phi}_I, M_I(x(1+\Delta z))\right) + \delta(1-\rho_I)-1)\frac{M_I(x(1+\Delta z))-M_I(\bar{x}_I(1+\Delta z))}{\delta}$$
$$+ \rho_I I_I(\bar{x}_I(1+\Delta z))$$

Rewriting the expected profit functions for non-innovating and innovating firms using the incentive-compatibility conditions gives us:

$$E\left(\pi_N(x,x)\right) = s_N p_N q_N - (1-\delta)\left(\frac{q_N w}{x} + C_N\right) - \rho_N\left(M_N(x) + I_N(x)\right) - (1-\rho_N)K_N$$
$$= \left\{ \begin{array}{c} \frac{\overline{\Phi}_N \sigma}{\sigma-1}\left(\frac{M_N(x)}{\delta} - C_N\right) - \rho_N\left(M_N(x) + I_N(x)\right) - (1-\rho_N)K_N \\ -(1-\delta)\frac{M_N(x)}{\delta} \end{array} \right\} \tag{A5}$$

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$$E\left(\pi_I(x,x)\right) = \frac{\overline{\Phi}_I \sigma}{\sigma - 1}\left(\frac{M_I(x(1+\Delta z))}{\delta} - C_I\right) - \rho_I\left(M_I(x(1+\Delta z)) + I_I(x(1+\Delta z))\right)$$

$$- (1-\rho_N)K_I - (1-\delta)\frac{M_I(x(1+\Delta z))}{\delta} \tag{A6}$$

Since a firm's expected profit is increasing in its productivity level x, the productivity cutoff

for production for non-innovating firms, $\overline{x}_N$, has to satisfy the zero-profit condition:

$$E\left(\pi_N(x,x)\right) = 0$$

which leads to the following condition:

$$\rho_N I_N(\overline{x}_N) = \frac{\overline{\Phi}_N \sigma}{\sigma - 1}\left(\frac{M_N(\overline{x}_N)}{\delta} - C_N\right) - \rho_N M_N(\overline{x}_N) - (1-\rho_N)K_N - (1-\delta)\frac{M_N(\overline{x}_N)}{\delta} \tag{A7}$$

The innovation productivity cutoff satisfies the following condition:

$$E\left(\pi_N(\overline{x}_I,\overline{x}_I)\right) = E\left(\pi_I(\overline{x}_I(1+\Delta z),\overline{x}_I(1+\Delta z))\right)$$

Solving this condition using (A5) and (A6) gives us the productivity cutoff for innovation

activity:

$$\rho_I I_I(\overline{x}_I(1+\Delta z)) = \frac{\overline{\Phi}_I \sigma}{\sigma - 1}\left(\frac{M_I(\overline{x}_I(1+\Delta z))}{\delta} - C_I\right) - \rho_I M_I(\overline{x}_I(1+\Delta z)) - (1-\rho_I)K_I$$

$$+ (1-\rho_N)K_N - \frac{\overline{\Phi}_N \sigma}{\sigma - 1}\left(\frac{M_N(\overline{x}_I)}{\delta} - C_N\right) + \rho_N I_N(\overline{x}_N)$$

$$+ (\overline{\Phi}_N - 1 + \delta)\frac{M_N(\overline{x}_I)}{\delta} - (\overline{\Phi}_N + \delta(1-\rho_N) - 1)\frac{M_N(\overline{x}_N)}{\delta} \tag{A8}$$

$$- \frac{(1-\delta)}{\delta}\left[M_I(\overline{x}_I(1+\Delta z)) - M_N(\overline{x}_I)\right]$$

From the expressions above, it can be seen that the bank can freely choose the productivity cutoffs, $\bar{x}_N$ and $\bar{x}_I$, independently. Once these cutoffs are selected, the interest payment will depend on the cutoff $\bar{x}_N$.

Substituting (A6) and (A7) into the bank's profit-maximization problem, we obtain:

$$
\begin{aligned}
\operatorname{Max}_{\bar{x}_N,\bar{x}_I} & \int_{\bar{x}_N}^{\bar{x}_I}\left[\begin{array}{l}\left(\overline{\Phi}_N + \delta(1-\rho_N)-1\right)\dfrac{M_N(x)-M_N(\bar{x}_N)}{\delta} + \rho_N I_N(\bar{x}_N) \\ -(1-\rho_N)(M_N(x)-K_N)-i\tau_N M_N(x))\end{array}\right]f(x)dx \\
+ & \int_{\bar{x}_I}^{\infty}\left[\begin{array}{l}\left(\overline{\Phi}_I + \delta(1-\rho_I)-1\right)\dfrac{M_I(x(1+\Delta z))-M_I(\bar{x}_I(1+\Delta z))}{\delta} \\ + \rho_I I_I(\bar{x}_I(1+\Delta z))-(1-\rho_I)(M_I(x(1+\Delta z))-K_I)-i\tau_I M_I(x(1+\Delta z))\end{array}\right]f(x)dx
\end{aligned}
$$

The first-order condition (FOC) of the bank's problem with respect to $\bar{x}_N$ gives us:

$$
\begin{aligned}
& \int_{\bar{x}_N}^{\infty}\rho_N\dfrac{dI_N(\bar{x}_N)}{d\bar{x}_N}-\dfrac{1}{\delta}\left(\overline{\Phi}_N+\delta(1-\rho_N)-1\right)\dfrac{dM_N(\bar{x}_N)}{d\bar{x}_N}f(x)dx \\
& = \left[\rho_N I_N(\bar{x}_N)-(1-\rho_N)(M_N(\bar{x}_N)-K_N)-i\tau_N M_N(\bar{x}_N)\right]f(\bar{x}_N)
\end{aligned}
$$

Notice that from the condition (A7) for interest payment for the non-innovating firm with productivity cutoff $\bar{x}_N$, we have:

$$
\rho_N\dfrac{dI_N(\bar{x}_N)}{d\bar{x}_N}=\dfrac{1}{\delta}\left[\dfrac{\sigma}{\sigma-1}\overline{\Phi}_N+\delta(1-\rho_N)-1\right]\dfrac{dM_N(\bar{x}_N)}{d\bar{x}_N}
$$

$$
\begin{aligned}
& \left[\rho_N I_N(\bar{x}_N)-(1-\rho_N)(M_N(\bar{x}_N)-K_N)-i\tau_N M_N(\bar{x}_N)\right]f(\bar{x}_N) \\
& = \left[\dfrac{\overline{\Phi}_N\sigma}{\sigma-1}\left(\dfrac{M_N(\bar{x}_N)}{\delta}-C_N\right)-(1+i\tau_N)M_N(\bar{x}_N)-(1-\delta)\dfrac{M_N(\bar{x}_N)}{\delta}\right]f(\bar{x}_N)
\end{aligned}
$$

Under the Pareto distribution: $\dfrac{1-F(\bar{x}_N)}{\bar{x}_N f(\bar{x}_N)} = \dfrac{1}{\theta}$, and from the bank's loan schedule for non-

innovating firm under Pareto distribution: $\dfrac{dM_N(\bar{x}_N)}{d\bar{x}_N} = \dfrac{\sigma-1}{\bar{x}_N}\left(\dfrac{M_N(\bar{x}_N)}{\delta}-C_N\right)\delta$, the FOC with

respect to $\bar{x}_N$ can be simplified as:

$$\dfrac{M_N(\bar{x}_N)}{\delta}-C_N = \dfrac{\theta(1+i\delta\tau_N)}{\left(\dfrac{\sigma\theta}{\sigma-1}-1\right)\overline{\Phi}_N}C_N$$

Under Pareto distribution, the credit constraint parameter can be simplified as:

$$\overline{\Phi}_N = -(1+i\delta\tau_N)\left[\dfrac{\sigma-1}{\sigma\theta}-1\right]^{-1} \tag{A9}$$

and the FOC with respect to $\bar{x}_N$ can be further simplified as:

$$\dfrac{M_N(\bar{x}_N)}{\delta}-C_N = (\sigma-1)C_N \quad \text{or} \quad M_N(\bar{x}_N) = \delta\sigma C_N \tag{A10}$$

From (A3):

$$\dfrac{M_N(\bar{x}_N)}{\delta} = \left[\dfrac{\sigma-1}{\sigma}\left(\dfrac{\bar{x}_N P}{w}\right)^{\frac{\sigma-1}{\sigma}}Y^{1/\sigma}\right]^{\sigma}\left[\dfrac{\overline{\Phi}_N}{s_N}\right]^{-\sigma}+C_N$$

Combining the two above equations, the solution for the productivity of the cutoff non-

innovating firm can be obtained:

$$\bar{x}_N = w\left(\dfrac{\sigma}{\sigma-1}\left(\dfrac{(\sigma-1)C_N}{s_N^{\sigma}YP^{\sigma-1}}\right)^{1/\sigma}\overline{\Phi}_N\right)^{\sigma/(\sigma-1)}$$

Substituting the solution above into (A7), we have the expected interest payment for the cutoff non-innovating firm:

$$\rho_N I_N(\bar{x}_N) = \left[\overline{\Phi}_N + \delta(1-\rho_N)-1\right]\frac{M_N(\bar{x}_N)}{\delta} - (1-\rho_N)K_N = \sigma\left[\overline{\Phi}_N + \delta(1-\rho_N)-1\right]C_N - (1-\rho_N)K_N$$

Using (A8) and the above equation, we obtain the interest payment schedule for non-innovating firm as:

$$\rho_N I_N(x) = \left[\overline{\Phi}_N + \delta(1-\rho_N)-1\right]\frac{M_N(x)}{\delta} - (1-\rho_N)K_N \quad \forall x \in [\bar{x}_N, \bar{x}_I] \tag{A11}$$

FOC with respect to $\bar{x}_I$ gives us:

$$\int_{\bar{x}_I}^{\infty}\left[\rho_I \frac{dI_I(\bar{x}_I)}{d\bar{x}_I} - \frac{1}{\delta}(\Phi_I + \delta(1-\rho_I)-1)\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I}\right]f(x)dx$$

$$= \left[\begin{array}{l}\rho_I I_I(\bar{x}_I(1+\Delta z)) - i\tau_I M_I(\bar{x}_I(1+\Delta z)) - \rho_N I_N(\bar{x}_I) + i\tau_N M_N(\bar{x}_I) \\ -(1-\rho_I)M_I(\bar{x}_I(1+\Delta z)) + (1-\rho_N)M_N(\bar{x}_I) + (1-\rho_I)K_I - (1-\rho_N)K_N\end{array}\right]f(\bar{x}_I)$$

From (A6), we have:

$$\rho_I \frac{dI_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I} = \frac{1}{\delta}\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I}\left[\frac{\Phi_I \sigma}{\sigma-1} - \delta\rho_I - (1-\delta)\right]$$

$$-\frac{1}{\delta}\frac{dM_N(\bar{x}_I)}{d\bar{x}_I}\left[\frac{\Phi_N \sigma}{\sigma-1} - (\Phi_N - 1+\delta) - (1-\delta)\right]$$

$$= \frac{1}{\delta}\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I}\left[\frac{\Phi_I \sigma}{\sigma-1} + \delta(1-\rho_I)-1\right] - \frac{1}{\delta}\frac{\Phi_N}{\sigma-1}\frac{dM_N(\bar{x}_I)}{d\bar{x}_I}$$

From the loan schedule for innovating firms under Pareto distribution, we have:

$$\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I} = \frac{\sigma-1}{\bar{x}_I}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right)\delta$$

Substituting the above expression into the left hand side of the FOC with respect to $\bar{x}_I$ gives

us:

$$\int_{\bar{x}_I}^{\infty} \left[\rho_I \frac{dI_I(\bar{x}_I)}{d\bar{x}_I} - \frac{1}{\delta}(\Phi_I + \delta(1-\rho_I) - 1)\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I} \right] f(x)dx$$

$$= \int_{\bar{x}_I}^{\infty} \left[\frac{1}{\delta}\frac{\Phi_I}{\sigma-1}\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I} - \frac{1}{\delta}\frac{\Phi_N}{\sigma-1}\frac{dM_N(\bar{x}_I)}{d\bar{x}_I} \right] f(x)dx$$

$$= \int_{\bar{x}_I}^{\infty} \left[\frac{\Phi_I}{\bar{x}_I}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right) - \frac{\Phi_N}{\bar{x}_N}\left(\frac{M_N(\bar{x}_I)}{\delta} - C_N\right) \right] f(x)dx$$

$$= \left[\Phi_I\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right) - \Phi_N\left(\frac{M_N(\bar{x}_I)}{\delta} - C_N\right) \right] \frac{f(\bar{x}_I)}{\theta}$$

The right hand side of the FOC with respect to $\bar{x}_I$ can be simplified as follows:

$$\left[\begin{array}{l} \rho_I I_I(\bar{x}_I(1+\Delta z)) - i\tau_I M_I(\bar{x}_I(1+\Delta z)) - \rho_N I_N(\bar{x}_I) + i\tau_N M_N(\bar{x}_I) \\ -(1-\rho_I)M_I(\bar{x}_I(1+\Delta z)) + (1-\rho_N)M_N(\bar{x}_I) + (1-\rho_I)K_I - (1-\rho_N)K_N K \end{array} \right] f(\bar{x}_I)$$

$$= \left[\begin{array}{l} \frac{\Phi_I \sigma}{\sigma-1}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right) - (1+i\tau_I)M_I(\bar{x}_I(1+\Delta z)) + (1+i\tau_N)M_N(\bar{x}_I) \\ -\frac{\Phi_N \sigma}{\sigma-1}\left(\frac{M_N(\bar{x}_I)}{\delta} - C_N\right) - \frac{(1-\delta)}{\delta}[M_I(\bar{x}_I(1+\Delta z)) - M_N(\bar{x}_I)] \\ +\left\{ \rho_N I_N(\bar{x}_N) - \rho_N I_N(\bar{x}_I) + (\Phi_N - 1 + \delta)\frac{M_N(\bar{x}_I)}{\delta} - (\Phi_N + \delta(1-\rho_N) - 1)\frac{M_N(\bar{x}_N)}{\delta} - \rho_N M_N(\bar{x}_I) \right\} \end{array} \right] f(\bar{x}_I)$$

Using (A9), we can see that the last expression of the right hand side of the above equation

equals 0:

$$\left\{ \rho_N I_N(\bar{x}_N) - \rho_N I_N(\bar{x}_I) + (\Phi_N - 1 + \delta)\frac{M_N(\bar{x}_I)}{\delta} - (\Phi_N + \delta(1-\rho_N) - 1)\frac{M_N(\bar{x}_N)}{\delta} - \rho_N M_N(\bar{x}_I) \right\}$$

$$= \left[\overline{\Phi}_N + \delta(1-\rho_N) - 1\right]\left[\frac{M_N(\bar{x}_N)}{\delta} - \frac{M_N(\bar{x}_I)}{\delta}\right] - (\Phi_N + \delta(1-\rho_N) - 1)\left[\frac{M_N(\bar{x}_N)}{\delta} - \frac{M_N(\bar{x}_I)}{\delta}\right]$$

$$= 0$$

So the RHS of the FOC with respect to x_I can be further simplified as:

$$\left[\begin{array}{l}\dfrac{\Phi_I\sigma}{\sigma-1}\left(\dfrac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-\dfrac{\Phi_N\sigma}{\sigma-1}\left(\dfrac{M_N(\bar{x}_I)}{\delta}-C_N\right)-(1+i\tau_I)M_I(\bar{x}_I(1+\Delta z))+(1+i\tau_N)M_N(\bar{x}_I)\\[3mm]-\dfrac{(1-\delta)}{\delta}\left[M_I(\bar{x}_I(1+\Delta z))-M_N(\bar{x}_I)\right]\end{array}\right]f(x_I)$$

From the expression of the loan schedule under Pareto distribution of firm productivity, i.e. (A1), we have:

$$\frac{M_N(\bar{x}_I)}{\delta}-C_N=(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)$$

Putting together the above expressions, we can solve the FOC with respect to x_I as follows:

$$\left[\Phi_I\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-\Phi_N\left(\frac{M_N(\bar{x}_I)}{\delta}-C_N\right)\right]\frac{1}{\theta}$$

$$=\frac{\Phi_I\sigma}{\sigma-1}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-(1+i\tau_I)M_I(\bar{x}_I(1+\Delta z))+(1+i\tau_N)M_N(\bar{x}_I)$$

$$-\frac{\Phi_N\sigma}{\sigma-1}\left(\frac{M_N(\bar{x}_I)}{\delta}-C_N\right)-\frac{(1-\delta)}{\delta}\left[M_I(\bar{x}_I(1+\Delta z))-M_N(\bar{x}_I)\right]$$

or

$$\left[\Phi_I\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-\Phi_N(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)\right]\frac{1}{\theta}$$

$$=\frac{\Phi_I\sigma}{\sigma-1}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-\delta(1+i\tau_I)\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-\delta(1+i\tau_I)C_I$$

$$-\frac{\Phi_N\sigma}{\sigma-1}(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-(1-\delta)\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-(1-\delta)C_I$$

$$+\left[\delta(1+i\tau_N)+(1-\delta)\right]\left\{(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)+C_N\right\}$$

So

$$\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I = \Pi\left[(1+\delta i\,\tau_N)C_N - (1+\delta i\,\tau_I)C_I\right]$$

(A12)

where

$$\Pi = \frac{\Phi_I}{\theta} - \frac{\Phi_I\sigma}{\sigma-1} + (1+i\delta\tau_I) + (1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\left[\frac{\Phi_N\sigma}{\sigma-1} - \frac{\Phi_N}{\theta} - (1+i\delta\tau_I)\right]$$

which, under the assumption of Pareto distribution of firm productivity, using (A1) and (A2) can

be written as

$$\Pi = (1+i\delta\tau_I)\left(1 - \frac{\sigma-1}{\sigma\theta}\right)^{-1}\left[\frac{1}{\theta} - \frac{\sigma}{\sigma-1}\right] + (1+i\delta\tau_I)$$

$$+ (1+\Delta z)^{1-\sigma}\left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\left[(1+i\delta\tau_N)\left(1 - \frac{\sigma-1}{\sigma\theta}\right)^{-1}\left[\frac{1}{\theta} - \frac{\sigma}{\sigma-1}\right] - (1+i\delta\tau_I)\right]$$

$$= -(1+i\delta\tau_I)\frac{\sigma}{\sigma-1} + (1+i\delta\tau_I) + (1+\Delta z)^{1-\sigma}\left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\left[(1+i\delta\tau_N)\frac{-\sigma}{\sigma-1} - (1+i\delta\tau_I)\right]$$

or

$$\Pi = \frac{-1}{\sigma-1}(1+i\delta\tau_I) - (1+\Delta z)^{1-\sigma}\left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\left[\frac{\sigma}{\sigma-1}(1+i\delta\tau_N) + (1+i\delta\tau_I)\right]$$

From (A4):

$$\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} = \left[\frac{\sigma-1}{\sigma}\left(\frac{\bar{x}_I(1+\Delta z)P}{w}\right)^{\frac{\sigma-1}{\sigma}}Y^{1/\sigma}\right]^{\sigma}\left[\frac{\overline{\Phi}_I}{s_I}\right]^{-\sigma} + C_I$$

Combining the expression above with (A12), we can solve for the productivity of the cutoff innovating firm:

$$\bar{x}_I = w \left(\frac{\sigma}{\sigma-1} \left(\frac{(\Pi[(1+\delta i\tau_N)C_N - (1+\delta i\tau_I)C_I])^{1/\sigma}}{s_I^\sigma Y(1+\Delta z)^{\sigma-1} P^{\sigma-1}} \overline{\Phi}_I \right)^{1/\sigma} \right)^{\sigma/(\sigma-1)}$$

Note that

$$\frac{\partial \Pi}{\partial i} = -\frac{-1}{\sigma-1}\delta\tau_I$$

$$-(1+\Delta z)^{1-\sigma} \left\{ \begin{array}{l} (-\sigma)\left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)}\cdot\frac{s_I}{s_N}\right]^{-\sigma-1}\frac{s_I}{s_N}\frac{\delta(\tau_N-\tau_I)}{(1+i\delta\tau_I)^2}\left[\frac{\sigma}{\sigma-1}(1+i\delta\tau_N)+(1+i\delta\tau_I)\right] \\ +\left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\frac{\sigma\delta(\tau_N+\tau_I)}{\sigma-1} \end{array} \right\}$$

Since $\tau_N < \tau_I$, $\frac{\partial\Pi}{\partial i} < 0$. Since $\tau_N < \tau_I$ and $C_N < C_I$, this, in turns, implies that $\bar{x}_I$ is

increasing in i.

Substituting the above solution of the loan for the cutoff innovating firm into (A8), we can

solve for the interest payment for the cutoff innovating firm:

$$\rho_I I_I(\bar{x}_I(1+\Delta z)) = \frac{\Phi_I\sigma}{\sigma-1}\Pi[(1+\delta i\tau_N)C_N - (1+\delta i\tau_I)C_I] - (1-\delta(1-\rho_I))\{\Pi[(1+\delta i\tau_N)C_N - (1+\delta i\tau_I)C_I] + C_I\}$$

$$-(1-\rho_I)K_I + (1-\rho_N)K_N - \frac{\Phi_N}{\sigma-1}(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}\cdot\frac{s_I}{s_N}\right]^{-\sigma}\Pi[(1+\delta i\tau_N)C_N - (1+\delta i\tau_I)C_I]$$

$$+\sigma[\overline{\Phi}_N + \delta(1-\rho_N) - 1]C_N - (1-\rho_N)K_N$$

$$+\Phi_N C_N - \sigma(\Phi_N + \delta(1-\rho_N) - 1)C_N$$

which can be rearranged as:

$$\rho_I I_I(\overline{x}_I(1+\Delta z)) = \left\{\frac{\Phi_I \sigma}{\sigma-1} - (1-\delta(1-\rho_I)) - \frac{\Phi_N}{\sigma-1}(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I} \cdot \frac{s_I}{s_N}\right]^{-\sigma}\right\}\Pi\left[(1+\delta i \tau_N)C_N - (1+\delta i \tau_I)C_I\right]$$
$$- (1-\rho_I)K_I + \Phi_N C_N - (1-\delta(1-\rho_I))C_I$$

Taking derivative of the equation above, we have the interest payment schedule for innovating firm as

$$\rho_I I_I(x(1+\Delta z)) = \left(\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) + \delta(1-\rho_I) - 1\right)\frac{M_I(x(1+\Delta z))}{\delta}$$
$$+ \rho_I I_I(\overline{x}_I(1+\Delta z)) + \Pi\left[(1+\delta i \tau_N)C_N - (1+\delta i \tau_I)C_I\right] + C_I$$

or

$$\rho_I I_I(x(1+\Delta z)) = \left(\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) + \delta(1-\rho_I) - 1\right)\frac{M_I(x(1+\Delta z))}{\delta} + \Psi \qquad (A13)$$

where

$$\Psi = \left\{\frac{\Phi_I \sigma}{\sigma-1} + \delta(1-\rho_I) - \frac{\Phi_N}{\sigma-1}(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I} \cdot \frac{s_I}{s_N}\right]^{-\sigma}\right\}\Pi\left[(1+\delta i \tau_N)C_N - (1+\delta i \tau_I)C_I\right]$$
$$- (1-\rho_I)K_I + \Phi_N C_N + \delta(1-\rho_I)C_I$$

Under the assumption of Pareto distribution of firm productivity, using (A1) and (A2), the expression above can be simplified as

$$\Psi = \left\{ \begin{array}{l} \dfrac{\sigma}{\sigma-1}(1+i\delta\tau_I)\left(1-\dfrac{\sigma-1}{\sigma\theta}\right)^{-1} + \delta(1-\rho_I) \\[4mm] -\dfrac{1}{\sigma-1}(1+i\delta\tau_N)\left(1-\dfrac{\sigma-1}{\sigma\theta}\right)^{-1}(1+\Delta z)^{1-\sigma}\left[\dfrac{1+i\delta\tau_N}{1+i\delta\tau_I}\cdot\dfrac{s_I}{s_N}\right]^{-\sigma} \end{array} \right\} \Pi\left[(1+\delta i\tau_N)C_N - (1+\delta i\tau_I)C_I\right]$$

$$-(1-\rho_I)K_I + (1+i\delta\tau_N)\left(1-\dfrac{\sigma-1}{\sigma\theta}\right)^{-1}C_N + \delta(1-\rho_I)C_I$$

III.   Monotonicity of Profits

We have derived earlier the expected profit for innovating firms and non-innovating firms as follows:

$$E(\pi_N(x,x)) = \frac{\Phi_N\sigma}{\sigma-1}\left(\frac{M_N(x)}{\delta} - C_N\right) - \rho_N\big(M_N(x) + I_N(x)\big) - (1-\rho_N)K_N - (1-\delta)\frac{M_N(x)}{\delta}$$

Recall that under the assumption that firm productivity follows a Pareto distribution, Φ_N and Φ_I are both constants (see (A1) and (A2)) and denoted as $\overline{\Phi}_N$ and $\overline{\Phi}_I$. Therefore, using the corresponding incentive-compatibility condition for innovating firms and non-innovating firms, i.e. conditions (5) and (8), we have:

$$\frac{dE(\pi_N(x,x))}{dx} = \left(\frac{\sigma}{\sigma-1}\overline{\Phi}_N + \delta(1-\rho_N) - 1\right)\frac{M_N'(x)}{\delta} - \rho_N I_N'(x)$$

$$= \left(\frac{\sigma}{\sigma-1}\overline{\Phi}_N + \delta(1-\rho_N) - 1\right)\frac{M_N'(x)}{\delta} - \left(\overline{\Phi}_N + \delta(1-\rho_N) - 1\right)\frac{M_N'(x)}{\delta}$$

$$= \frac{\overline{\Phi}_N}{\sigma-1}\frac{M_N'(x)}{\delta} > 0$$

$$\frac{dE(\pi_I(x(1+\Delta z)), x(1+\Delta z))}{dx} = (1+\Delta z)\left\{\left(\frac{\sigma}{\sigma-1}\overline{\Phi}_I + \delta(1-\rho_I)-1\right)\frac{M'_I(x(1+\Delta z))}{\delta} - \rho_I I'_I(x)\right\}$$

$$= (1+\Delta z)\left\{\left(\frac{\sigma}{\sigma-1}\overline{\Phi}_I + \delta(1-\rho_I)-1\right)\frac{M'_I(x(1+\Delta z))}{\delta} - \left(\overline{\Phi}_I + \delta(1-\rho_I)-1\right)\frac{M'_I(x(1+\Delta z))}{\delta}\right\}$$

$$= (1+\Delta z)\frac{\overline{\Phi}_I}{\sigma-1}\frac{M'_I(x(1+\Delta z))}{\delta} > 0$$

Therefore, expected profits are increasing in productivity level for both non-innovating and innovating firms.

Furthermore, from the formula for the optimal loan amounts under Pareto distribution of firm productivity, i.e. equations (A3) and (A4), it can easily be seen that $M'_I(x(1+\Delta z)) > M'_N(x)$. Also, it has been proved above that $\overline{\Phi}_I > \overline{\Phi}_N$. Combining these two inequalities, it can be readily seen that $\frac{dE(\pi_I)}{dx} > \frac{dE(\pi_N)}{dx}$. Thus, the slope of the expected profit function for innovating firms is higher than the slope of the expected profit function for non-innovating firms. Combined with monotonicity of profit, this implies that firms with productivity above will all choose to innovate and firms with productivity below will not opt for innovation activities. This means that in an equilibrium where there are both non-innovating firms and innovating firms, the productivity cutoff for innovation is higher than the productivity cutoff for operation: $\bar{x}_I > \bar{x}_N$

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