Financial Innovation, Firm Size and Growth

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Abstract

Small firm lending has historically been very costly because of the paucity of information. We study the disproportionate impact of financial development (measured as the current level of a financial system) and financial innovation (measured as its change) on small firm sectors. We incorporate financial innovation and financial development into a Schumpeterian endogenous growth model. Entrepreneurial skill on a continuum of types is private information; thereby creating adverse selection problems. In the absence of financial innovation, an arrival of new technology frontier renders existing screening technology obsolete; thereby having largely negative impacts on small firm sectors. Our model suggests that financial innovation is more pronounced in small-firm sectors in more financially developed countries. The linkage between financial innovation and the disproportionate impact on small firm-sectors is weak in less financially developed countries. At the European industry level, empirical evidence is more consistent with our model prediction.

JEL codes : G2, L11, L25, O1

Key words : firm size distribution, financial innovation, financial development, contract theory , economic growth

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Introduction

During the past several decades, technological innovation has permitted financial intermediaries to interact with real sectors more efficiently. Particularly, to finance new entrepreneurial projects, such innovation has promoted more effective risk management. Much of the research on finance and growth has been devoted to empirical investigation of the impact of financial innovation (measured as a change in financial systems) on growth (Jayaratne and Strahan, 1996; Peterson and Rajan, 2002; Bertrand, Schoar and Thesmar, 2007). A recent theoretical development (Michalopoulos, Laeven and Levine, 2010) has fleshed out a linkage between financial innovation and growth across countries. In the model, financial entrepreneurs innovate to maximize their profit. In the absence of successful financial innovation, an arrival of new technology frontier renders the previous screening technology obsolete. In essence, it dampens growth. Yet, there are less theoretical developments which capture the issue within countries. This paper attempts to model a linkage between technological innovation and financial innovation across firms and across sectors.

The empirical evidence that motivates this paper originated in two recent works on corporate finance. Peterson and Rajan (2002) finds evidence that financial innovation has increased credit availability for small firms. Guiso, Sapienza and Zingales (2004) provides evidence in favor of the disproportionate impact of financial development (measured as a current level of financial systems) on small firms. Small firms lending has historically been very costly because of the paucity of information. As regards to the findings, financial innovation would disproportionately benefit sectors (or firms) which are more informationally opaque and more financially constrained. This is a main issue which this paper aims to address. We specifically focus on the interaction between financial innovation and financial development on sectoral growth, based on a size distribution of firms. We find empirical evidence that financial innovation has large impacts on small-firm sectors in more financially developed countries. The linkage between financial innovation and the disproportionate impact on small firm-sectors is weak in less financially developed countries.

In this paper, we incorporate financial innovation and financial development into a Schumpeterian growth model with a continuum of entrepreneurial skill types in R&D sectors. The economy consists of investors, financial entrepreneurs, entrepreneurs and producers. An entrepreneur starts up a research venture by borrowing R&D funds from an investor. A successful entrepreneur invents a design for new intermediate goods and earns profits by selling its infinitely lived patent to a monopoly producer. Skill is private information, creating adverse selection problems for the investor who in turn designs a truth-telling mechanism. R&D investments and debt repayments increase in skill on the optimal mechanism, thereby making entrepreneurs reveal their true types. [1] The low skilled types are more financially constrained. The investor confronts a scaled reduction of expected profits in order to maintain incentive compatibility on optimal mechanism. As in Michalopoulos, Laeven and Levine (2010), we assume technological progress makes existing screening devices obsolete. In the absence of financial innovation, the current level of the financial system (financial development) becomes outdated and thus is unable to allocate R&D funds to potential entrepreneurs, thereby exacerbating the adverse selection problem. To resolve the problem, financial entrepreneurs invent new screening devices by maximizing their monopoly profits (by competing other financial entrepreneurs). In the model, the financial entrepreneur is more active in sectors (or firms) more suffered by capital market imperfection because successful innovation increases his monopoly profit. Hence the larger in sectors is asymmetric information, the more pronounced is a role of financial innovation in growth. As in Lucas(1978), we use firm size as a proxy for entrepreneurial skill by viewing

[1] As in previous literatures (e.g., King and Levine,1993a), the low skilled type allures to the high skilled type on a pooling equilibrium. On a separating equilibrium, R&D investments and debt repayments increase in skill to maintain incentive compatibility.

the innovation skill of the entrepreneur as a manifestation of managerial efficiency.[2] We derive the rate of financial innovation that are more crucial in sectors with the low mean (via increasing R&D investment and productivity) and the more dispersion (via reducing the severity of adverse selection) on a size distribution of firms.

Recent research represents the relationship between growth and a size distribution of firms. Pagano and Schivardi (2003) suggests the positive and robust relationship between average firm size and growth. Plehn-Dujowich (2009) addresses the negative and robust relationship between the dispersion of firm size and growth via the severity of adverse selection. We are however interested in examining the link between firm size, financial innovation and its impact on growth. Unlike Plehn-Dujowich (2009), technological progress in our model has largely negative impacts on small firm sectors; thereby making the role of financial innovation in the sectors more pronounced.[3]

In this paper, we document two results: first, the rate of financial innovation decreases in skill mean. The low skilled type presents low R&D productivity, thereby being more financially constrained. The high demand of financial innovation (by investors) occurs in the sectors which are mainly composed of the low skilled types. Because monopoly rents to a successful financial entrepreneur increase, the rate of financial innovation increases in the sector. Second, the rate of financial innovation increases in the dispersion of skill distribution within the sectors of same skill on average. The intuition is that the greater the dispersion of the skill distribution, the larger the informational rents will be to maintain the high type incentive compatibility ; thus the higher the demand of financial innovation. Because skill determines firm size, the results indicate financial innovation is more

[2]There is ample evidence that large firms have better managerial ability (Lucas, 1978; Jovanovic, 1982) and perform more R&Ds studies (Griliches, 1984; Cohen, Levin, and Mowery, 1987).

[3]Plehn-Dujowich (2009) assumes innovation technology is exogenous. Hence technological progress causes more distortions on small firm sectors (and more size-dispersed sectors) than in Plehn-Dujowich (2009).

pronounced in small-firm sectors and more size-dispersed sectors within small firm sectors.

One distinctive feature of the model is the high skilled types more easily adapt to the technology frontier than the low skilled types, because of complementarity between skill level and technology frontier. In the absence of financial innovation, technological progress makes it more challenging for an investor to maintain incentive compatibility; thereby leading to more distortions in small firm sectors (and more size dispersed sectors). This does not only impede technological innovation, but also dampen the rate of change in technological innovation in the sectors. The more severe the distortion in the sectors, the more pronounced the role of financial innovation in growth will be. Because the high skilled types more contribute technological innovation by revealing their true types, the only investor who owns new screening devices takes full advantage of technological innovation.

In the absence of financial development, however, inventing financial innovation itself does not largely benefit small firm sectors (more size-dispersed sectors). The cost to innovate new screening methodology decreases in the current level of financial systems. Facing identical adverse selection problems, financial entrepreneurs in more financially developed countries can be more active in innovation. In the model, on the one hand, the rate financial innovation increases in small firm sectors (and more size-dispersed sectors) because of high monopoly profits to financial entrepreneurs. The more distortion financial innovation resolves, the more technological innovation per financial innovation is achieved in the sectors. On the other hand, technological innovation is initially more dampened in the sectors. [4] Unless the innovation cost is sufficiently low so that the benefit dominates the cost, financial innovation does not have a disproportionate impact on small firm sectors (and more size-dispersed sectors), but rather large firm sectors (and less size-dispersed sectors).

[4] In Plehn-Dujowich (2009), an increase in the mean skill enhances growth via increasing R&D productivity and investment (referred as the positive scale effect). An increase in the skill dispersion dampens growth via increasing the severity of adverse selection (referred as the negative adverse selection effect). These are general properties in the absence of financial innovation.

This is a main discriminating feature of the model.

Though the major contribution of this paper is the theoretical development, we present empirical evidence to support our model prediction. To test our main proposition, we perform cross-sector, cross-country empirical studies by using 22 sectors spanning 24 European countries, over the sample period 2002-2006. The dataset allows us to examine the 2002 cross-firm, cross-sector distributional effect of financial development and financial innovation on the average 2002-2006 growth. We use a size distribution of firms (FSD) as a proxy for entrepreneurial skill distribution, wherein firm size is measured by employment. Hence the severity of adverse selection is measured by a standard deviation of the FSD. We find evidence in favor of our prediction : In the absence of financial development, the interaction between financial innovation and the mean (the standard deviation) of the FSD enters positively (negatively) and significantly; suggesting that financial innovation largely helps large firm sectors (and less size-dispersed sectors). However, the interaction between financial development, financial innovation and the mean (the standard deviation) of the FSD enters negatively (positively) and significantly. Financial innovation has a disproportionate impact on small firm sectors (and more size-dispersed sectors) in more financially developed countries. All of our empirical results are robust even when we control for other industrial traits and use alternative measures of financial intermediary development. Despite a short sample period (2002 to 2006), the results strongly suggest that the interaction between financial innovation and financial development is very crucial for cross-sector, cross-firm growth. Our empirical analysis differs from the previous literatures (Pagano and Schivardi, 2003; Plehn-Dujowich, 2009; Michalopoulos, Laeven and Levine, 2010) by first attempting to estimate the impact of financial innovation on sectoral growth relating to the mean and the standard deviation of a size distribution of firms.

The debate on the relationship between growth and finance is about as old as growth theory itself. Schumpeter (1911) argued that financial systems are important in promoting innovations; economies with more efficient financial systems grow faster. Despite disagreement about the role of the financial system in economic growth (Robinson , 1952 ; Lucas, 1988), a substantial body of works has shown that an economy's financial system is positively correlated with its future growth in per capita, real income. (Goldsmith, 1969 ; King and Levine, 1993b ; Aghion, Howitt and Mayer-Foulkes, 2004 and 2005). With regards to cross-sector, cross-firm growth, recent empirical studies offer insight about financial development and firm growth, based on firm sizes. Guiso, Sapienza and Zingales (2004) and Beck, Demirguc-Kunt, Laeven and Levine (2008) present empirical evidence that financial development exerts a disproportionate impact on small firms. Beck, Demirguc-Kunt and Maksimovic (2005) shows that financial and institutional development helps small firms by weakening financial and legal constraints. As regards to a change in financial systems, Bertrand, Schoar and Thesmar (2007) finds empirical evidence that the deregulation of the French banking industry in the 1980s improved asset allocative efficiency across firms. These results are in the line with our empirical investigation. We emphasize more on the fact that a positive linkage between financial innovation and financial development helps small firms.

At the theoretical standpoint, this paper closely relates to Greenwood, Sanchez and Wang (2010) by attempting to allow a change of the financial system as the economy develops. This study, however, is different from our work in the sense that financial intermediaries choose their monitoring technology , not by competing with other capable financial intermediaries. The model does not leave any chance for the relationship between investors and financial entrepreneurs to be severed at any point in time and seek better partners. Ultimately, the rate of financial innovation is not fully determined by the choices of profit maximizing agents.

One limitation of our analysis is that we define finance narrowly. We examine on the role of the financial system in screening innovative activities and mitigating asymmetric information problems. We do not model risk diversification, pooling, and trading. However, our paper attempts to emphasize on a role of creative destruction of the financial system itself in cross-sector, cross-firm growth.

The remainder of the paper is organized as follows, Section 2 outlines the basic structures and theoretical model. Section 3 presents empirical evidences. The last section concludes.

2 Theoretical Framework

2.1 The Environment

We follow Michalopoulos, Laeven and Levine (2010) by introducing heterogenous entrepreneurs in terms of their R&D productivity. There are M countries which do not exchange goods or factors but do make use of each other's technological ideas. We assume that there are the cross-country differences in financial development, in terms of the cost to innovate financial systems. In each country, the economy consists of i industries that consist of multiple product line, where $i \in [0, 1]$. There are four types of agents in each country : households, entrepreneurs, financial entrepreneurs and producers. Each household lives two periods and endowed with three units of labor in the first period and nothing in the second period. In the first period, he is hired by the final goods firm, earning the competitive wage w_t. In the second period, he becomes a risk-neutral investor who provides R&D funds to promising entrepreneurs. The utility function is linear in consumptions so that $U = c_1 + \beta c_2$ where $0 < \beta < 1$.[5]

[5]Linear utility implies that people are indifferent between investing in any country. We assume that all investment is locally financed, but if β were the same across all countries, we could allow perfect capital

In every period, there is a continuum of risk-neutral entrepreneurs in each intermediate good sector are indexed by a skill level s drawn from the distribution F with the support $[\underline{s}, \overline{s}]$, where $\underline{s} \geq 1$. Let m_s and σ_s^2 denote the mean and variance, respectively, of the entrepreneurial skill distribution. The skill distribution itself is exogenous: we do not consider the effect of finance on the acquisition of skills. Each entrepreneur has the idea and know-how to start up a research venture that produces new innovation for the sector but lacks the fund, thereby borrowing it from the investor. Entrepreneurial skill is private information, thereby creating an adverse selection problem for the investor. To resolve the problem, the investor designs a truth-telling compatible mechanism by using available financially screening devices. Because entrepreneurs and the research venture they create exist for one period, the investor does not face repeated adverse selection. When an entrepreneur succeeds to invent new technology in the sector, he receives an infinitely-lived patent granting it monopoly rights over the intermediate good. He earns profits by selling it to a monopolist that manufactures and sells it to the final good firm.

In each sector, financial entrepreneurs innovate screening methodology and provide it for the investor. A financial entrepreneur can earn monopoly rents by successfully inventing a better screening technology than competitor financial entrepreneurs. In the absence of successful financial innovation, existing screening devices become less effective as technology advances. Successful financial entrepreneurs are paid by the investor in the form of a share of the investor's profits.

The timing of events is as follows: At the beginning of each period $t-1$, a household solicits financial entrepreneurs to innovate screening methodology. The financial entrepreneur borrows a loan from the household and starts financial innovation. At the next period, the household lends R&D funds to screened entrepreneurs who innovate and repay the funds.

mobility without change in the analysis.

The household will pay a share of his expected profit to the financial entrepreneur. If possible, the financial entrepreneur pay back to the household.

Within each sector in each country, the growth path is determined as follows.

2.2 Final good sectors

In every period, a competitive firm purchases intermediate goods and hires production workers to manufacture the final goods according to the following production technology:

$$Y_t = L^\eta \int_0^1 A_t(i)^\eta x_t(i)^{1-\eta} di \tag{1}$$

where $0 < \eta < 1$. $x_t(i)$ is the input of the latest version of intermediate good in a sector i and $A_t(i)$ is the productivity parameter associated with it. L is labor supply which is normalized to unity. The final good Y_t is used for consumptions, as an input into the production of intermediate goods. The final good is produced under perfect competition. The profit maximization problem in this sector is

$$\max_{L, x_t(i)} L^\eta \int_0^1 A_t(i)^\eta x_t(i)^{1-\eta} di - wL - \int_0^1 p_t(i) x_t(i) di$$

The wage is determined by

$$w_t = \eta \int_0^1 A_t(i)^\eta x_t(i)^{1-\eta} di = \eta Y_t \qquad \text{(Assume } L = 1) \tag{2}$$

The price of each intermediate good equals its marginal product

$$p_t(i) = (1-\eta)A_t(i)^{\eta} x_t(i)^{-\eta} \tag{3}$$

(3) is the inverse demand for intermediate good in the sector i

2.3 Intermediate good sectors

In each intermediate good i, there is a continuum of entrepreneurs who has the idea and know-how to start up a research venture. After inventing new innovation, they sell the right to their infinitely-lived patents to monopolists that manufacture the intermediate goods at constant marginal cost c. The firm maximizes profits by taking into account of the demand function (3). The quantity of demand in the sector i is

$$x_t(i) = (\frac{(1-\eta)^2}{c})^{\frac{1}{\eta}} A_t(i), \tag{4}$$

It follows that the profit of the innovator will be $\pi_t(i) = (\frac{\eta c}{1-\eta})(\frac{(1-\eta)^2}{c})^{\frac{1}{\eta}} A_t(i)$ in next period. Each entrepreneur who is indexed by skill s, where $s \in [\underline{s}, \overline{s}]$, $\underline{s} > 1$, adopts his productivity level, defined as,

$$A_t(i) = \begin{Bmatrix} \overline{A}_t & \text{with probability } \mu_t^i(s) \\ A_{t-1}(i) & \text{with probability } 1-\mu_t^i(s) \end{Bmatrix} \tag{5}$$

where $\overline{A}_t$ is the world technology frontier, which grows at the constant rate $g > 0$, taken as given. The ith innovator with high $\mu_t^i(s)$ is more likely to adopt the world technology frontier and invent high-quality innovation. We assume that there is only 1 leading country whereby its productivity is same as $\overline{A}_t$. Other $m-1$ countries invest on R&D to catch up to the leading technology frontier.

2.4 Financial entrepreneurs

A financial entrepreneur innovates financially screening devices by facing technological innovation in intermediate good sectors. Every period, they borrow funds from households and provide update methodology to screen promising individuals with entrepreneurial ideas for the next period. In each sector, there are unlimited of people capable of inventing new financial methodology with the probability $\mu_t^f(i)$. The only financial entrepreneur who successfully innovates in sector i in period $t-1$, will provide update screening devices for investors. He receives a fraction of expected entrepreneurial profits Γ_t which is endogenously determined in the model. Financial entrepreneurs who fail to innovate in the sector i receives no profit. In the absence of the services, the investors screen individuals with entrepreneurial ideas by using the existent screening devices, thereby losing expected profits. The successful financial entrepreneur charges a price such that the investor indifferent between using the new screening devices and using the existent screening devices. For simplicity, we assume that the perfect competitive fringe can provide the existent screening devices at zero cost. The entrepreneurs screened by using the competitive fringe of financial entrepreneurs keep 100% of profits.

2.5 Innovation and Aggregate Growth

2.5.1 Entrepreneurial Innovation

An entrepreneur creates and runs a research venture financed by an investor. Each entrepreneur is indexed by a skill level s, drawn from the distribution F with the support $[\underline{s}, \overline{s}]$, where $\underline{s} > 1$, $\overline{s} < \infty$. The entrepreneur adopts new technology as follows : when the investor provides I_t in R&D funding, the entrepreneur invents new technology with the innovation probability function : $\mu_t^E(I_t;s) = (\theta s^{1+g})^{1-\alpha}(\frac{I_t(s)}{\overline{A}_t})^{\alpha}$ where $\alpha \in (0,1)$, $\theta > 0$, the target frontier technology level $\overline{A}_t$. The term $\frac{I_t(s)}{\overline{A}_t}$ is an efficient investment level whereby the further ahead the frontier moves, the more difficult it is to innovate. By $\underline{s} > 1$, the term θs^{1+g} includes the entrepreneurial skill level whereby high skill entrepreneurs are more easily to adopt technology frontier. The market value of the firm is $V(I_t;s) = \pi_t \mu_t^E(I_t;s) = \pi_t(\theta s^{1+g})^{1-\alpha}(\frac{I_t(s)}{\overline{A}_t})^{\alpha}$ where π_t is the payoff per innovation that accrues to the entrepreneur. Entrepreneurial skill and investments in R&D are complements in innovation process.

Because skill is private information to the entrepreneur, the investor designs a loan contract that compels the entrepreneur to reveal his true type of skill by maintaining incentive compatibility and voluntarily participate in the contract by maintaining individual rationality. Due to the revelation principle, the household may restrict his attention to truthful mechanisms in which the message space is restricted to be the private information possessed by the entrepreneur, namely his skill level. When the research project is complete, the entrepreneur earns the market value of firm $V(I_t;s)$ and makes debt payment $D(I_t;s)$. The outside option of the entrepreneur is to become a production worker earning the competitive wage w_t. The expected income of the investor, conditional on the signal, is

$$U^E(D_t(s), I_t(s); s) = V(I_t(s); s) - D_t(s), \tag{6}$$

and the expected income of the entrepreneur, conditional on the signal, is

$$U^I(D_t(s), I_t(s)) = D_t(s) - I_t(s). \tag{7}$$

The household's mechanism design problem is

$$\max_{D_t(s),I_t(s)} \int_{\underline{s}}^{\overline{s}} [D_t(s) - I_t(s)]dF(s), \tag{8}$$

subject to the participation constraint of the entrepreneur

$$V(I_t(s); s) - D_t(s) \geq w_t \quad \text{for all } s \in [\underline{s}, \overline{s}]; \tag{9}$$

the truth-telling constraint of the entrepreneur

$$V(I_t(s); s) - D_t(s) \geq V(I_t(\widetilde{s}); s) - D_t(\widetilde{s}) \quad \text{for all } s, \widetilde{s} \in [\underline{s}, \overline{s}]; \tag{10}$$

and the non-negativity constraint $I_t(s) \geq 0$.

Let $\phi(s) = [1 - F(s)]/f(s)$ denote the inverse of the hazard rate of F. As is common in the mechanism design literature, we assume

$$\phi'(s) \leq 0 \text{ and } \phi(\overline{s}) = 0 \tag{A 1}$$

Lemma 1 *The mechanism design problem is equivalent to having the investor maximizes the "virtual surplus" of the research venture:*

$$\max_{I_t(s) \geq 0} V(I_t(s); s) - I_t(s) - \phi(s)V_s(I_t(s); s) \tag{11}$$

The solutions to this problem is described by (11) in the absence of financial innovation are as follows: (1) the R&D investment policy is

$$I_t(s) = \theta s^{1+g}\{\frac{\alpha\pi_t}{\overline{A}_t^{\alpha}}[1 - (1 - \alpha)(1 + g)\phi(s)/s]\}^{1/(1-\alpha)} \tag{12}$$

(2) the expected innovation probability is

$$\mu_t(s) = \theta s^{1+g}\{(\alpha\pi_t/\overline{A}_t)[1-(1-\alpha)(1+g)\phi(s)/s]\}^{\alpha/(1-\alpha)} \tag{13}$$

(3) the expected value of the firm is

$$V_t(s) = \theta s^{1+g}\pi_t^{1/(1-\alpha)}\{\alpha/\overline{A}_t[1-(1-\alpha)(1+g)\phi(s)/s]\}^{\alpha/(1-\alpha)} \tag{14}$$

The participation constraint of the lowest-skilled entrepreneur binds:

$$D_t(\underline{s}) = V_t(\underline{s}) - \Omega A_t \tag{15}$$

The term $\phi(s)V_s(I_t(s);s)$ in equation (11) quantifies the impact of the adverse selection problem on the social surplus. This measures the extent to which the investor's objective deviates from the social surplus of the research venture $V(I_t(s);s) - I_t(s)$, which is the investor's objective in the absence of the adverse selection problem.[6] Because of the single-crossing property $V_{sI} > 0$, the term $\phi(s)V_s(I_t(s);s)$ is increasing in the investment I_t. An upward shift in the function over the range $[\underline{s}, \overline{s}]$ or a reduction in the skill level of the entrepreneur under assumption (A1) increases the inverse of hazard rate $\phi(s)$ itself, thereby exacerbating the adverse selection problem. Furthermore, the more is technology advances at a growth rate g, the more the investor's objective deviation from the social surplus, the greater the distortion caused by the adverse selection problem will be.

Lemma 1 requires that the investment policy is non-increasing in skill on the optimal mechanism. A sufficient, but not necessary condition, for this to hold is (A1). To satisfy the second-order condition (SOC) of the investor's problem, and ensure the investment

[6]The second best solution under perfect informaton is obtained by solving $\max_{I_t(s)\geq 0} V(I_t(s);s) - I_t(s)$ subject to the participatiion constraint. The second best R&D investment is $I_t(s) = \theta s^{1+g}(\frac{\alpha\pi_t}{\overline{A}_t^{\alpha}})^{1/(1-\alpha)}$.

policy (12) is well defined, we must assume $1-(1-\alpha)(1+g)\phi(s)/s>0$ for all $s \in [\underline{s}, \overline{s}]$. Under assumption (A1), this condition becomes $1-(1-\alpha)(1+g)\phi(\underline{s})/\underline{s}>0$.

2.5.2 Financial Innovation

In each sector, a financial entrepreneur borrows funds from households and invests in financial innovation to screen individuals with entrepreneurial ideas for technological innovation in next period. The probability that the capable financial entrepreneur in sector i successfully innovates, $\mu_t^f(i)$ depends positively on the quality of resources invested in financial innovation in period $t-1$, $I_{t-1}^f(i) = \theta^f(\mu_t^f(i))^2$, whereby the more financially developed country is, the lower θ^f is. In other words, the cost of financial innovation positively relates the probability of successful financial innovation and negatively relates the country's level of financial development.

If the financial entrepreneur successfully innovates, then new screening methodology stops the process of exacerbating adverse selection problems as technology frontier advances. If the financial entrepreneur fails to innovate, the degree of adverse selection increases, thereby dampening the investment decision in R&D funding.

In equilibrium, in the sector, each intermediate good is produced in the amount

$$x_t(i) = [(1-\eta)^2/c]^{1/\eta} A_t(i). \tag{16}$$

Since the successful entrepreneurial profit is $\pi_t = (\frac{\eta c}{1-\eta})(\frac{(1-\eta)^2}{c})^{\frac{1}{\eta}} \overline{A}_t$ with the probability $\mu_t(s)$, in the absence of financial innovation, the equilibrium innovation probability function is

$$\mu_t(s) = \theta s^{1+g}\{\alpha\Psi[1-(1-\alpha)(1+g)\phi(s)/s]\}^{\alpha/(1-\alpha)} \tag{17}$$

where $\Psi = (\frac{\eta c}{1-\eta})(\frac{(1-\eta)^2}{c})^{\frac{1}{\eta}}$. The term $(1+g)\phi(s)/s$ captures the distortion of the degree of adverse selection in innovation process caused by the growth of technology frontier. By $\underline{s} > 1$, the high skilled more easily adopts new technology frontier than the low skilled. By this property, technology progress has more a disproportionately negative impact on on sectors which mainly consists of low skilled types in the absence of financial innovation. This does not only impede technological innovation, but also dampens the rate of change in technological innovation in the sectors. This also more dampens the rate of change in technological innovation in the more skill dispersed sectors.[7] To resolve the adverse selection problem, we add a role of financial innovation to the innovation probability function by reforming (17) as:

$$\mu_t^J(s) = \theta s^{1+g}\{\alpha\Psi[1-(1-\alpha)(1+g)\phi(s)/(\gamma_t s)]\}^{\alpha/(1-\alpha)} \tag{18}$$

where

$$\gamma_t(i) = \left\{ \begin{array}{ll} (1+g) & \text{with probability } \mu_t^f(i)\ (J=s) \\ 1 & \text{with probability } 1-\mu_t^f(i)\ (J=u) \end{array} \right\}$$

In the absence of successful financial innovation $(J=u)$, $\gamma_t = 1$, and thus technological progress causes more distortions in the adverse selection problem. With successful financial innovation $(J=s)$, $\gamma_t = 1+g$, and thus there is no more distortion in the adverse selection problem by technological progress. The new equilibrium value of firm is

$$V_t^J(s) = \theta s^{1+g}\Psi^{1/(1-\alpha)}\{\alpha[1-(1-\alpha)(1+g)\phi(s)/(\gamma_t s)]\}^{\alpha/(1-\alpha)} \tag{19}$$

[7] The mathematical proof is given in the appendix.

For the successful financial entrepreneur, the investor pays the fraction of the entrepreneurial profit Γ_t such that the investor is indifferent between making a contract with successful financial innovation and with unsuccessful financial innovation. The financial entrepreneur's profit Γ_t is equal to $\int_{\underline{s}}^{\overline{s}} \delta_t(s) V_{i,t}^s(s) dF(s)$ where $\delta_t(s)(V_t^s(s) - I_t^s(s) - \phi(s)V_s^s) = V_t^u(s) - I_t^u(s) - \phi(s)V_s^u$, and thus $\delta_t(s) = 1 - [\frac{1-(1-\alpha)(1+g)\phi(s)/s}{1-(1-\alpha)\phi(s)/s}]^{1/(1-\alpha)}$. This equation indicates that the better role of successful financial innovation is in resolving the adverse selection problem, the higher the financial entrepreneur's profit is.

The financial entrepreneur chooses $\mu_t^f(i)$ to maximize his expected profit $\pi_t^f(i) = \mu_t^f(i)\beta \int_{\underline{s}}^{\overline{s}} \delta_t(s) V_{i,t}^s(s) dF(s)$. The probability $\mu_t^f(i)$ to maximize $\pi_t^f(i)$ is

$$\mu_t^f(i) = \frac{\beta \int_{\underline{s}}^{\overline{s}} \delta_t(s) V_{i,t}^s(s) dF(s)}{2\theta^f}$$

$$= \frac{\left\{ \begin{array}{c} \beta\theta(\alpha\Psi)^{1/(1-\alpha)} \int_{\underline{s}}^{\overline{s}} s^{1+g}[\{[1-(1-\alpha)\phi(s)/s]\}^{\alpha/(1-\alpha)} \\ -\{[1-(1-\alpha)(1+g)\phi(s)/s]\}^{\alpha/(1-\alpha)} dF(s) \end{array} \right\}}{2\theta^f} \quad (20)$$

The rate of financial innovation $\mu_t^f(i)$ is decreasing in θ^f : the higher is the country's level of financial development, the higher is the rate of financial innovation. Under identical asymmetric information, a financial entrepreneur can choose a higher rate of financial innovation in more financially developed countries. The following lemma shows how the rate of financial innovation changes in regards to properties of entrepreneurial skill distribution.

Lemma 2 *Assume (A1) holds. Consider the entrepreneurial skill distribution G and H with the support* $[\underline{s}, \overline{s}]$*, where* $\underline{s} > 1$*,* $\overline{s} < \infty$*. Let* $\mu_t^f(G)$ *denotes the rate of financial* *innovation associated with* G *and* $\mu_t^f(H)$ *denotes the rate of financial innovation associated with* H*.*

(1) Suppose H *first-order stochastically dominates* G*; then* $\mu_t^f(G) \geq \mu_t^f(H)$ *if* $\alpha > \epsilon(s)$*, where* $\epsilon(s) = \max[-\frac{s-\phi(s)}{\phi'(s)s}]$*,* $s \in [\underline{s}, \overline{s}]$*.*

(2) Suppose H *second-order stochastically dominates* G*; then* $\mu_t^f(G) \geq \mu_t^f(H)$ *if* $\alpha \leq 1/2$ *,* $\underline{s} > (1+g)/(1-\alpha)$ *and* $\phi''(s) \geq 0$*.*

The first part of the lemma indicates that the rate of financial innovation decreases in skill mean. The low skilled type presents low R&D productivity, thereby being more financially constrained. The high demand of financial innovation (by investors) occurs in the sectors which are mainly composed of the low skilled types. The high demand for financial innovation in the sectors leads to an increase in monopoly rents to a successful financier, thereby raising the rate of financial innovation. The sufficient, but not necessary, condition $\alpha > \epsilon(s)$ implies that the effect of financial innovation becomes trivial, as $\alpha \to 0$, because R&D investment becomes trivial for technological innovation. The second part of the lemma implies that the rate of financial innovation increases in dispersion of skill distribution within the sectors of the same skill on average.[8] The greater is the dispersion of the skill distribution, the large is the informational advantage of skilled types; thus the higher is the demand of investors for financial innovation. The requirement $\alpha \leq 1/2$, $\underline{s} > (1+g)/(1-\alpha)$ and $\phi''(s) \geq 0$ are sufficient, but not necessary, conditions for the second property of the lemma 2. The requirement $\phi''(s) \geq 0$ is satisfied if the entrepreneurial skill distribution is uniform, exponential, or Pareto. The condition $\underline{s} > (1+g)/(1-\alpha)$ excludes a case that an advance in technology frontier outpaces financial innovation.

[8] In the second part of lemma 1, the statement " H second-order stochastically dominates G." is equivalent to the statement " G is a mean preserving spread of H.", thereby suggesting that "more dispersed small firm sectors are more informationally opaque."

2.5.3 Aggregate Economic Activity

This section aggregates an economy's activity at the industry level and examines its components. We define each sector's average level of productivity, $A_t = \int_0^1 A_t(i)di$ where aggregation is performed across the continuum of intermediate sectors. In aggregate equilibrium, the probability of innovation in R&D sectors, $\mu_t^J(i) = \int_{\underline{s}}^{\overline{s}} \mu_t^J(s)dF(s)$ for all $i \in [0,1]$ where $J = s, u$. At the aggregate level, the rate of financial innovation is $\mu_t^f = \int_0^1 \mu_t^f(i)di$ for all $i \in [0,1]$. Since we aggregate financial efficiency across a continuum of sectors, we ignore negligible relative size differences. The average technology productivity evolves according to

$$A_t = \{\mu_t^f \mu_t^s + (1-\mu_t^f)\mu_t^u\}\overline{A}_t + \{\mu_t^f(1-\mu_t^s) + (1-\mu_t^f)(1-\mu_t^u)\}A_{t-1} \tag{21}$$

At the industry level, the average technology productivity in period t is a weighted average of sectors with the technology frontier $\overline{A}_t$ and of sectors with the previous average technology productivity A_{t-1}. The weight depends on the rate of financial innovation(μ_t^f), the rate of entrepreneurial innovation by using new screening devices (μ_t^s) and the rate of entrepreneurial innovation by using previous screening devices (μ_t^u). Hence the weight is indirectly affected by the properties of entrepreneurial skill distribution.

In final good sectors, the competitive wage w_t is $\eta(\frac{(1-\eta)^2}{c})^{\frac{1-\eta}{\eta}} A_t$ and $Y_t = \xi A_t$ where $\xi = (\frac{(1-\eta)^2}{c})^{\frac{1-\eta}{\eta}}$. Denote the cross-industry distance from the world technology frontier as $a_t = \frac{A_t}{\overline{A}_t} \in (0,1)$. The technology gap evolves according to

$$a_t = [\mu_t^f \mu_t^s + (1-\mu_t^f)\mu_t^u] + \frac{\mu_t^f(1-\mu_t^s) + (1-\mu_t^f)(1-\mu_t^u)}{1+g} a_{t-1} \tag{22}$$

This converges to the steady state a_{ss} in the long run :

$$a_{ss} = \frac{(1+g)(\mu^f(\mu^s - \mu^u) + \mu^u)}{g + \mu^f(\mu^s - \mu^u) + \mu^u} \tag{23}$$

The disproportionate impact of financial innovation on growth is determined by $\mu^f(\mu^s - \mu^u)$ and μ^u. On the one hand, the rate financial innovation (μ^f) increases in sectors with the low mean skill and the high size dispersion because of high monopoly profits to financial entrepreneurs. The more distortion financial innovation resolves, the more technological innovation per financial innovation ($\mu^s - \mu^u$) is achieved in the sectors. On the other hand, technological innovation (μ^u) is initially more dampened in the sectors. Unless the innovation cost is sufficiently low so that the benefit dominates the cost, financial innovation does not have a disproportionate impact on sectors with the low skill mean (and the more skill-dispersion), but rather on sectors with the high skill mean (and the less skill-dispersion).

The following proposition characterizes the growth of economies depending on each country's level of financial system (financial development) and its change (financial innovation).

Proposition 1 *As a country is more financially developed, then in the steady state,*

(1) the effect of financial innovation on the growth of sectors (which converge to the leading technology frontier) decreases in the mean of entrepreneurial skill distribution.

(2) the effect of financial innovation on the growth of sectors (which converge to the leading technology frontier) increases in the dispersion of entrepreneurial skill distribution.

As regards to a firm size, the main implication of our theory is that as a country is more financially developed, the impact of financial innovation on growth in the steady state decreases in the mean of a size distribution of firms and increases in the dispersion of a size distribution of firms.

We assume that the growth rate of the technology frontier is determined by the equilibrium rate of entrepreneurial innovation in the leading industry in a leading country 1:

$$g = \mu_1^f(\mu_1^s - \mu_1^u) + \mu_1^u \tag{24}$$

2.6 Firm size and Financial Innovation

In the previous section, we discussed the impact of financial innovation on growth depends on the mean and the dispersion of a size distribution of firms. The first part of Lemma 1 indicates that a role of financial innovation in growth is more pronounced in small firm sectors.

Now we consider a theoretical background suggesting that financial innovation has a disproportionately positive impacts on small firms within each sector. There has been a well-known fact that small firms are more suffered by costly borrowing due to a paucity of information. Small firms confront high financial and legal obstacles and severe competition to obtain R&D resources. In our model, financial innovation plays a crucial role in the growth of small firms in a sector. This follows from the fact that the inverse of the hazard rate is decreasing in skill under assumption (A1) $\phi'(s) < 0$ and $\phi(\bar{s}) = 0$. The severity of adverse selection decreases in skill. Therefore, the less skilled an entrepreneur, the greater reduction in his R&D investment will be. The low skilled types are more financially constrained. A financial entrepreneur's profit decreases in skill, as we see in equation (20), the term $[1-(1-\alpha)\phi(s)/s] - [1-(1-\alpha)(1+g)\phi(s)/s]$ decreases in skill. The demand of financial innovation is high in small firms in each sector. Hence, our theory predicts that financial innovation largely benefits small firms in each sector.

3 Empirical Evidence

In this section we confront our theoretical predictions with evidence. Because skill determines firm size in our theory, we use a size distribution of firms (Firm Size Distribution; FSD) to proxy entrepreneurial skill distribution F such that average firm size measures the mean of F and the standard deviation of the FSD measures the dispersion of F, as in Plehn-Dujowich (2009). In our regression framework, we interact sector characteristics — consist of Mean, Standard Deviation of the FSD — with a country's characteristics — the level of Financial Development and the rate of Financial Innovation. We test the effect of each own and interaction terms (in 2002) on the average 2002-6 growth rate of European 2-digit manufacturing sectors.[9] After describing our data, we explain our test for the main implication.

3.1 Data

This study uses an unbalanced panel of European (NACE) 2-digit manufacturing sectors from Eurostat. The panel includes the number of firms and employment by firm size class, together with investment, employment, payroll, and value added. The panel includes 22 sectors spanning 24 countries. The dataset allows us to examine the cross-firm, cross-sector distributional effect of financial development and financial innovation on growth. There are five firm size classes based on the number of employees : 1-9, 10-19, 20-49, 50-249, and 250+. As in Ace, Morck and Yeung (1999) and Pagano and Schivardi (2003), we construct the Weighted Mean and Standard Deviation of the FSD in 2002 by using the average firm

[9] By considering country- and sector- fixed effects, we estimate the impact of financial systems on the growth of sectors which converge to the leading technology frontier, as in our theory.

size in a sector weighted by employment. The Weighted Mean and Standard Deviation are considerably right-skewed, so we use their logs ($MEAN_i$ and SD_i). Employment is measured by the number of person employed. Value Added is measured by value added at factor cost. Real Value Added per Worker (VAD) is value added divided by country-level Purchasing Power Parities (PPP) published by Eurostat, which is then divided by the number of persons employed. VAD is our measure of labor productivity. As in growth literature, VAD growth relates two kinds of variables — initial level of VAD ($VAD2002$) and proxies for the level of physical capital and labor. We do not have a measure of the capital stock to calculate the capital-labor ratio, we use the log of Investment instead. To avoid multicollinearity (with the initial level of VAD), we use the log of Payroll instead. Investment is measured by gross investment in tangible goods. . Payroll is measured by personnel costs. Investment and payroll are also deflated using PPP.

We follow Aghion, Howitt and Mayer-Foulkes (2005) and Michalopoulos, Laeven and Levine (2010) in using the ratio of Private Credit to GDP (F_k) in 2002 as our preferred measure of financial development. This is the value of credits by financial intermediaries to the private sector (excluding credit granted to the public sector and credit granted the central bank and development bank), divided by GDP. This is based on the theoretical sound notion that developed financial markets grant individuals and firms easier access to external funds. An ideal proxy for financial innovation would measure improvements in financially screening devices. However, such information is not available. As in Michalopoulos, Laeven and Levine (2010), we use the growth rate of the ratio of Private Credit to GDP (f_k) over the sample period as our preferred proxy for financial innovation. This index may be an unsatisfactory measure because it measures overall improvements in the country's financial system. Our empirical finding supports, however, that the previous empirical literature focusing on financial development underscore the value of incorporating its change.

Table 1 presents summary statistics of country-industry specific variables and country variables. Table 2 and 3 present country-level and sector-level means of Weighted Mean and Standard Deviation of the FSD across the entire panel. The average Weighted Mean of FSD is 398.55, with a median of 271.98 and the average Standard Deviation of the FSD is 281.75, with a median of 255.23. Table 2 contains the mean across sectors of the Weighted Mean and Standard Deviation for each country. Sweden has the largest firms and the most dispersed FSD. Estonia has the smallest firms and the least dispersed FSD. Table 3 contains the mean across countries of the weighted mean and standard deviation for each sector. Motor (NACE 34) has the largest firms and largely dispersed FSD. Recycling (NACE 37) has the smallest firms and the least dispersed FSD. Overall, the correlation between the weighted mean and standard deviation is 87%.

Table 1 also presents indexes of Financial Development (F_k) and Financial Innovation (f_k). Denmark is the most financially developed country. Lithuania is the least financially developed country. Estonia shows the most rate of financial innovation. Germany shows the least rate of financial innovation. Overall, the correlation between F_k and f_k is - 60%. Financial innovation is high in less financially developed countries.

3.2 Methodology and results

3.2.1 Main Implication

To examine our main implication for proposition 1, we focus on the effect of two interaction terms $MEAN_i \cdot f_k \cdot F_k$and $SD_i \cdot f_k \cdot F_k$ in 2002 on the average 2002-2006 VAD growth.

Consider the following regression :

$$g_{i,k} = \gamma_0 + \gamma_1 MEAN_i + \gamma_2 SD_i + \gamma_3 MEAN_i \cdot f_k + \gamma_4 SD_i \cdot f_k + \gamma_5 MEAN_i \cdot f_k \cdot F_k$$
$$+\gamma_6 SD_i \cdot f_k \cdot F_k + \delta'_X X + \sum_i \alpha_i Country_i + \sum_k \beta_k Industry_k + \varepsilon_{i,k} \tag{25}$$

where $g_{i,k}$ is the average 2002-6 log VAD growth rate in sector i and country k. The vector of other controlled regressors X contains the log of 2002 real Investment ($Investment$), the log of 2002 real Payroll ($Payroll$) and the log of 2002 VAD ($VAD2002$). We do not include financial innovation and financial development on their own, since we focus on within-country, within-industry growth rate. The dummy variables for sectors and countries control for country-and-sector specific characteristics that might determine sector growth patterns. We always report heteroskedasticity-robust standard errors.

The Financial Development index F_k and the Financial Innovation index f_k may be endogenous because feedback from growth to finance, or because of the common effect of omitted variables on both growth and finance. We test our main implications by using a various set of interaction with the instruments which contains $MEAN_i \cdot f_k$, $SD_i \cdot f_k$, $MEAN_i \cdot F_k$, $SD_i \cdot F_k$,.$MEAN_i \cdot f_k \cdot F_k$ and $SD_i \cdot f_k \cdot F_k$. The endogeneity of F_k and f_k are likely to entail endogeneity of the interaction variables. We try to tackle the issues using the method of instrumental variables. To deal with endogeneity problem with regard to F_k, we estimated the equation using instrumental variables, instrumenting for $MEAN_i \cdot F_k$ and $SD_i \cdot F_k$ using legal origins(L_k) interacted with $MEAN_i$ and SD_i ($MEAN_i \cdot L_k$ and $SD_i \cdot L_k$ respectively). Legal origins is a set of four dummy variables for the country's legal system based on French, English, German or Scandinavian tradition, used first in La Portra et al (1998). The variables are a good set of instruments for financial development because they were established too long ago to escape from reverse causation.

To deal with endogeneity problem with regard to f_k, we estimated the equation using an instrumental variable, instrumenting for f_k using the average growth rate of financial reform index (R_k) over the period 1996 to 2006, as in Michalopoulos, Laeven and Levine (2010). The financial reform index , developed by Abiad and Mody (2005), is an aggregate index which measures the degree of policy liberalization on six policy dimensions — credit controls, interest rate controls, entry barriers in the banking sector, operational restriction, privatization in the financial sector and restrictions on international financial transactions. The index captures improvements in the country's financial system, but is positively as well as negatively affected by omitted factors for promoting economic growth (Chui, Titman and Wei; 2001). For example, a successful financial reform improves the matching between entrepreneurs with good projects and capital. However, it may deter the growth in corporate groups which have close relationships with policymakers and providers of capital that are likely to be less valuable in a more open and less regulated environment. We estimated the equation by instrumenting $MEAN_i \cdot f_k$ and $SD_i \cdot f_k$ using reform indexes(R_k) interacted with $MEAN_i$ and SD_i ($MEAN_i \cdot R_k$ and $SD_i \cdot R_k$ respectively). We construct the interaction terms $MEAN_i \cdot f_k \cdot F_k$ and $SD_i \cdot f_k \cdot F_k$ by multiplying the first stage fitted values of $MEAN_i \cdot F_k$ and $SD_i \cdot F_k$ by the first stage fitted value of f_k, respectively.

Our model prediction includes the positive scale effect and the negative adverse selection effect of the FSD on growth, discussed by Pagano and Schivardi (2003) and Plehn-Dujowich (2009) ($\gamma_1 > 0$ and $\gamma_2 < 0$). In the absence of financial development, financial innovation itself is not sufficient to largely benefit small firm sectors (and more size-dispersed sectors); rather may have disproportionate impacts on large firm sectors (and less size-dispersed sectors) ($\gamma_3 > 0$ and $\gamma_4 < 0$). As a country is more financially developed, our model predicts that the effect of financial innovation on growth decreases in the mean of the FSD and increases in the dispersion of the FSD ($\gamma_5 < 0$ and $\gamma_6 > 0$).

Our main results are presented in Table 4. The column (1) and (2) report the OLS estimates concerning the positive scale effect ($\gamma_1 > 0$) and the negative adverse selection effect ($\gamma_2 < 0$). Regardless of including sector and country dummies, the regression results are consistent with the finding in Plehn-Dujowich (2009). The column (3) reports the slope-coefficient of the OLS estimates for the case including only financial development(F_k). The result shows that the interaction between financial development and the mean of the FSD ($MEAN_i \cdot F_k$) enters negatively and significantly (–0.0887<0). The interaction between financial development and the dispersion of the FSD ($SD_i \cdot F_k$) enters positively and significantly (0.100122>0). The impact of financial development on growth is decreasing in the mean and increasing the dispersion of the FSD. The estimates may show potential bias in seeing more financial development in richer places. It may bias the OLS estimate for $MEAN_i \cdot F_k$ upward and for $SD_i \cdot F_k$ downward. In column (4), the slope-coefficients of the IV estimates for the case including only financial development(F_k). They are also consistent with the OLS results. These results suggest that financial development largely helps small firm sectors (and more size-dispersed sectors), which is in the line with the previous literature on corporate finance (Guiso, Sapienza and Zingales, 2004; Beck, Demirguc-Kunt, Laeven and Levine, 2008). Furthermore, these results cast insights concerning our prediction, in that financial development matters to the disproportionate effect of financial innovation on growth. The column (5) reports the slope-coefficients of the IV estimate for financial innovation interacted with mean and dispersion of the FSD ($MEAN_i \cdot f_k$ and $SD_i \cdot f_k$.) in the absence of financial development. The result shows that $MEAN_i \cdot f_k$ enters positively and significantly (0.7056>0). The interaction $SD_i \cdot f_k$ enters negatively but insignificantly. Financial innovation itself has a larger impact on large firm sectors.

To assess the effect of financial innovation on growth depending on the country's level of financial development, we estimate our main regression framework (25) including two interaction terms $MEAN_i \cdot f_k \cdot F_k$ and $SD_i \cdot f_k \cdot F_k$. Column (6) reports the slope-coefficient

IV estimates for the regression framework (25). The result shows that financial innovation itself largely helps large firm sectors (and less size-dispersed sectors) ($\gamma_3 = 1.340531 > 0$ and $\gamma_4 = -0.524278 < 0$). However, the slope-coefficients of the IV estimates for financial innovation interacted with financial development, mean and dispersion of the FSD ($MEAN_i \cdot f_k \cdot F_k$ and $SD_i \cdot f_k \cdot F_k$.) are consistent with our prediction for the main implication. The disproportionate impact of financial innovation on growth significantly decreases in the mean of the FSD ($\gamma_5 = -2.401205 < 0$) and significantly increases in the dispersion of the FSD ($\gamma_6 = 2.22523 > 0$). As the country is more financially developed, financial innovation is more pronounced in small-firm sectors and more size-dispersed sectors within small firm sectors.

3.2.2 Controlling for Industry Characteristics

In this subsection, we control for additional industry traits. First, we were concerned that sectors that are naturally heavy users of external finance grow faster with higher levels of financial innovation and financial development. Given the influential findings of Rajan and Zingales (1998), a firm's dependence on external finance (RZ indexes; $FIN\ DEP$) is defined as the share of investment that cannot be financed through internal cash flows. Assuming that the variance of the need for external finance persists across sectors, we use the United States to compute the natural external dependence of sectors. In Table 4, column (7) reports the slope-coefficient IV estimates for the regression framework (25) after controlling for the interaction terms between RZ indexes, Financial Innovation and Financial Development ($FIN\ DEP$ x F x f). The triple interaction term ($FIN\ DEP$ x F x f) enters positively and significantly. Financial innovation largely benefits sectors that are naturally heavy users of external finance in more financially developed countries.

Second, financial development may disproportionately help sectors with good growth opportunities in competition with U.S. firms. We control for US Sales Growth ($US\ Sales$), which is calculated as real annual growth in net sales of U.S. firms over the sample period using data from COMPUSTAT. We add the interaction term of US Sales Growth with Financial Development ($US\ Sales$ x F). In Table 4, column (8) reports the slope-coefficient IV estimates for the regression framework (25) after controlling for the two interaction terms $FIN\ DEP$ x F x f and $US\ Sales$ x F. $FIN\ DEP$ x F x f enters positively and significantly. $US\ Sales$ x F enters negatively but insignificantly.[10]

The column (7) and (8) show that the results for $MEAN_i \cdot f_k \cdot F_k$ and $SD_i \cdot f_k \cdot F_k$ are invariant and significant even when controlling for other industrial traits.

3.2.3 Sensitivity to Alternative Measures of Financial Development / Financial Innovation

The findings are also robust to using an alternative measure of financial intermediary development. Specifically, we use (i) the sum of Stock Market Capitalization and bank and non-bank credit to the private sectors, (ii) Liquid Liabilities. We measure financial innovation by calculating the average growth of such alternative measures over the sample periods. In Table 5, column (1) to (4) show the slope-coefficient IV estimates for the regression framework (25) when we use the sum of Private Credit and Stock Market Capitalization, divided by GDP. The Stock Market Capitalization equals the value of listed shares of the stock market, used as an indicator of the size of the stock market. Column (5) to (8) show the slope-coefficient IV estimates for the regression framework (25) when we use another alternative measure, liquid liabilities which is currency plus demand and interest-bearing liabilities of banks and nonbank financial intermediaries divided by GDP. Liquid Liabilities simply measure the size of financial intermediaries and do not focus on

[10] When we add the interaction term $US\ Sales$ x F x f to (25), it also enters insigificantly.

the intermediation of credit to the private sector. As shown in Table 5, the results hold when using alternative measures of financial development.

3.2.4 Using dummies for the above 50 percentile Financial Development / Financial Innovation

We examine the robustness of our finding by using dummies for the above 50 percentile Financial Development (F_k) and Financial Innovation (f_k), instead of their own variables. In Table 6, our main results for γ_5 and γ_6 of the regression framework (25) are unaltered. The results are robust even when we use alternative measures of financial development and financial innovation.

3.2.5 Instruments Validity

We tested the strength of our instruments with the usual F-test of joint significance in the first-stage regression of various instrument sets : $MEAN_i \cdot F_k$, $SD_i \cdot F_k$, $MEAN_i \cdot f_k$, $SD_i \cdot f_k$. The p-values reported in the bottom of Table 4 and 5 indicate that the instruments passed this test at the 1 percent level in all equations for our implications. Thus, our addition of the interacted instruments does not appear to have created a “many instruments" problem.

To be valid, our instruments must not affect growth through any channel other than finance, since otherwise the effects we are attributing to finance might actually be effects of these nonfinancial channels. We tested the restriction using the standard J test. For all IV estimations, the null hypothesis that the instruments are uncorrelated with IV residuals are not rejected, and thereby the large p-values show that the instruments pass the test in all cases.

Overall, we interpret the results of this section as robust evidence in favor of our implications. Although our empirical analysis is based on a short sample period 2002 to 2006, it still suggests that financial innovation largely helps small firm sectors (and more size-dispersed sectors) in more financially developed countries. In the absence of financial development, financial innovation has rather a disproportionate impact on large firm sectors and (less size dispersed sectors).

4 Conclusion

Technological innovation has historically permitted financial intermediaries to interact with real sectors more efficiently. In this paper, we study the economic consequence of financial innovation on small firm sectors. We model the rate of financial innovation increases more in sectors more informationally opaque and financially constrained, because a successful financial entrepreneur earns high monopoly profits. In the model every screening process becomes less effective to screen prospective entrepreneurs, as technology advances. Due to complementarity between skill and technology frontier, an advance in technology causes more distortions in small firm sectors (and more size-dispersed sectors within small firm sectors). Hence our model predicts that financial innovation is more pronounced in small-firm sectors (and more size-dispersed sectors within small firm sectors). Financial development however still matters for the disproportionate impact of financial innovation on small firms sectors because financial entrepreneurs are more active in innovation in more financially developed countries.

Our empirical findings are consistent with the theoretical predictions In 22 sectors spanning 24 European countries, over the sample period 2002-2006. Financial innovation largely helps small firm sectors in more financially developed countries. The link between financial innovation and the disproportionate impact on small firm sectors is weak in less financially developed countries. The findings are unaltered even when controlling for other industrial traits and using alternative measures of financial intermediary development.

Incorporating financial innovation in growth theory, therefore appears an effective way to examine the distributional impact of financial intermediaries across sectors and across firms. Our result however does not reject the previous studies which emphasize a role of financial development in a growth process. Rather, this emphasizes the impact of financial development on growth via financial innovation. In future work, we plan to assess a disproportionate impact of the interaction between financial innovation and financial development on growth, depending firm age, entry and exit.

Appendix A: Mathematical Proofs

Proof of Lemma 1. : The proof follows the lines of Salanie (2005, Ch. 2.). We omit time index t in this proof. Let $U^E(s,\widetilde{s}) = V(I_t(\widetilde{s}); s) - D_t(\widetilde{s})$ denote the expected income of an entrepreneur of type s who announces his type as $\widetilde{s}$ who announces his type as $\widetilde{s}$. The entrepreneur announces the type $\widetilde{s}$ that maximizes his expected income $U^E(s,\widetilde{s})$. For the mechanism $(I_t(s), D_t(s))$ to be incentive compatible , it must satisfy the first-order condition(FOC) of the entrepreneur's problem, $\partial U^E(s,s)/\partial\widetilde{s} = 0$:

$$V_I(I(s); s)I_s(s) - D_s(s) = 0; \tag{B1}$$

and the second-order condition(SOC) of the entrepreneur's problem, $\partial^2 U^E(s,s)/\partial\widetilde{s}^2 \leq 0$.

$$V_{II}(I(s); s)(I_s(s))^2 + V_I(I(s); s)I_{ss}(s) - D_{ss}(s) \leq 0. \tag{B2}$$

Differentiate the FOC (B1) with respect to s:

$$V_{II}(I(s);s)(I_s(s))^2 + V_{Is}(I(s);s)I_s(s) + V_I(I(s);s)I_{ss}(s) - D_{ss}(s) = 0 \tag{B3}$$

Applying to the SOC (B2), the SOC becomes

$$V_{Is}(I(s);s)I_s(s) \geq 0 \tag{B4}$$

we have $V_{Is} > 0$: the return on R&D is greater the more skilled is the entrepreneur. This is the "single-crossing property" familiar from the mechanism design literature, which here is satisfied since entrepreneur skill and R&D are complement in the innovation production. Let $u^E(s)$ denote the expected income the entrepreneur of type s gets at the optimum of his program. As the optimal mechanism is truthful, we have

$$u^E(s) = U^E(s;s) = V(I(s);s) - D(s) \tag{B5}$$

Applying the envelope theorem, the FOC of the entrepreneur's problem (B1) implies that

$$\frac{du^E(s)}{ds} = \frac{\partial V(I(s);s)}{\partial s}, \tag{B6}$$

which is positive. Integrating (B6), we obtain

$$u^E(s) = \int_{\underline{s}}^{\overline{s}} \frac{\partial V(I(y);y)}{\partial y} dy, \tag{B7}$$

Combining (B5) and (B7), we infer the debt payment:

$$D(s) = V(I(s); s) - \int_{\underline{s}}^{\overline{s}} \frac{\partial V(I(y); y)}{\partial y} dy. \tag{B8}$$

The objective function of the investor is

$$\int_{\underline{s}}^{\overline{s}} [D(s) - I(s)] dF(s). \tag{B9}$$

Substituting for D from (B8), the objective function (B9) becomes

$$\int_{\underline{s}}^{\overline{s}} [V(I(s); s) - \int_{\underline{s}}^{\overline{s}} \frac{\partial V(I(y); y)}{\partial y} dy - I(s)] dF(s). \tag{B10}$$

Integrating (B10) by parts, it becomes

$$\int_{\underline{s}}^{\overline{s}} [V(I(s); s) - \phi(s) \frac{\partial V(I(s); s)}{\partial s} - I(s)] dF(s), \tag{B11}$$

where $\phi(s)$ is the inverse of the hazard rate of F. It follows that the investor's problem involves the point-wise maximization of the integrand, termed the "virtual surplus." The FOC of the investor's problem (11) yields other solutions (12) to (14). The debt payment D may be recovered by integrating the FOC of the entrepreneur's problem (B1) and using the boundary condition (15). ■

Proof of Lemma 2. : The solution of the rate of financial innovation is

$$\mu_t^f(i) = \frac{\beta\theta(\alpha\Psi)^{1/(1-\alpha)} \int_{\underline{s}}^{\overline{s}} \lambda(s) dF(s)}{2\theta^f}, \tag{B12}$$

where $\lambda(s) = s^{1+g}[\{1 - (1-\alpha)\phi(s)/s\}^{\alpha/(1-\alpha)} - \{1 - (1-\alpha)(1+g)\phi(s)/s\}^{\alpha/(1-\alpha)}]$.

Let $\mu^f(G)$ and $\mu^f(H)$ denote the rate of financial innovation associated with G and H, respectively. Therefore, to prove $\mu^f(G) \geq \mu^f(H)$, we must show that the inequality $\int_{\underline{s}}^{\overline{s}} \lambda(s)dG(s) \geq \int_{\underline{s}}^{\overline{s}} \lambda(s)dH(s)$ holds.

We first prove Part I. Because H first-order stochastically dominates G, we have $\int_{\underline{s}}^{\overline{s}} \phi(s)dH(s) \geq \int_{\underline{s}}^{\overline{s}} \phi(s)dG(s)$, for every non-decreasing function $\phi(s)$. Hence, to prove the result, we must show that $\lambda(s)$ is non-increaseing. Taking its derivative with respect to s, we obtain

$$\begin{aligned}
\lambda'(s) &= s^g\{1-(1-\alpha)\phi(s)/s\}^{\alpha/(1-\alpha)}[(1+g)A_1 - \alpha s(\frac{(\phi(s)-\phi'(s)s)/s^2}{1-(1-\alpha)\phi(s)/s}) \\
&\quad \times\{(1+g)(\frac{1-(1-\alpha)(1+g)\phi(s)/s}{1-(1-\alpha)\phi(s)/s})^{\alpha/(1-\alpha)-1} - 1\}] \\
&< (1+g)s^g\{1-(1-\alpha)\phi(s)/s\}^{\alpha/(1-\alpha)}\{A_1 - \alpha s(\frac{(\phi(s)-\phi'(s)s)/s^2}{1-(1-\alpha)\phi(s)/s})A_2 \\
&< (1+g)s^g\{1-(1-\alpha)\phi(s)/s\}^{\alpha/(1-\alpha)}A_1A_2[1 - \alpha s(\frac{(\phi(s)-\phi'(s)s)/s^2}{1-(1-\alpha)\phi(s)/s}]
\end{aligned} \tag{B13}$$

where $0 < g < 1$,

$$\begin{aligned}
A_1 &= \{1-(\frac{1-(1-\alpha)(1+g)\phi(s)/s}{1-(1-\alpha)\phi(s)/s})^{\alpha/(1-\alpha)}\} > 0 \\
A_2 &= \{(\frac{1-(1-\alpha)(1+g)\phi(s)/s}{1-(1-\alpha)\phi(s)/s})^{\alpha/(1-\alpha)-1} - 1\} > 0
\end{aligned}$$

The inequality in the second row of (B13) holds because $A_1 < A_2$ by

$$\frac{1-(1-\alpha)(1+g)\phi(s)/s}{1-(1-\alpha)\phi(s)/s} < 1$$

For possible ranges of parameters, sufficient, but not necessary condition for $\lambda'(s) \leq 0$ to be negative are assumption (A1) ($\phi'(s) < 0$) and $\alpha > \epsilon(s)$ where $\epsilon(s) = \max[-\frac{s-\phi(s)}{\phi'(s)s}]$,

$s \in [\underline{s}, \overline{s}]$. This condition implies that the effect of financial innovation becomes trivial, as $\alpha \to 0$, because R&D investment becomes trivial for technical innovation.

We next prove Part II. Because H second-order stochastically dominates G, we have $\int_{\underline{s}}^{\overline{s}} \phi(s)dH(s) \geq \int_{\underline{s}}^{\overline{s}} \phi(s)dG(s)$, for every concave function $\phi(s)$. Hence, to prove the result, we must show that $\lambda(s)$ is convex. Taking the derivative of (B13) with respect to s, we obtain

$$\begin{aligned}
\lambda''(s) &= g(1+g)s^{g-1}B_1 + \alpha s^{1+g}\{\frac{\phi''(s)s^2 + 2\phi(s)s - 2\phi'(s)s^2}{s^4}\}B_2 + [s^{1+g}\alpha(1-2\alpha)B_3 \tag{B14} \\
&\quad -2(1+g)\alpha s^g B_2](\frac{\phi(s) - \phi'(s)s}{s^2}) \\
&> g(1+g)s^{g-1}B_1 + \alpha s^{1+g}\{\frac{\phi''(s)s^2 + 2\phi(s)s - 2\phi'(s)s^2}{s^4}\}B_2 + [s^{1+g}\alpha(1-2\alpha)B_4 \\
&\quad -2(1+g)\alpha s^g B_2](\frac{\phi(s) - \phi'(s)s}{s^2}) \\
&> g(1+g)s^{g-1}B_1 + [\alpha s^{1+g} + s^{1+g}\alpha(1-2\alpha) - 2(1+g)\alpha s^g]B_2
\end{aligned}$$

where

$$\begin{aligned}
B_1 &= [\{1-(1-\alpha)\phi(s)/s\}^{\alpha/(1-\alpha)} - \{1-(1-\alpha)(1+g)\phi(s)/s\}^{\alpha/(1-\alpha)}] > 0 \\
B_2 &= [(1+g)\{1-(1-\alpha)(1+g)\phi(s)/s\}^{\alpha/(1-\alpha)-1} - \{1-(1-\alpha)\phi(s)/s\}^{\alpha/(1-\alpha)-1}] > 0 \\
B_3 &= [(1+g)^2\{1-(1-\alpha)(1+g)\phi(s)/s\}^{\alpha/(1-\alpha)-2} - \{1-(1-\alpha)\phi(s)/s\}^{\alpha/(1-\alpha)-2}] > 0 \\
B_4 &= [(1+g)\{1-(1-\alpha)(1+g)\phi(s)/s\}^{\alpha/(1-\alpha)-2} - \{1-(1-\alpha)\phi(s)/s\}^{\alpha/(1-\alpha)-2}] > 0
\end{aligned}$$

and $B_2 < B_4 < B_3$. The inequality in the forth row of (B14) holds because $\{\frac{\phi''(s)s^2+2\phi(s)s-2\phi'(s)s^2)}{s^4}\} > (\frac{\phi(s)-\phi'(s)s}{s^2})$. For possible ranges of parameters, sufficient, but not necessary, conditions under which $\lambda''(s)$ is positive are $\alpha \leq 1/2$, $\underline{s} > (1+g)/(1-\alpha)$ and $\phi''(s) \geq 0$. ■

Proof of proposition 1. : For a simplicity, define Θ as a change in parameters : a decrease in mean and an increase in dispersion of entrepreneurial skill distribution F. By lemma 2, we know that

$$\frac{\partial \mu^f}{\partial \Theta} > 0 \text{ and } \frac{\partial(\mu^s - \mu^u)}{\partial \Theta} > 0 \tag{B14}$$

By the positive scale effect and the negative adverse selection effect, $\frac{\partial \mu^u}{\partial \Theta} < 0$.

Take total differentiation of (23) with respect to Θ,

$$\frac{da^{ss}}{d\Theta} = [\frac{g(1+g)}{(g+\mu^f(\mu^s-\mu^u)+\mu^u)^2}][\frac{\partial \mu^f}{\partial \Theta}(\mu^s-\mu^u)+\mu^f\frac{\partial(\mu^s-\mu^u)}{\partial \Theta}+\frac{\partial \mu^u}{\partial \Theta}]$$

Hence $\frac{da^{ss}}{d\Theta} > 0$, if $\left|\frac{\partial \mu^f}{\partial \Theta}(\mu^s-\mu^u)+\mu^f\frac{\partial(\mu^s-\mu^u)}{\partial \Theta}\right| > \left|\frac{\partial \mu^u}{\partial \Theta}\right|$; $\frac{da^{ss}}{d\Theta} < 0$,otherwise.

Since both $\frac{\partial \mu^f}{\partial \Theta}$ and μ^f is decreasing θ^f, the two properties of proposition 1 hold If the country" level of financial development is sufficiently high with low θ^f. ∎

Proof of the Lemma : . "The advance in technology frontier dampens the rate of change in technological innovation in the low skilled sectors and the more dispersed sectors"

How much the rate of change in technological innovation is dampend by technological progress measured as:

$$(\frac{\partial \mu_t^u(s)}{\partial g})/\mu_t^u(s) = \int_{\underline{s}}^{\overline{s}} \psi(s)dF(s), \tag{B15}$$

where $\psi(s) = [\frac{1}{(1+g)s} - \frac{\alpha^2\Psi\phi(s)/s}{1-(1-\alpha)(1+g)\phi(s)/s}]$. Let $(\frac{\partial \mu_t^u(G)}{\partial g})/\mu_t^u(G)$ and $(\frac{\partial \mu_t^u(H)}{\partial g})/\mu_t^u(H)$ denote the rate of financial innovation associated with G and H, respectively. Suppose G first-order stochastically dominates H. The inequality $\int_{\underline{s}}^{\overline{s}} \psi(s)dG(s) \geq \int_{\underline{s}}^{\overline{s}} \psi(s)dH(s)$ holds , for every non-decreasing function $\psi(s)$. To prove $(\frac{\partial \mu_t^u(G)}{\partial g})/\mu_t^u(G) \geq (\frac{\partial \mu_t^u(H)}{\partial g})/\mu_t^u(H)$, we must show that $\psi(s)$ is non-decreasing. This holds by

$$\psi'(s) = -\frac{1}{(1+g)s^2} + \frac{\alpha^2 \Psi(\frac{\phi(s)-\phi'(s)s}{s^2})[1+(1-\alpha)(1+g)\phi(s)/s]}{[1-(1-\alpha)(1+g)\phi(s)/s]^2} > 0 \text{ for } \underline{s} > 1 \quad \text{(B16)}$$

Suppose G second-order stochastically dominates H, we have $\int_{\underline{s}}^{\overline{s}} \psi(s)dG(s) \geq \int_{\underline{s}}^{\overline{s}} \psi(s)dH(s)$, for every concave function $\psi(s)$. Hence, to prove the result, we must show that $\psi(s)$ is concave. Taking the derivative of (B16) with respect to s

$$\begin{aligned}\psi''(s) &= \frac{2}{(1+g)s^3} - \frac{\alpha^2 \Psi(\frac{\phi''(s)s^2+2\phi(s)s-2\phi'(s)s^2}{s^4})[1+(1-\alpha)(1+g)\phi(s)/s]}{[1-(1-\alpha)(1+g)\phi(s)/s]^2} \\ &\quad - \frac{\alpha^2 \Psi(1-\alpha)(1+g)(\frac{\phi(s)-\phi'(s)s}{s^2})^2}{[1-(1-\alpha)(1+g)\phi(s)/s]^2} - \frac{2(1-\alpha)(1+g)\alpha^2 \Psi(\frac{\phi(s)-\phi'(s)s}{s^2})^2[1+(1-\alpha)(1+g)\phi(s)/s]}{[1-(1-\alpha)(1+g)\phi(s)/s]^3}\end{aligned}$$

is negative for $\underline{s} > 1$. ■

Appendix B: Data Appendix

- The "Weighted Mean" and "Weighted Standard Deviation" of Firm Size Distribution :

  Following Ace, Morck and Yeung (1999) and Pagano and Schivardi (2003), we construct a measure of average firm size that is employment-weighted. Let $EMPL_i$ denote employment in industry i, $FIRM_{ij}$ the number of firms in size class j in industry i, $SHARE_{ij}$ the employment share of firm size class j in industry i and $MEAN_{ij} = EMPL_{ij}/FIRM_{ij}$ the average firm size of class j in industry i. We have five firm size classes based on the number of employees : 1-9, 10-19, 20-49, 50-249, and 250 or more. The "weighted average" firm size:

$$MEAN_i = \sum_{j=1}^{5} SHARE_{ij} MEAN_{ij};$$

and the "weighted standard deviation" is our measure of dispersion

$$WSD_i = \sqrt{\sum_{j=1}^{5} SHARE_{ij}(MEAN_{ij} - MEAN_i)^2}.$$

- External Dependence of Industries:

  Following Rajan and Zingales (1998), we construct external dependence indexes over the sample period by using COMPUSTAT data We calculate a firm's dependence on external finance as capital expenditure(COMPUSTAT #128) minus cash flow from operations divided by capital expenditures. Cash flow from operation is defined as the sum of COMPUSTAT # 123,125,126,106, 213, 217.

- US Net Sale Growth :

  We define US Net Sale Growth as growth in real sales, industry-level median of firm average growth rates over the sample period for US firms, from COMPUSTAT.

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Table 1 : Summary Statistics of Key variables

Variable	Mean	Median	Std Dev	Minimum	Maximum
Panel A. Country-industry variables					
2002-6 VAD growth	0.068991375	0.050618101	0.115818659	-0.281271337	1.465101982
Weighted Mean (MEAN)	398.5495621	279.9864024	394.9448649	3.47872487	2954.124984
Weighted Std. Dev. (WSD)	281.7586248	255.234024	174.0716796	8.499276221	1449.33824
External financial dependence	3.589091	3.83	1.90048	-3.22	7.41
US Sales Growth	0.144839857	0.137641	0.057101764	0.068386	0.30622
Panel B. Country variables					
Financial Development(F)	0.7410485	0.7476215	0.4249816	0.1436764	1.42713
Financial Innovation (f)	0.0856881	0.0502789	0.0891554	-0.0183658	0.3130189

Table 2 : Country-Level Means of Weighted Mean and Standard Deviation
of the 2002 FSD and of 2002-6 Growth in Real VAD per worker

Country	2002-6 VAD growth	Weighted Mean	Weighted StdDev	smallfirm50	obs.
Austria	0.051537186	291.4628287	197.4113205	0.293783776	16
Bulgaria	0.171360669	368.4871574	261.2338353	0.257747356	9
Czech Republic	0.089412286	397.4074565	292.3218232	0.280357938	18
Denmark	0.035448141	339.8385726	258.3299996	0.245034252	11
Estonia	0.073319716	111.1078854	111.1803994	0.32494123	4
Finland	0.063780775	596.2501458	352.6181715	0.209115375	15
France	0.025609883	551.8200484	349.5491354	0.292677085	20
Germany	0.059074239	599.5055448	346.8209698	0.241476295	17
Hungary	0.115964028	393.4614229	266.1425121	0.349308328	18
Ireland	0.069045508	315.9799845	221.1500918	0.186383061	5
Italy	0.028587683	273.8643678	277.7367664	0.518321947	20
Latvia	0.096054477	378.8162335	255.211165	0.317522083	17
Lithuania	0.137745798	391.0813436	295.8125892	0.302739353	11
Netherlands	0.049133134	254.2077646	209.040553	0.358914805	15
Norway	0.05518346	465.6165461	345.1370866	0.232664108	10
Poland	0.040648589	318.2248625	262.8123308	0.328680481	16
Portugal	0.043398982	189.9743068	191.8036212	0.510008396	13
Romania	0.14730419	564.0705991	291.0577872	0.719806949	17
Slovakia	0.14730419	564.0705991	291.0577872	0.14670368	14
Slovenia	0.08348667	315.7771466	257.1184408	0.285416409	15
Spain	0.03699777	244.8727584	259.724242	0.469369378	17
Sweden	0.125500431	691.364555	432.4117474	0.272040366	15
United Kingdom	0.028373682	328.4465705	283.0419186	0.32869925	20

Table 3 : Sector-Level Means of Weighted Mean and Standard Deviation of the 2002 FSD and of 2002-6 Growth in Real VAD per worker

Industry	NACE	2002-6 VAD growth	Weighted Mean	Weighted StdDev	smallfirm50	obs.
food	15	0.05860082	205.8007592	220.1181723	0.366080493	2
textiles	17	0.043564151	263.408099	220.4646718	0.275750826	17
wearing	18	0.04018688	206.4293915	220.4287786	0.409022833	17
leather	19	-0.002094429	152.4229745	165.5362423	0.425042918	5
wood	20	0.067379098	140.6819005	182.5019943	0.544564804	20
paper	21	-0.00362105	411.064303	260.0850785	0.187732545	18
publishing	22	0.034438847	202.6645984	245.9425608	0.480011649	19
chemicals	24	0.076132967	568.0012369	335.4564352	0.12140336	20
rubber	25	0.042890002	241.7260353	230.9934434	0.324110454	20
non-metallic	26	0.069372566	278.9831513	253.7335406	0.295045168	21
basic metal	27	0.182852029	800.7744543	394.0109486	0.102787065	18
fabricated metal	28	0.056828111	116.2688184	152.8982487	0.513069854	19
machinery	29	0.069993512	308.583409	277.7530009	0.277264357	23
office_computer	30	0.10852243	559.6262749	327.5792697	0.36988909	11
electrical	31	0.083533924	520.0351312	357.6164544	0.20183207	22
communication	32	0.202366903	717.7610153	383.5688593	0.165325881	15
precision	33	0.046873071	358.8122215	305.9436567	0.370940441	17
motor	34	0.079890825	942.3082907	428.3928856	0.11807744	12
other transport	35	0.046077807	800.6022621	477.7929766	0.156283134	14
furniture	36	0.033374801	298.9782241	299.9839137	0.43842615	12
recycling	37	0.132590499	65.88507066	82.37117063	0.628650564	11

Table 4: Regression results for the regression framework (25)

Dependent Variable Is Average Growth Rate Of Real Value Added Per Worker Over 2002 To 6								
	(1)OLS		(2)OLS		(3)OLS		(4)IV	
MEAN	0.090295	(2.54)**	0.06457	(2.53)**	0.125498	(3.25)***	0.172663	(2.91)***
SD	-0.10523	(-2.46)**	-0.07092	(-2.35)**	-0.13811	(-3.19)***	-0.22043	(-3.19)***
MEAN x F					-0.0888	(-2.28)**	-0.15726	(-2.14)**
SD x F					0.100122	(2.1)**	0.224302	(2.64)***
MEAN x f								
SD x f								
MEAN x F x f								
SD x F x f								
log of investment	-0.00113	(-0.09)	0.011489	(0.67)	0.01351	(0.83)	0.0176	(1.13)
log of payroll	0.000502	(0.03)	0.002658	(0.14)	0.000821	(0.04)	-0.00617	(-0.34)
log of VAD 2002	-0.01363	(-1.13)	-0.21469	(-2.57)**	-0.21708	(-2.56)**	-0.21327	(-2.55)**
constant	0.080848	(0.96)	-0.67608	(-1.88)*	-0.71331	(-2.05)	-0.77908	(-2.2)
1st-stage F test: L x MEAN							0	
1st-stage F test: R x MEAN							0	
1st-stage F test: L x WSD							0	
1st-stage F test: R x WSD							0	
country,industry dummy	NO		YES		YES		YES	
R Square	0.128		0.4862		0.4965		0.5004	
Num of Obs	336		336		336		336	
	(5)IV		(6)IV		(7)IV		(8)IV	
MEAN	0.039776	(1.02)	0.146206	(2.1)**	0.157205	(2.27)**	0.159165	(2.29)**
SD	-0.10452	(-2.03)**	-0.23706	(-2.64)***	-0.24987	(-2.78)***	-0.25314	(-2.81)***
MEAN x F								
SD x F								
MEAN x f	0.705659	(2.04)**	1.340531	(3.51)***	1.361703	(3.52)***	1.298196	(3.17)***
SD x f	-0.2756	(-0.97)	-0.52428	(-1.83)*	-0.49942	(-1.66)*	-0.44184	(-1.4)
MEAN x F x f			-2.40121	(-2.36)**	-2.42983	(-2.5)**	-2.42054	(-2.48)**
SD x F x f			2.22523	(2.33)**	2.193823	(2.44)**	2.193497	(2.43)**
FIN DEP x F x f					1.560761	(1.96)*	1.631145	(2.14)**
US SALES x F							-0.39319	(-1.24)
log of investment	0.0159	(0.88)	0.026952	(1.39)	0.024635	(1.3)	0.016643	(0.8)
log of payroll	0.005121	(0.24)	-0.02448	(-1.03)	-0.02955	(-1.2)	-0.01928	(-0.72)
log of VAD 2002	-0.23124	(-2.49)**	-0.15453	(-3.08)***	-0.16275	(-3.33)***	-0.16102	(-3.27)***
constant	-0.52426	(-1.36)	0.0629	(0.34)	0.126093	(0.69)	0.14298	(0.79)
1st-stage F test: L x MEAN	0		0		0		0	
1st-stage F test: R x MEAN	0		0		0		0	
1st-stage F test: L x WSD	0		0		0		0	
1st-stage F test: R x WSD	0		0		0		0	
country,industry dummy	YES		YES		YES		YES	
R Square	0.5465		0.6258		0.6452		0.6476	
Num of Obs	304		304		304		304	

NOTE : t-statistics are in parentheses. We do not report heteroskedasticity-robust standard errors.
* Singificance at the 10% level. ** Idem., 5%. ***Idem., 1%.
The p-value of F-test of joint significant is reported in the fist-stage regression,
FIN DEP is a measure of the industry's dependence of external dependence, based on the U.S. data.
US SALES is an industrt measure of sales growth over the sample period, based on the U.S. data.

Table 5: IV Regression Results : using other proxies for financial development/innovation

Dependent Variable Is Average Growth Rate Of Real Value Added Per Worker Over 2002 To 6								
	(1)credit+stock		(2)credit+stock		(3)credit+stock		(4)credit+stock	
MEAN	0.112326	(2.39)**	0.033026	(2.39)**	0.102537	(1.99)*	0.111303	(2.18)**
SD	-0.1566	(-2.85)**	-0.09034	(-2.85)***	-0.18957	(-2.71)***	-0.20004	(-2.89)***
MEAN x F	-0.03885	(-1.07)						
SD x F	0.075103	(1.92)*						
MEAN x f			0.647529	(2.04)*	1.342025	(3.76)***	1.305464	(3.5)***
SD x f			-0.2473	(-0.97)	-0.56184	(-2.16)**	-0.49211	(-1.76)*
MEAN x F x f					-1.50285	(-2.53)**	-1.48049	(-2.68)***
SD x F x f					1.388836	(2.55)**	1.326135	(2.67)**
FIN DEP x F x f							2.153736	(2.33)**
US SALES x F							-0.13829	(-0.9)
log of investment	0.015144	(0.92)	0.016614	(0.93)	0.029042	(1.41)	0.024241	(1.13)
log of payroll	-0.00451	(-0.26)	0.007104	(0.34)	-0.01156	(-0.48)	-0.0112	(-0.43)
log of VAD 2002	-0.21397	(-2.59)**	-0.22174	(-2.38)**	-0.13579	(-3.04)***	-0.14541	(-3.32)***
constant	-0.66283	(-1.91)*	-0.6046	(-1.59)*	-0.15516	(-0.86)	-0.11729	(-0.68)
1st-stage F test: L	0		0		0		0	
1st-stage F test: R	0		0		0		0	
country,industry dummy	YES		YES		YES		YES	
R Square	0.4988		0.5465		0.5001		0.658	
Num of Obs	336		304		340		304	
	(5)liquid liabilities		(6)liquid liabilities		(7)liquid liabilities		(8)liquid liabilities	
MEAN	0.275634	(2.83)***	-0.0086	(-0.14)	0.162688	(1.21)	0.176535	(1.3)
SD	-0.31938	(-2.92)***	-0.15135	(-2.34)**	-0.36247	(-2.23)**	-0.37375	(-2.29)**
MEAN x F	-0.34811	(-2.6)***						
SD x F	0.416375	(2.71)***						
MEAN x f			4.228411	(2.04)**	4.841676	(2.43)**	4.772389	(2.25)**
SD x f			-1.246	(-0.97)	-0.90667	(-0.67)	-0.6874	(-0.48)
MEAN x F x f					-7.50245	(-2.01)**	-7.88046	(-2.05)**
SD x F x f					7.321606	(1.85)*	7.378172	(1.86)*
FIN DEP x F x f							3.16678	(2.03)**
US SALES x F							-0.70852	(-1.28)
log of investment	0.017972	(1.14)	0.017482	(0.97)	0.020192	(1.09)	0.012913	(0.63)
log of payroll	-0.00194	(-0.11)	0.008269	(0.4)	-0.00255	(-0.09)	-0.00209	(-0.07)
log of VAD 2002	-0.21174	(-2.61)***	-0.21127	(-2.26)**	-0.17104	(-2.11)**	-0.16949	(-2.17)**
constant	-0.77944	(-2.37)**	-0.06919	(-0.15)	0.339531	(0.88)	0.486335	(1.33)
1st-stage F test: L	0		0		0		0	
1st-stage F test: R	0		0		0		0	
country,industry dummy	YES		YES		YES		YES	
R Square	0.5047		0.5465		0.5859		0.6018	
Num of Obs	336		304		304		304	

NOTE : t-statistics are in parentheses. We do not report heteroskedasticity-robust standard errors.
* Singificance at the 10% level. ** Idem., 5%. ***Idem., 1%.
The p-value of F-test of joint significant is reported in the fist-stage regression,
Column 1 to 4 reports the result when the sum of stock market capitalization and private credit is used.
Column 5 to 8 reports the result when liquid liabilities are used.
FIN DEP is a measure of the industry's dependence of external dependence, based on the U.S. data.
US SALES is an industrt measure of sales growth over the sample period, based on the U.S. data.

Table 6: OLS Regression Results : using dummies for financial development/innovation

Dependent Variable Is Average Growth Rate Of Real Value Added Per Worker Over 2002 To 6										
	(1)		(2)		(3)		(4)credit+stock		(5)credit+stock	
MEAN	0.09906	(3.33)***	0.043119	(3.4)***	0.044739	(1.48)	0.107632	(3.21)***	0.036913	(1.45)
SD	-0.107891	(-3.3)***	-0.052377	(-3.45)***	-0.055111	(-1.39)	-0.120296	(-3.13)***	-0.042897	(-1.34)
MEAN x F	-0.077033	(-2.3)**					-0.080035	(-2.27)**		
SD x F	0.087279	(2.03)**					0.09419	(2.18)**		
MEAN x f			0.044293	(1.3)	0.071915	(1.78)*			0.061979	(1.73)*
SD x f			-0.040645	(-0.98)	-0.072344	(-1.59)			-0.063809	(-1.45)
MEAN x F x f					-0.140464	(-3.34)***				
SD x F x f					0.177154	(3.52)***				
log of investment	0.010311	(0.68)	0.008246	(0.53)	0.011024	(0.73)	0.009681	(0.62)	0.00969	(0.62)
log of payroll	0.004633	(0.23)	0.007595	(0.39)	0.004133	(0.21)	0.005085	(0.26)	0.006691	(0.34)
log of VAD 2002	-0.207617	(-2.62)***	-0.206655	(-2.66)***	-0.207397	(-2.66)***	-0.205556	(-2.62)***	-0.208025	(-2.66)***
constant	-0.705717	(-2.22)**	-0.655725	(-2.06)**	-0.657648	(-2.06)**	-0.699505	(-2.11)**	-0.679382	(-2.05)**
country,industry dummy	YES		YES		YES		YES		YES	
R Square	0.4954		0.4887		0.4998		0.4961		0.492	
Num of Obs	340		340		340		340		340	

	(6)credit+stock		(7)liquid liabilities		(8)liquid liabilities		(9)liquid liabilities	
MEAN	0.03598	(1.39)	0.105936	(2.83)***	0.052851	(1.96)*	0.053304	(2.04)**
SD	-0.042684	(-1.32)	-0.11138	(-2.71)***	-0.060418	(-2.05)**	-0.064151	(-2.25)**
MEAN x F			-0.090875	(-2.55)**				
SD x F			0.087751	(2.3)**				
MEAN x f	0.084317	(2.07)**			0.023211	(0.67)	0.061686	(1.36)
SD x f	-0.090045	(-1.92)*			-0.021063	(-0.52)	-0.061531	(-1.22)
MEAN x F x f	-0.160106	(-3.46)***					-0.139871	(-2.7)***
SD x F x f	0.231154	(3.67)***					0.170815	(2.75)***
log of investment	0.00968	(0.61)	0.012912	(0.79)	0.00967	(0.59)	0.012822	(0.8)
log of payroll	0.006917	(0.35)	0.004192	(0.22)	0.004406	(0.23)	0.002602	(0.14)
log of VAD 2002	-0.209027	(-2.67)***	-0.205296	(-2.72)***	-0.201214	(-2.65)***	-0.199163	(-2.69)***
constant	-0.695482	(-2.09)**	-0.666007	(-2.08)**	-0.631865	(-1.88)*	-0.630363	(-1.89)*
country,industry dummy	YES		YES		YES		YES	
R Square	0.5025		0.5047		0.4853		0.4987	
Num of Obs	340		340		340		340	

NOTE : t-statistics are in parentheses. We do not report heteroskedasticity-robust standard errors.
* Singificance at the 10% level. ** Idem., 5%. ***Idem., 1%.
The p-value of F-test of joint significant is reported in the fist-stage regression,
Column 4 to 6 reports the result when the sum of stock market capitalization and private credit is used.
Column 7 to 9 reports the result when liquid liabilities are used.