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

Mai Anh Ngo

January 30, 2014

ABSTRACT

This paper explores the impact of credit constraints on a firm's performance and whether innovating firms face a tighter credit constraint. In the theoretical model of the paper, credit constraint arises from the asymmetric information problem where banks cannot observe a firm's true productivity. The longer time frame and the higher risks of innovation projects result in tighter credit constraints for innovating firms than for non-innovating firms. Thus, the theoretical model predicts a positive relationship between a firm's interest payment per worker and its revenue (and profits) per worker, as well as tighter credit constraints for innovating firms. Empirical evidence on a sample of Vietnamese small and medium enterprises supports these theoretical predictions.

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 be plagued by low capital and small internal funds. 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 feature 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 instead of export 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 and the higher risk of these projects. To test the theoretical predictions, empirical estimations were conducted using a panel 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[1] and the business environment is still immature and rapidly changing, banks face a much more acute problem of asymmetric information where it is a

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

challenge for the banks to determine the true profitability of the firm that apply for loans.[2] Moral hazards are still high due to little regulatory oversights, 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). The majority of firms in the Vietnamese private sector are small and medium enterprises SMEs. At the same time, there is (some ad-hoc) evidence/a general belief that SMEs in Vietnam are financially constrained. While the banking system in Vietnam has undergone significant improvement from a centrally planned state-owned system to a more market-oriented system, the Vietnamese banking sector is still relatively underdeveloped,[3] 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 private firms, studying how credit constraint affects innovation and ultimately, the competitiveness of SMEs is important for Vietnamese economic growth.

In the empirical application to the Vietnamese SME data set, 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

[2] 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."

[3] 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."

The literature of the importance of financing constraint on firm investment, R& D and recently, on firm's innovation output 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 constraint. The logic behind this approach is that if the credit market is perfect, cash flow should not affect firms' investment decisions. However, if the asymmetric information or contract enforcement problems 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, e.g. 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 sets 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, Hall (2005) reports evidence for the presence of liquidity constraints in a number of studies of R&D investment by firms in various developed countries. 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 panel firm-level 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 attributed 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. [4] Banerjee and

[4] 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 may also 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.

Duflo (2001) exploit a 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 direct measures of innovation output in developing countries instead of indirect measures such as R&D spending. One of the reasons for the switch of focus on innovation output is of 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 or small firms 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. First, 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. (2006) 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 theoretical 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 addition, my empirical estimation methods are different from theirs. I analyze a data set of Vietnamese small and medium enterprises (SMEs). My analysis focuses on an indicator of innovation on existing products, where adaptation of products is more relevant than creation of new products. My empirical results provide firm-level evidence of the presence of credit constraint on innovating firms from a developing country that is less studied, Vietnam.

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 homogenous 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:

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

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 and 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:

$$q(\omega) = \frac{Y}{P} \left(\frac{p(\omega)}{P} \right)^{-\sigma} \quad (1)$$

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 homogenous good sector are homogenous and 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, an innovating firm will enjoy higher revenue that comes from a greater productivity level compared to when it did not innovate.[5] 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 repayment in additional to project risks, it is assumed that $\rho_I \le s_I$ and $\rho_N \le s_N$. It is also assumed that $\rho_I \ge \rho_N$ 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.[6]

---

[5] 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.

[6] 61.55% firms in the final regression sample do not keep a formal accounting book in accordance with regulations.

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.

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.[7] 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.

$$\max_{x',q_N} E\left(\pi_N(x,x')\right) = s_N p_N q_N - (1-\delta)\left(\frac{q_N w}{x} + C_N\right) - \rho_N\left(M_N(x') + I_N(x')\right) - (1-\rho_N)K_N \quad (2)$$

s.t.

$$E\left(\pi_N(x,x)\right) \geq E\left(\pi_N(x,x')\right)$$
$$E\left(\pi_N(x,x)\right) \geq 0$$
$$M_N(x') \geq \delta\left(\frac{q_N w}{x} + C_N\right)$$
$$q_N = \frac{Y}{P}\left(\frac{p(x)}{P}\right)^{-\sigma}$$

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 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:

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

$$q_N = \left(\frac{M_N(x')}{\delta} - C_N \right) \frac{x}{w} \tag{3}$$

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

$$\frac{\partial E(\pi_N(x, x''))}{\partial x'}\Big|_{x'=x} = 0 \tag{4}$$

Solving the firm profit-maximization problem and then taking the derivative as in (4) gives us the following condition in equilibrium:

$$\left(\Phi_N(x, M_N(x)) + \delta(1-\rho_N) - 1\right) \frac{M_N'(x)}{\delta} = \rho_N I_N'(x) \tag{5}$$

where the apostrophe denotes a derivative and

$$\begin{aligned} \Phi_N(x, M_N(x)) &\equiv \left[\frac{\sigma-1}{\sigma} s_N p_N \right] / \frac{w}{x} \\ &= s_N \frac{\sigma-1}{\sigma} \left(\frac{M_N(x)}{\delta} - C_N \right)^{-1/\sigma} \left(\frac{xP}{w} \right)^{\frac{\sigma-1}{\sigma}} Y^{1/\sigma} \end{aligned} \tag{6}$$

As can be seen from the first line of (6), Φ_N is the ratio of expected marginal revenue to marginal cost. The expression in the second line of (6) can be obtained by rewriting the first line using (3) and (1).

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

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

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 $\overline{\Phi}_N = 1$. Then, from (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 $\overline{\Phi}_N$ is greater than unity, $q_N(x)$ 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 (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. While one may argue that it is difficult for a bank to monitor whether its loan is used for innovation, it is true that. 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.

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

$$E(\pi_I(x(1+\Delta z), x(1+\Delta z))) \geq E(\pi_I(x(1+\Delta z), x'))$$
$$E(\pi_I(x(1+\Delta z), x(1+\Delta z))) \geq 0$$

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

In equilibrium, the third constraint is binding:

$$q_I = \left(\frac{M_I(x')}{\delta} - C_I\right)\frac{x(1+\Delta z)}{w} \quad (7)$$

The incentive-compatibility condition requires that:

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

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:

$$\begin{aligned}\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) &\equiv \left[\frac{\sigma-1}{\sigma} s_I p_I\right] / \frac{w}{x(1+\Delta z)} \\ &= s_I \frac{\sigma-1}{\sigma}\left(\frac{M_I(x(1+\Delta z))}{\delta} - C_I\right)^{-1/\sigma}\left(\frac{x(1+\Delta z)P}{w}\right)^{\frac{\sigma-1}{\sigma}} Y^{1/\sigma}\end{aligned} \quad (7)$$

and in equilibrium, the following equality holds:

$$\left(\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) + \delta(1-\rho_N) - 1\right)\frac{M_I'(x(1+\Delta z))}{\delta} = \rho_I I_I'(x(1+\Delta z)) \quad (8)$$

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*.[8] In the Appendix, it is proved that only more productive firms find it profitable to innovate. Together, these implies 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,

[8] 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)

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:

$$\mathrm{Max}_{M,I} \int_{\bar{x}_N}^{\bar{x}_I} \rho_N I_N(x) - (1-\rho_N)(M_N(x) - K_N) - i\tau_N M_N(x)) f(x)dx$$
$$+ \int_{\bar{x}_I}^{\infty} \rho_I I_I(x(1+\Delta z)) - (1-\rho_I)(M_I(x(1+\Delta z)) - K_I) - i\tau_I M_I(x(1+\Delta z))) f(x)dx$$

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 the *Appendix* that the optimal loan schedules for the bank satisfy the following conditions:

$$\Phi_N(x, M_N(x)) = (1+i\delta\tau_N)\left[1-\left(\frac{\sigma-1}{\sigma}\right)\frac{1-F(x)}{xf(x)}\right]^{-1} \quad (9)$$

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

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:

$$\Phi_N(x, M_N(x)) = (1+i\tau_N)\left[1-\left(\frac{\sigma-1}{\sigma}\right)\frac{(1/x)^{\theta}}{\theta x(1/x)^{\theta-1}(1/x^2)}\right]^{-1}$$

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

$$\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) = (1+i\delta\tau_I)\left(1-\frac{\sigma-1}{\sigma\theta}\right)^{-1} \equiv \overline{\Phi}_I$$

(10)

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

$$\frac{M_I(x(1+\Delta z))}{\delta} = \left[\frac{\sigma-1}{\sigma}\left(\frac{x(1+\Delta z)P}{w}\right)^{\frac{\sigma-1}{\sigma}} Y^{1/\sigma}\right]^{\sigma}\left[\frac{\overline{\Phi}_I}{s_I}\right]^{-\sigma} + C_I \qquad (11)$$

Equation (10) indicates that if 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 $\Phi_N > 1$ and $\Phi_I > 1$, 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 the *Appendix*, and are as follows:

$$\rho_N I_N(x) = \left[\overline{\Phi}_N + \delta(1-\rho_N) - 1\right]\frac{M_N(x)}{\delta} - (1-\rho_N)K_N\,, \quad \forall x \in [\bar{x}_N, \bar{x}_I) \tag{12}$$

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

where

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

and

$$\Pi = \frac{\overline{\Phi}_I}{\theta} - \frac{\overline{\Phi}_I \sigma}{\sigma - 1} + (1+i\delta\tau_I) + (1+\Delta z)^{1-\sigma}\left[\frac{\overline{\Phi}_N}{\overline{\Phi}_I}.\frac{s_I}{s_N}\right]^{-\sigma}\left[\frac{\overline{\Phi}_N \sigma}{\sigma - 1} - \frac{\overline{\Phi}_N}{\theta} - (1+i\delta\tau_I)\right]$$

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 the Appendix, the productivity cutoff for production is:

$$\bar{x}_N = w\left(\frac{\sigma}{\sigma - 1}\left(\frac{(\sigma-1)C_N}{s_N^{\sigma} Y P^{\sigma-1}}\right)^{1/\sigma}\overline{\Phi}_N\right)^{\sigma/(\sigma-1)} \tag{13}$$

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:

$$\bar{x}_I = w\left(\frac{\sigma}{\sigma-1}\left(\frac{(\Pi\left[(1+\delta i\tau_N)C_N-(1+\delta i\tau_I)C_I\right]}{s_I^{\sigma}Y(1+\Delta z)^{\sigma-1}P^{\sigma-1}}\right)^{1/\sigma}\overline{\Phi}_I\right)^{\sigma/(\sigma-1)} \qquad (14)$$

where

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

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 hypotheses. The first one is that credit constraint negatively affects firm's output and revenues. The second hypothesis is that innovating firms are more credit constrained than non-innovating ones. In the following Empirical Testing section, I derive an estimating equation linking firm-level formal interest payments, innovation and revenue. This estimating equation will then be estimated using a panel firm-level data set of Vietnamese small and medium enterprises.

IV. Empirical Testing

1. Data

For the empirical application, I analyzed a panel data set of Vietnamese private, small and medium enterprises (SMEs) in the manufacturing sector. Vietnam provides an interesting case to study the impact of credit constraint on firm innovation. There is ample evidence that Vietnamese firms face high credit constraint. For example, most surveys of private company owners in Vietnam cite difficulty of accessing credit as one of the leading obstacles to private sector development (see Malesky 2008 for a summary of the information from these surveys).

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 constantly innovate 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.[9] 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,[10] 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 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 two the last two wave 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

[9] The survey project was started as a 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.

[10] 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.

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.[11] Some overview information on the firms in the data set is provided in Table 1.1 to Table 1.3. Table 2.1 and 2.2 presents 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 were in both survey waves.

2. Estimating Equations

Recall that under 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:

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

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

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

[11] Firms that are joint venture 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.

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

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

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

where

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

and

$$\Pi = \frac{\overline{\Phi}_I}{\theta} - \frac{\overline{\Phi}_I\sigma}{\sigma-1} + (1+i\delta\tau_I) + (1+\Delta z)^{1-\sigma}\left[\frac{\overline{\Phi}_N}{\overline{\Phi}_I}.\frac{s_I}{s_N}\right]^{-\sigma}\left[\frac{\overline{\Phi}_N\sigma}{\sigma-1} - \frac{\overline{\Phi}_N}{\theta} - (1+i\delta\tau_I)\right]$$

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:

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

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

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

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

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*:

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

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 summary, the theoretical model predicts that in the above regression of the firm's revenue, the coefficient on the interest payment is positive while the coefficient on the interaction term between the interest payment and the innovation indicator is negative. The constant term in the regression is expected to be 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.

In estimating the equation above, I added two transformations. First, I scaled 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 took 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. 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:

$$\ln\left(\frac{y_{it}}{L_{it}}\right) = \alpha_0 + \alpha_1 \frac{\text{InterestPayment}_{it}}{L_{it}} + \alpha_2 \text{Innovation}_{it} + \alpha_3 \text{Innovation}_{it} * \frac{\text{InterestPayment}_{it}}{L_{it}} + \alpha_4 \ln\left(\frac{K_{it}}{L_{it}}\right) + \alpha_5 \ln(L_{it}) + \alpha_6 S_{it} + \alpha_7 T_t + \eta_i + \varepsilon_{it} \tag{15}$$

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. Thus, in effect, the estimating equation is an augmented scaled production function. 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 $(0, \sigma_\varepsilon^2)$.

The innovation indicator is defined as follows. 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 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 nonlinearity between a firm's formal interest payment per worker and its credit constraint degree. The first 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 while the second group is more likely to be credit constrained due to the high costs of borrowing. I would argue that this concern is likely not applicable to the case of Vietnam, where, according to Rand (2009), there is little variance in the terms of bank loans to private firms.

The second concern is that the formal interest payment per worker is a mixed signal of the degree of credit constraint. For example, while 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. 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.

To estimate the baseline regression, i.e. equation (15), I used 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 unobservable. However, an important estimation issue with estimating 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) 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 since being financially distressed because of high indebtedness is not a relevant issue for the population of firms in my data. 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. Therefore, I constructed a credit constraint indicator such that the indicator takes value of one if the firm's formal interest payment per worker is greater than the 80^{th} percentile of the variable in the same sector and the same survey wave.[12]

The endogenous switching regression accounts for self-selection into credit constraint or innovation. By explicitly modeling the credit constraint status, the switching regression method

---

[12] 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.

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. The latter method may suffer from “sensitivity caused by arbitrarily choosing and 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 assumption. 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 is the credit constraint status, hereafter called the credit constraint endogenous switching regression, is as follows:

$$\ln\left(\frac{y_{it}}{L_{it}}\right) = \alpha_1 + \alpha_2 \ln\left(\frac{K_{it}}{L_{it}}\right) + \alpha_3 \ln(L_{it}) + \alpha_4 CC_{it} + \alpha_5 Innovation_{it} + \alpha_6 S_{it} + \alpha_7 T_t + \mu_{1i} + \varepsilon_{1it} \quad (16)$$

$$CC_{it}^{*} = Z_{it}'\beta + \mu_{2i} + \varepsilon_{2it}$$

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 constrain indicator is defined to take value of one if the firm’s formal interest payments 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:

$$\begin{aligned} \mu_{1i} &= \gamma_1 + \alpha_1 y_{i0} + \bar{X}_i \delta_1 + a_{1i} \\ \mu_{2i} &= \gamma_2 + \alpha_2 CC_{i0} + \bar{z}_i \delta_2 + a_{2i} \end{aligned} \qquad (17)$$

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. $\bar{X}_i$ and $\bar{z}_i$ are vectors of averages over time of the regressors for firm *i* in the main regression and the credit constraint equation, i.e. $\bar{X}_i = \left(\sum_{t=1}^{T} X_{it} \right) / T$ and $\bar{Z}_i = \left(\sum_{t=1}^{T} Z_{it} \right) / T$. 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 (17) into equation (16) yields the credit constraint endogenous switching regression equation to be estimated:

$$\begin{aligned} \ln\left(\frac{y_{it}}{L_{it}}\right) &= (\alpha_1 + \gamma_1) + \alpha_2 \ln\left(\frac{K_{it}}{L_{it}}\right) + \alpha_3 \ln(L_{it}) + \alpha_4 Innovation_{it} + \alpha_5 CC_{it} + \alpha_1 y_{i0} \\ &\quad + \bar{X}_i \delta_1 + (a_{1i} + \varepsilon_{1it}) \\ CC_{it}^* &= (\theta + \gamma_2) + Z_{it}' \beta + \alpha_2 CC_{i0} + \bar{Z}_i \delta_2 + (a_{2i} + \varepsilon_{2it}) \end{aligned} \qquad (18)$$

with

$$\begin{aligned} CC_{it} &= 1 \text{ if } CC_{it}^* \geq 0 \\ CC_{it} &= 0 \text{ if } CC_{it}^* < 0 \end{aligned}$$

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:

$$\ln\left(\frac{y_{it}}{L_{it}}\right) = \beta_1 + \beta_2 \ln\left(\frac{K_{it}}{L_{it}}\right) + \beta_3 \ln(L_{it}) + \beta_4 \frac{IP_{it}}{L_{it}} + \beta_5 Innovation_{it} + \beta_6 S_{it} + \beta_7 T_t$$

$$+ \beta_8 \ln\left(\frac{y_{i0}}{L_{i0}}\right) + \overline{X}_i \eta_1 + (b_{1i} + \varepsilon_{1it}) \qquad (19)$$

$$Innovation_{it}^* = \lambda_1 + z_{it}'\gamma + \lambda_2 Innovation_{i0} + \bar{z}_i \eta_2 + (b_{2i} + \varepsilon_{2it})$$

with

$$Innovation_{it} = 1 \text{ if } Innovation_{it}^* \geq 0$$

$$Innovation_{it} = 0 \text{ if } \mathrm{Innovation}_{it}^* < 0$$

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 payments 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' age 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: the baseline regression using fixed effect method, the credit constraint endogenous switching regression and the innovation endogenous switching regression. These estimation results are presented in the following section (Section 3 – 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.

3. Empirical Results

3.3.1. 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 1.3).

3.3.2. Estimation Results

Table 3 presents the fixed-effect estimation results of the baseline regression. All of the coefficients have the expected signs and statistical significances. 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 faced 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. In short, the estimation of the baseline regression confirms the theoretical model's predictions that credit constraint is, on average, tighter for innovating firms and has a negative impact on revenues and profits.

Table 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 4.2 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 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.

4. Robustness Checks

4.4.1. Addressing the Reverse Causation Concern by Estimating a Regression in the Reverse Causation Direction

Secondly, 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 lag of revenues lag of profits per worker have no significant impact on the interest payments per worker (see Table 5). This gives some confidence that reverse causation may not be a serious problem in the data set used in this paper.

4.4.2. 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.[13] For this reason, matching helps to eliminate (or at least alleviate) the self-selection problem and makes it more 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 affect either the treatment assignment or the outcomes, matching with difference-in-difference will be unbiased.[14] The set of covariates used in matching will be presented in Section 4.4.2.1.

4.4.2.1. 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 assumption is the common support assumption which requires that the distributions of

[13] 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.

[14] 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.

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 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 show 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.

4.4.2.2. Matching Results

The matching and estimation of the 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 logic 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 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 values 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.

The results in Table 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 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 liberalizaton would lead to increased credit access were less likely to be credit constrained.

Table 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.

4.4.3. Other Robustness Checks and Next Step

For additional robustness checks, I estimate the innovation endogenous switching regression with the interest payments per worker replaced by the credit constraint indicator (based on the 80^{th} percentile of interst payments per worker in a sector-wave) or replaced by the actual formal debts per worker. The results are very similar. To make the analysis more complete, I am planning to conduct an empirical estimation to investigate whether credit constraint results in firms dropping innovative projects that they indicated they had planned to undertake.

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.

References

Abadie, A., and G. W. Imbens. 2008. On the failure of the bootstrap for matching estimators. ***Econometrica*, 76: 1537–1557.**

Abadie, A., and G. W. Imbens.. 2011. Bias-corrected matching estimators for average treatment effects. Journal of Business and Economic Statistics 29: 1–11.

Aghion, P., Askenazy, P., Berman, N., Cette, G., & Eymard, L. 2012. Credit constraints and the cyclicality of R&D investment: Evidence from france. ***Journal of the European Economic Association***, 10(5): 1001-1024.

Alessandrini, P., Presbitero, A., & Zazzaro, A. 2006. Banks, distances and financing constraints for firms. ***Universita Politecnica delle Marche Economics Working Paper***(266).

Ayyagari, M., Demirguc-Kunt, A., & Maksimovic, V. 2011. Firm innovation in emerging markets: The role of finance, governance, and competition. ***Journal of Financial and Quantitative Analysis***, 46(6): 1545-1580.

Badia, M. M., & Slootmaekers, V. 2009. ***The missing link between financial constraints and productivity.*** INTERNATIONAL MONETARY FUND.

Banerjee, A., & Duflo, E. 2001. ***The nature of credit constraints: Evidence from an indian bank***. Paper presented at Manuscript, MIT. Available at: http://www. chicagobooth. edu/research/workshops/AppliedEcon/archive/WebAr chive20012002/duflo.pdf.

Baron, David P. and Roger B. Myerson. 1982. "Regulating a Monopolist with Unknown Costs" ***Econometrica: Journal of the Econometric Society***: 911-930.

Bigsten, A. 2000. Rates of return on physical and human capital in africa's manufacturing sector. ***Economic Development and Cultural Change***, 48(4): 801-827.

Bigsten, A., Collier, P., Dercon, S., Fafchamps, M., Gauthier, B., Gunning, J. W., Oduro, A., Oostendorp, R., Patillo, C., Soderbom, M., Teal, F., & Zeufack, A. 2003. Credit constraints in manufacturing enterprises in africa. ***J Afr Econ***, 12(1): 104-125.

Bond, S., & Meghir, C. 1994. Dynamic investment models and the firm's financial policy. ***The Review of Economic Studies***, 61(2): 197-222.

Campello, M., Graham, J. R., & Harvey, C. R. 2010. The real effects of financial constraints: Evidence from a financial crisis. ***Journal of Financial Economics***, 97(3): 470-487.

Campello, M., Graham, J. R., & Harvey, C. R. 2010. The real effects of financial constraints: Evidence from a financial crisis. ***Journal of Financial Economics***, 97(3): 470-487.

Cooley, T. F., & Quadrini, V. 2001. Financial markets and firm dynamics. ***American Economic Review***, 91(5): 1286-1310.

Easterly, W., & Levine, R. 2002. ***It's Not Factor Accumulation: Stylized Facts and Growth Models***. Central Bank of Chile.

Fazzari, S., Hubbard, R. G., & Petersen, B. 1988. Investment, financing decisions, and tax policy. ***American Economic Review***, 78(2): 200.

Feenstra, R. C., Li, Z., & Yu, M. 2011. ***Exports and credit constraints under incomplete information: Theory and evidence from china***. NBER Working Paper, forthcoming in ***Review of Economics and Statistics*** 2013.

Gatti, R., & Love, I. 2008. Does access to credit improve productivity? evidence from Bulgaria1. ***Economics of Transition***, 16(3): 445-465.

Gomes, J. F. 2001. Financing investment. ***American Economic Review***: 1263-1285.

Gorodnichenko, Y., Schnitzer, M., & National Bureau of Economic Research. ***Financial constraints and innovation: why poor countries don't catch up.***

Guiso, L., & Minetti, R. 2004. ***Multiple Creditors and Information Rights: Theory and Evidence from US Firms***. CEPR Discussion Papers.

Hall, B., & Lerner, J. 2010. ***The Financing of R&D and Innovation, UNU-MERIT***.

Hall, B. H. 2005. The financing of innovation. ***The Handbook of Technology and Innovation Management***: 409-430.

Klenow, P., & Rodriguez-Clare, A. 1997. The neoclassical revival in growth economics: Has it gone too far? In ***NBER macroeconomics annual 1997, volume 12***: 73-114MIT Press.

Le, N. T., & Nguyen, T. V. 2009. The impact of networking on bank financing: The case of small and medium-sized enterprises in Vietnam. ***Entrepreneurship Theory and Practice***, 33(4): 867-887.

Le, N. T., Venkatesh, S., & Nguyen, T. V. 2006. Getting bank financing: A study of Vietnamese private firms. ***Asia Pacific Journal of Management***, 23(2): 209-227.

Levine, R. 2001. International financial liberalization and economic growth. ***Review of International economics***, 9(4): 688-702.

Levine, R., Loayza, N., & Beck, T. 2000. Financial intermediation and growth: Causality and causes. ***Journal of Monetary Economics***, 46(1): 31-77.

Malesky, E. J., & Taussig, M. 2009. Where is credit due? Legal institutions, connections, and the efficiency of bank lending in Vietnam. ***Journal of Law, Economics, and Organization***, 25(2): 535-578.

Maria Herrera, A., & Minetti, R. 2007. Informed finance and technological change: Evidence from credit relationships. ***Journal of Financial Economics***, 83(1): 223-269.

Melitz, M. 2003. The impact of trade on aggregate industry productivity and intra-industry reallocations. ***Econometrica***, 71(6): 1695.

Murtazashvili, Irina and Jeffrey M. Wooldridge. 2008. "Fixed Effects Instrumental Variables Estimation in Correlated Random Coefficient Panel Data Models" ***Journal of Econometrics***, 142(1): 539-552.

Myerson, Roger B. 1979. "Incentive Compatibility and the Bargaining Problem" ***Econometrica: Journal of the Econometric Society***: 61-73.

Nguyen, T. V., TB LE, N., & Freeman, N. J. 2006. Trust and uncertainty: A study of bank lending to private SMEs in vietnam. ***Asia Pacific Business Review***, 12(4): 547-568.

Paulson, A., & Townsend, R. 2001. The nature of financial constraints: Distinguishing the micro underpinnings of macro models. ***Manuscript.University of Chicago***.

Piga, C. A., & Atzeni, G. 2007. R&D investment, credit rationing and sample selection. ***Bulletin of Economic Research***, 59(2): 149-178.

Reyes, A., Kuyvenhoven, A., & Moll, H. 2012. ***Dynamics of investment for market-oriented farmers in Chile***.

Rosenzweig, M. R., & Wolpin, K. I. 1993. Credit market constraints, consumption smoothing, and the accumulation of durable production assets in low-income countries: Investments in bullocks in India. ***Journal of political economy***: 223-244.

Savignac, F. 2008. Impact of financial constraints on innovation: What can be learned from a direct measure? ***Econ.Innov.New Techn.***, 17(6): 553-569.

Schiantarelli, F. 1996. Financial constraints and investment: Methodological issues and international evidence. ***Oxford Review of Economic Policy***, 12(2): 70-89.

Schündeln, M. 2005. Modeling firm dynamics to identify the cost of financing constraints in Ghanaian manufacturing. PhD Dissertation

Sharma, S. 2007. Financial development and innovation in small firms. ***World Bank Policy Research Working Paper Series, Vol***.

Tybout, J. R. 2000. Manufacturing firms in developing countries: How well do they do, and why? ***Journal of Economic literature***, 38(1): 11-44.

Table 1.1 - Innovation Activities of Enterprises

	Yes	No
Product Innovation	192	4815
Improvement of 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

Table 1.2 - 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
Sample Total	5,007	100

Table 1.3 - 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

Table 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: Revenue, costs, TFP, and interest payment are in million 1994 VND. N=5007. TFP values are calculated from the regression of firms' value added using Levinsohn-Petrin method to account for unobserved production shocks.

Table 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: 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 - Fixed Effect Estimation of the Baseline Regression

	(1) log of revenue per worker b/se	(2) log of gross profits per worker b/se
wave 2	0.234***	0.179***
	(0.02)	(0.02)
interest payment per worker	0.035**	0.052***
	(0.01)	(0.01)
interest payment per worker * innovation_existing	-0.024*	-0.037**
	(0.01)	(0.01)
innovation_existing	0.164***	0.131***
	(0.03)	(0.03)
log of K/L	0.119***	0.101***
	(0.02)	(0.02)
log of L	-0.349***	-0.415***
	(0.03)	(0.04)
constant	2.824***	2.767***
	(0.40)	(0.41)
Observations	3960	3956

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 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 4.2 - 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	-0.102*	-0.119*

competition		
	(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 5 - Regression of Interest Payment per Worker against Lag of ln(Revenue per Worker) or Against Lag of ln(Gross Profits per Worker)

	(1) actual value of formal interest payment per worker b/se	(2) actual value of formal interest payment per worker b/se
Wave 2	0.509	0.816
	(0.40)	(0.65)
Lag of ln(Revenue per worker)	-1.707	
	(1.45)	
Lag of ln(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 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: In the matching without controlling for past outcomes, the past outcome variables (lag values of revenue per worker, profit per worker, innovation of existing product, TFP) are not included in the set of matching covariates. The numeric ending 1 indicates that the variable is from survey wave 2007. The numeric ending 2 indicates that the variable is from survey wave 2009. The ending "diff" denotes the difference in the variable between survey wave 2009 and survey wave 2007.

Table 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 8 - Propensity Score Matching Results using Stata 13 command *teffects*

	(1) revenuepcdiff b/se	(2) profitgrosspcdiff b/se	(3) revenuepc2 b/se	(4) profitgrosspc2 b/se	(5) revenue1 b/se	(6) emplog1 b/se	(7) revenuepc1 b/se	(8) profitgrosspc1 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)
Observations	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).

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

APPENDIX A

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 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 $$(1-\rho_I + i\tau_I) f\left(\frac{t}{1+\Delta z}\right) + \left(\Phi_I + \delta(1-\rho_I) - 1\right)\frac{\lambda'(t)}{\delta} + \frac{\lambda(t)}{\delta}\frac{\partial \Phi_I}{\partial t} = 0$$

Tranversality 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 $$-\lambda(\infty) + \lambda(\bar{x}_I(1+\Delta z)) = (1+\Delta z)(1-F(\bar{x}_I))$$

or $$\lambda(\bar{x}_I(1+\Delta z)) = (1+\Delta z)(1-F(\bar{x}_I))$$

Similarly, it can be proved that $\lambda(t) = (1+\Delta z)\left(1-F(x)\right)$ and thus,
$\lambda'(t) = (1+\Delta z)\dfrac{d\left(1-F(x)\right)}{dx}.\dfrac{dx}{dt} = -f(x)$ 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 $$\lambda(x) = 1 - F(\bar{x}_I) + F(\bar{x}_I) - F(x) = 1 - F(x)$$

and thus, $\lambda'(x) = -f(x)$ 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 $$\Phi_N(x,M_N(x))=(1+i\delta\tau_N)\left[1-\left(\frac{\sigma-1}{\sigma}\right)\frac{1-F(x)}{xf(x)}\right]^{-1}$$

Similarly, we can solve for the loan schedule for non-innovating firms:

$$(1-\rho_I+i\tau_I)f(x)+\left(\Phi_I+\delta(1-\rho_I)-1\right)\frac{-f(x)}{\delta}+\frac{(1+\Delta z)\left(1-F(x)\right)}{\delta}\frac{\sigma-1}{\sigma}\frac{\Phi_I}{x(1+\Delta z)}=0$$

or $$\Phi_I(x(1+\Delta z),M_I(x(1+\Delta z)))=(1+i\delta\tau_I)\left[1-\left(\frac{\sigma-1}{\sigma}\right)\frac{1-F(x)}{xf(x)}\right]^{-1}$$

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:

$$\begin{aligned}\Phi_N(x,M_N(x))&=(1+i\delta\tau_N)\left[1-\left(\frac{\sigma-1}{\sigma}\right)\frac{(1/x)^{\theta}}{\theta x(1/x)^{\theta-1}(1/x^2)}\right]^{-1}\\&=(1+i\delta\tau_N)\left(1-\frac{\sigma-1}{\sigma\theta}\right)^{-1}\equiv\overline{\Phi}_N\end{aligned}\qquad\text{(A1)}$$

$$\Phi_I(x(1+\Delta z),M_I(x(1+\Delta z)))=(1+i\delta\tau_I)\left(1-\frac{\sigma-1}{\sigma\theta}\right)^{-1}\equiv\overline{\Phi}_I\qquad\text{(A2)}$$

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:

$$\frac{M_N(x)}{\delta}=\left[\frac{\sigma-1}{\sigma}\left(\frac{xP}{w}\right)^{\frac{\sigma-1}{\sigma}}Y^{1/\sigma}\right]^{\sigma}\left[\frac{\overline{\Phi}_N}{s_N}\right]^{-\sigma}+C_N\qquad\text{(A3)}$$

$$\frac{M_I(x(1+\Delta z))}{\delta}=\left[\frac{\sigma-1}{\sigma}\left(\frac{x(1+\Delta z)P}{w}\right)^{\frac{\sigma-1}{\sigma}}Y^{1/\sigma}\right]^{\sigma}\left[\frac{\overline{\Phi}_I}{s_I}\right]^{-\sigma}+C_I\qquad\text{(A4)}$$

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:

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

Rewriting the expected profit functions for non-innovating and innovating firms using the incentive-compatibility conditions gives us:

$$E(\pi_N(x,x)) = s_N p_N q_N - (1-\delta)\left(\frac{q_N w}{x} + C_N\right) - \rho_N\left(M_N(x) + I_N(x)\right) - (1-\rho_N)K_N$$
$$= \left\{\begin{matrix} \frac{\overline{\Phi}_N \sigma}{\sigma-1}\left(\frac{M_N(x)}{\delta} - C_N\right) - \rho_N\left(M_N(x) + I_N(x)\right) - (1-\rho_N)K_N \\ -(1-\delta)\frac{M_N(x)}{\delta} \end{matrix}\right\} \quad \text{(A5)}$$

$$E(\pi_I(x,x)) = \frac{\overline{\Phi}_I \sigma}{\sigma-1}\left(\frac{M_I(x(1+\Delta z))}{\delta} - C_I\right) - \rho_I\left(M_I(x(1+\Delta z)) + I_I(x(1+\Delta z))\right) - (1-\rho_N)K_I - (1-\delta)\frac{M_I(x(1+\Delta z))}{\delta} \quad \text{(A6)}$$

Since a firm's expected profit is increasing in its productivity level x, the productivity cutoff for production for non-innovating firms, $\bar{x}_N$, has to satisfy the zero-profit condition:

$$E(\pi_N(x,x)) = 0$$

which leads to the following condition:

$$\rho_N I_N(\bar{x}_N) = \frac{\overline{\Phi}_N \sigma}{\sigma - 1}\left(\frac{M_N(\bar{x}_N)}{\delta} - C_N\right) - \rho_N M_N(\bar{x}_N) - (1-\rho_N)K_N - (1-\delta)\frac{M_N(\bar{x}_N)}{\delta} \tag{A7}$$

The innovation productivity cutoff satisfies the following condition:

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

Solving this condition using (A5) and (A6) gives us the productivity cutoff for innovation activity:

$$\begin{aligned}
\rho_I I_I(\bar{x}_I(1+\Delta z)) = {} & \frac{\overline{\Phi}_I \sigma}{\sigma - 1}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right) - \rho_I M_I(\bar{x}_I(1+\Delta z)) - (1-\rho_I)K_I \\
& + (1-\rho_N)K_N - \frac{\overline{\Phi}_N \sigma}{\sigma - 1}\left(\frac{M_N(\bar{x}_I)}{\delta} - C_N\right) + \rho_N I_N(\bar{x}_N) \\
& + (\overline{\Phi}_N - 1 + \delta)\frac{M_N(\bar{x}_I)}{\delta} - (\overline{\Phi}_N + \delta(1-\rho_N) - 1)\frac{M_N(\bar{x}_N)}{\delta} \\
& - \frac{(1-\delta)}{\delta}\left[M_I(\bar{x}_I(1+\Delta z)) - M_N(\bar{x}_I)\right]
\end{aligned} \tag{A8}$$

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:

$$\begin{aligned}
& \mathrm{Max}_{\bar{x}_N, \bar{x}_I} \int_{\bar{x}_N}^{\bar{x}_I} \left[\begin{array}{l} (\overline{\Phi}_N + \delta(1-\rho_N) - 1)\dfrac{M_N(x) - M_N(\bar{x}_N)}{\delta} + \rho_N I_N(\bar{x}_N) \\ - (1-\rho_N)(M_N(x) - K_N) - i\tau_N M_N(x)) \end{array}\right] f(x)dx \\
& + \int_{\bar{x}_I}^{\infty} \left[\begin{array}{l} (\overline{\Phi}_I + \delta(1-\rho_I) - 1)\dfrac{M_I(x(1+\Delta z)) - M_I(\bar{x}_I(1+\Delta z))}{\delta} \\ + \rho_I I_I(\bar{x}_I(1+\Delta z)) - (1-\rho_I)(M_I(x(1+\Delta z)) - K_I) - i\tau_I M_I(x(1+\Delta z)) \end{array}\right] f(x)dx
\end{aligned}$$

The F.O.C of the bank's problem with respect to $\bar{x}_N$ gives us:

$$\begin{aligned}
& \int_{\bar{x}_N}^{\infty} \rho_N \frac{dI_N(\bar{x}_N)}{d\bar{x}_N} - \frac{1}{\delta}(\overline{\Phi}_N + \delta(1-\rho_N) - 1)\frac{dM_N(\bar{x}_N)}{d\bar{x}_N} f(x)dx \\
& = \left[\rho_N I_N(\bar{x}_N) - (1-\rho_N)(M_N(\bar{x}_N) - K_N) - i\tau_N M_N(\bar{x}_N)\right] f(\bar{x}_N)
\end{aligned}$$

Notice that from the condition (A7) for interest payment for the non-innovating firm with productivity cutoff $\bar{x}_N$, we have:

$$\rho_N \frac{dI_N(\bar{x}_N)}{d\bar{x}_N} = \frac{1}{\delta}\left[\frac{\sigma}{\sigma - 1}\overline{\Phi}_N + \delta(1-\rho_N) - 1\right]\frac{dM_N(\bar{x}_N)}{d\bar{x}_N}$$

$$\left[\rho_N I_N(\bar{x}_N)-(1-\rho_N)(M_N(\bar{x}_N)-K_N)-i\tau_N M_N(\bar{x}_N)\right]f(\bar{x}_N)$$
$$=\left[\frac{\overline{\Phi}_N\sigma}{\sigma-1}\left(\frac{M_N(\bar{x}_N)}{\delta}-C_N\right)-(1+i\tau_N)M_N(\bar{x}_N)-(1-\delta)\frac{M_N(\bar{x}_N)}{\delta}\right]f(\bar{x}_N)$$

Under the Pareto distribution: $\frac{1-F(\bar{x}_N)}{\bar{x}_N f(\bar{x}_N)}=\frac{1}{\theta}$, and from the bank's loan schedule for non-innovating firm under Pareto distribution: $\frac{dM_N(\bar{x}_N)}{d\bar{x}_N}=\frac{\sigma-1}{\bar{x}_N}\left(\frac{M_N(\bar{x}_N)}{\delta}-C_N\right)\delta$, the F.O.C with respect to $\bar{x}_N$ can be simplified as:

$$\frac{M_N(\bar{x}_N)}{\delta}-C_N=\frac{\theta(1+i\delta\tau_N)}{\left(\frac{\sigma\theta}{\sigma-1}-1\right)\overline{\Phi}_N}C_N$$

Under Pareto distribution, the credit constraint parameter can be simplified as:

$$\overline{\Phi}_N=-(1+i\delta\tau_N)\left[\frac{\sigma-1}{\sigma\theta}-1\right]^{-1} \qquad \text{(A9)}$$

and the F.O.C with respect to $\bar{x}_N$ can be further simplified as:

$$\frac{M_N(\bar{x}_N)}{\delta}-C_N=(\sigma-1)C_N \quad \text{or} \quad M_N(\bar{x}_N)=\delta\sigma C_N \qquad \text{(A10)}$$

From (A3):

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

Combining the two above equations, the solution for the productivity of the cutoff non-innovating firm can be obtained:

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

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:

$$\rho_N I_N(x) = \left[\overline{\Phi}_N + \delta(1-\rho_N) - 1\right]\frac{M_N(x)}{\delta} - (1-\rho_N)K_N \quad \forall x \in [\bar{x}_N, \bar{x}_I] \tag{A11}$$

F.O.C with respect to $\bar{x}_I$ gives us:

$$\int_{\bar{x}_I}^{\infty}\left[\rho_I \frac{dI_I(\bar{x}_I)}{d\bar{x}_I} - \frac{1}{\delta}\left(\Phi_I + \delta(1-\rho_I) - 1\right)\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I}\right] f(x)dx$$
$$= \begin{bmatrix} \rho_I I_I(\bar{x}_I(1+\Delta z)) - i\tau_I M_I(\bar{x}_I(1+\Delta z)) - \rho_N I_N(\bar{x}_I) + i\tau_N M_N(\bar{x}_I) \\ -(1-\rho_I)M_I(\bar{x}_I(1+\Delta z)) + (1-\rho_N)M_N(\bar{x}_I) + (1-\rho_I)K_I - (1-\rho_N)K_N \end{bmatrix} f(\bar{x}_I)$$

From (A6), we have:

$$\begin{aligned}
\rho_I \frac{dI_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I} &= \frac{1}{\delta}\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I}\left[\frac{\Phi_I \sigma}{\sigma-1} - \delta\rho_I - (1-\delta)\right] \\
&\quad - \frac{1}{\delta}\frac{dM_N(\bar{x}_I)}{d\bar{x}_I}\left[\frac{\Phi_N \sigma}{\sigma-1} - (\Phi_N - 1 + \delta) - (1-\delta)\right] \\
&= \frac{1}{\delta}\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I}\left[\frac{\Phi_I \sigma}{\sigma-1} + \delta(1-\rho_I) - 1\right] - \frac{1}{\delta}\frac{\Phi_N}{\sigma-1}\frac{dM_N(\bar{x}_I)}{d\bar{x}_I}
\end{aligned}$$

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 F.O.C with respect to $\bar{x}_I$ gives us:

$$\begin{aligned}
&\int_{\bar{x}_I}^{\infty}\left[\rho_I \frac{dI_I(\bar{x}_I)}{d\bar{x}_I} - \frac{1}{\delta}\left(\Phi_I + \delta(1-\rho_I) - 1\right)\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I}\right] f(x)dx \\
&= \int_{\bar{x}_I}^{\infty}\left[\frac{1}{\delta}\frac{\Phi_I}{\sigma-1}\frac{dM_I(\bar{x}_I(1+\Delta z))}{d\bar{x}_I} - \frac{1}{\delta}\frac{\Phi_N}{\sigma-1}\frac{dM_N(\bar{x}_I)}{d\bar{x}_I}\right] f(x)dx \\
&= \int_{\bar{x}_I}^{\infty}\left[\frac{\Phi_I}{\bar{x}_I}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right) - \frac{\Phi_N}{\bar{x}_N}\left(\frac{M_N(\bar{x}_I)}{\delta} - C_N\right)\right] f(x)dx \\
&= \left[\Phi_I\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right) - \Phi_N\left(\frac{M_N(\bar{x}_I)}{\delta} - C_N\right)\right]\frac{f(\bar{x}_I)}{\theta}
\end{aligned}$$

The right hand side of the F.O.C with respect to $\bar{x}_I$ can be simplified as follows:

$$\begin{bmatrix} \rho_I I_I(\bar{x}_I(1+\Delta z)) - i\tau_I M_I(\bar{x}_I(1+\Delta z)) - \rho_N I_N(\bar{x}_I) + i\tau_N M_N(\bar{x}_I) \\ -(1-\rho_I)M_I(\bar{x}_I(1+\Delta z)) + (1-\rho_N)M_N(\bar{x}_I) + (1-\rho_I)K_I - (1-\rho_N)K_N K \end{bmatrix} f(\bar{x}_I)$$

$$= \begin{bmatrix} \frac{\Phi_I \sigma}{\sigma-1}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right) - (1+i\tau_I)M_I(\bar{x}_I(1+\Delta z)) + (1+i\tau_N)M_N(\bar{x}_I) \\ -\frac{\Phi_N \sigma}{\sigma-1}\left(\frac{M_N(\bar{x}_I)}{\delta} - C_N\right) - \frac{(1-\delta)}{\delta}\left[M_I(\bar{x}_I(1+\Delta z)) - M_N(\bar{x}_I)\right] \\ +\left\{\rho_N I_N(\bar{x}_N) - \rho_N I_N(\bar{x}_I) + (\Phi_N - 1 + \delta)\frac{M_N(\bar{x}_I)}{\delta} - (\Phi_N + \delta(1-\rho_N) - 1)\frac{M_N(\bar{x}_N)}{\delta} - \rho_N M_N(\bar{x}_I)\right\} \end{bmatrix} f(\bar{x}_I)$$

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 F.O.C with respect to x_I can be further simplified as:

$$\begin{bmatrix} \frac{\Phi_I \sigma}{\sigma-1}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right) - \frac{\Phi_N \sigma}{\sigma-1}\left(\frac{M_N(\bar{x}_I)}{\delta} - C_N\right) - (1+i\tau_I)M_I(\bar{x}_I(1+\Delta z)) + (1+i\tau_N)M_N(\bar{x}_I) \\ -\frac{(1-\delta)}{\delta}\left[M_I(\bar{x}_I(1+\Delta z)) - M_N(\bar{x}_I)\right] \end{bmatrix} f(x_I)$$

From the expression of the loan schedule under Pareto distribution of firm productivity, i.e. (A1), we have:

$$\frac{M_N(\bar{x}_I)}{\delta} - C_N = (1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}.\frac{s_I}{s_N}\right]^{-\sigma}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta} - C_I\right)$$

Putting together the above expressions, we can solve the F.O.C 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

$$\left[\Phi_I\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-\Phi_N(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}.\frac{s_I}{s_N}\right]^{-\sigma}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)\right]\frac{1}{\theta}$$
$$=\frac{\Phi_I\sigma}{\sigma-1}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-\delta(1+i\tau_I)\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-\delta(1+i\tau_I)C_I$$
$$-\frac{\Phi_N\sigma}{\sigma-1}(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}.\frac{s_I}{s_N}\right]^{-\sigma}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-(1-\delta)\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)-(1-\delta)C_I$$
$$+\left[\delta(1+i\tau_N)+(1-\delta)\right]\left\{(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}.\frac{s_I}{s_N}\right]^{-\sigma}\left(\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I\right)+C_N\right\}$$

So

$$\frac{M_I(\bar{x}_I(1+\Delta z))}{\delta}-C_I=\Pi\left[(1+\delta i\tau_N)C_N-(1+\delta i\tau_I)C_I\right] \quad \text{(A12)}$$

where

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

which, under the assumption of Pareto distribution of firm productivity, using (A1) and (A2) can be written as:

$$\Pi = (1+i\delta\tau_I)\left(1 - \frac{\sigma-1}{\sigma\theta}\right)^{-1}\left[\frac{1}{\theta} - \frac{\sigma}{\sigma-1}\right] + (1+i\delta\tau_I)$$

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

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

or

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

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:

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

Note that

$$\frac{\partial \Pi}{\partial i} = -\frac{-1}{\sigma - 1}\delta\tau_I$$

$$-(1+\Delta z)^{1-\sigma}\left\{\begin{array}{l}(-\sigma)\left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)}.\frac{s_I}{s_N}\right]^{-\sigma-1}\frac{s_I}{s_N}\frac{\delta(\tau_N-\tau_I)}{(1+i\delta\tau_I)^2}\left[\frac{\sigma}{\sigma-1}(1+i\delta\tau_N)+(1+i\delta\tau_I)\right] \\ +\left[\frac{1+i\delta\tau_N}{(1+i\delta\tau_I)}.\frac{s_I}{s_N}\right]^{-\sigma}\frac{\sigma\delta(\tau_N+\tau_I)}{\sigma-1}\end{array}\right\}$$

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:

$$\begin{aligned}\rho_I I_I(\bar{x}_I(1+\Delta z)) &= \frac{\Phi_I\sigma}{\sigma-1}\Pi\left[(1+\delta i\tau_N)C_N-(1+\delta i\tau_I)C_I\right]-(1-\delta(1-\rho_I))\left\{\Pi\left[(1+\delta i\tau_N)C_N-(1+\delta i\tau_I)C_I\right]+C_I\right\} \\ &-(1-\rho_I)K_I+(1-\rho_N)K_N-\frac{\Phi_N}{\sigma-1}(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I}.\frac{s_I}{s_N}\right]^{-\sigma}\Pi\left[(1+\delta i\tau_N)C_N-(1+\delta i\tau_I)C_I\right] \\ &+\sigma\left[\overline{\Phi}_N+\delta(1-\rho_N)-1\right]C_N-(1-\rho_N)K_N \\ &+\Phi_N C_N-\sigma(\Phi_N+\delta(1-\rho_N)-1)C_N\end{aligned}$$

which can be rearranged as:

$$\rho_I I_I(\bar{x}_I(1+\Delta z)) = \left\{ \frac{\Phi_I \sigma}{\sigma - 1} - (1-\delta(1-\rho_I)) - \frac{\Phi_N}{\sigma - 1}(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I} . \frac{s_I}{s_N}\right]^{-\sigma} \right\} \Pi\left[(1+\delta \tilde{\imath}\, \tau_N)C_N - (1+\delta \tilde{\imath}\, \tau_I)C_I\right]$$
$$- (1-\rho_I)K_I + \Phi_N C_N - (1-\delta(1-\rho_I))C_I$$

Taking derivative of the equation above, we have the interest payment schedule for innovating firm as

$$\rho_I I_I(x(1+\Delta z)) = \left(\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) + \delta(1-\rho_I) - 1\right)\frac{M_I(x(1+\Delta z))}{\delta}$$
$$+ \rho_I I_I(\bar{x}_I(1+\Delta z)) + \Pi\left[(1+\delta \tilde{\imath}\, \tau_N)C_N - (1+\delta \tilde{\imath}\, \tau_I)C_I\right] + C_I$$

or

$$\rho_I I_I(x(1+\Delta z)) = \left(\Phi_I(x(1+\Delta z), M_I(x(1+\Delta z))) + \delta(1-\rho_I) - 1\right)\frac{M_I(x(1+\Delta z))}{\delta} + \Psi \qquad \text{(A13)}$$

where

$$\Psi = \left\{ \frac{\Phi_I \sigma}{\sigma - 1} + \delta(1-\rho_I) - \frac{\Phi_N}{\sigma - 1}(1+\Delta z)^{1-\sigma}\left[\frac{\Phi_N}{\Phi_I} . \frac{s_I}{s_N}\right]^{-\sigma} \right\} \Pi\left[(1+\delta \tilde{\imath}\, \tau_N)C_N - (1+\delta \tilde{\imath}\, \tau_I)C_I\right]$$
$$- (1-\rho_I)K_I + \Phi_N C_N + \delta(1-\rho_I)C_I$$

Under the assumption of Pareto distribution of firm productivity, using (A1) and (A2), the expression above can be simplified as

$$\Psi = \left\{ \begin{array}{l} \frac{\sigma}{\sigma-1}(1+i\delta\tau_I)\left(1-\frac{\sigma-1}{\sigma\theta}\right)^{-1} + \delta(1-\rho_I) \\ -\frac{1}{\sigma-1}(1+i\delta\tau_N)\left(1-\frac{\sigma-1}{\sigma\theta}\right)^{-1}(1+\Delta z)^{1-\sigma}\left[\frac{1+i\delta\tau_N}{1+i\delta\tau_I}.\frac{s_I}{s_N}\right]^{-\sigma} \end{array} \right\} \Pi\left[(1+\delta i\tau_N)C_N - (1+\delta i\tau_I)C_I\right]$$

$$-(1-\rho_I)K_I + (1+i\delta\tau_N)\left(1-\frac{\sigma-1}{\sigma\theta}\right)^{-1} C_N + \delta(1-\rho_I)C_I$$

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:

$$\begin{aligned} \frac{dE(\pi_N(x,x)}{dx} &= \left(\frac{\sigma}{\sigma-1}\overline{\Phi}_N + \delta(1-\rho_N) - 1\right)\frac{M'_N(x)}{\delta} - \rho_N I'_N(x) \\ &= \left(\frac{\sigma}{\sigma-1}\overline{\Phi}_N + \delta(1-\rho_N) - 1\right)\frac{M'_N(x)}{\delta} - \left(\overline{\Phi}_N + \delta(1-\rho_N) - 1\right)\frac{M'_N(x)}{\delta} \\ &= \frac{\overline{\Phi}_N}{\sigma-1}\frac{M'_N(x)}{\delta} > 0 \end{aligned}$$

$$\frac{dE(\pi_I(x(1+\Delta z), x(1+\Delta z))}{dx} = (1+\Delta z)\left\{\left(\frac{\sigma}{\sigma-1}\overline{\Phi}_I + \delta(1-\rho_I) - 1\right)\frac{M_I'\ (x(1+\Delta z))}{\delta} - \rho_I I_I'(x)\right\}$$

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

$$= (1+\Delta z)\frac{\overline{\Phi}_I}{\sigma-1}\frac{M_I'\ (x(1+\Delta z))}{\delta} > 0$$

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: $\bar{x}_I > \bar{x}_N$