ESSAYS IN FINANCIAL DEVELOPMENT, INNOVATION, AND ECONOMIC GROWTH

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ESSAYS IN FINANCIAL DEVELOPMENT, INNOVATION, AND ECONOMIC GROWTH

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Abstract:

My dissertation comprises two chapters. The first chapter uses country-level data and examines the diminishing effect of financial development on innovation, and how "too much finance" affects economic growth through this diminishing effect. The second chapter uses industry-level data aggregated from firm-level data to examine the nonlinear effect of financial development on innovation as well as explores the channels.

The first chapter explores the nonlinear effect of financial development on innovation and growth. We show that the expansion of the financial sector may hurt innovative activities and hence the innovation-led growth, using data on 50 countries over the 1990-2016 period. Countries with a higher level of financial development are found to have a smaller positive or insignificant effect on innovation. The marginal effect of innovation on growth is a decreasing function of financial development. Using a novel dynamic panel threshold method we examine the possible non-linearity between finance, innovation, and growth. We find that innovation exhibits an insignificant effect on output growth when credit to the private sector exceeds the level of 60% as a share of GDP. These results are not driven by banking crises, the long-run effect of the 2007-2008 financial crisis, or the ongoing European sovereign debt crisis.

The second chapter studies the nonlinear effect of financial development on innovation as well as the potential channels, primarily using a unique database constructed from the Worldscope Fundamentals Annual from 1980 to 2017. Our results can be summarized as follows. 1) Using a broad index of financial development, we find that the overall effect on innovation is a diminishing one, and the patterns are robust under different robustness checks. 2) We also have documented that, using traditional one-dimension indicators of financial development for both equity and credit markets, equity markets have a kick-in effect on innovation, while the diminishing effects still hold for credit markets. 3) We find industry-specific effects. In particular, the equity market development has a diminishing effect on innovations in high-technology industries, while credit market development has a diminishing effect on innovations in non-high-technology industries. 4) We show that the nonlinear effect of financial development on market competition serves as a potential channel through which finance affects innovation nonlinearly. 5) Our last finding is that the effect is heterogeneous across different stages of development.

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CHAPTER I

FINANCIAL DEVELOPMENT AND INNOVATION-LED GROWTH: IS TOO MUCH FINANCE BETTER?

1. Introduction

The basic Schumpeterian model of economic growth considers technological progress as an important factor for long-run growth ([Schumpeter, 1934]). The positive role of innovation on growth has been discussed and tested by a number of subsequent works ([Scherer et al., 1986], [Freeman et al., 1994]). Among determinants of innovation, R&D expenditure, talents, technology transfer and networking have been identified as important factors that shape and promote innovation and hence the innovation-led growth ([Love and Roper, 1999], [Acemoglu et al., 2016]). Recent years have seen an expansion in financial sector around the world with several implications on innovation and growth. First, financial development may facilitate innovation activities by alleviating credit constraints on the flow of capital to its most productive projects and hence promote R&D financing and growth (e.g. [King and Levine, 1993a, King and Levine, 1993b], [Benfratello et al., 2008], [Brown et al., 2009], [Amore et al., 2013], [Gorodnichenko, 2013], [Hsu et al., 2014] and [Levine et al., 2017]). Second, the expansion of financial sector has raised the concern of "brain drain" between industries ([Boustanifar et al., 2017]). Third, credit expansion shows its dark side on resource allocation, both on physical and human capital ([Tobin, 1984], [Cecchetti and Kharroubi, 2015] and [Borio et al., 2016]).

The main outline of this chapter is the result of joint work with Stylianos Asimakopoulos and Jaebeom Kim.

Collectively, these competing theories and evidences lead to the following questions: What is the overall effect of financial development on innovation? Will the monotonic relationship between finance and innovation hold as financial sector continues to expand? How does financial development affect innovation-led growth?

This paper attempts to answer these questions empirically. Previous studies on the finance-innovation-growth nexus support the existence of a positive monotonic relationship. However, we explore whether there exists a non-monotonic relationship with a possible threshold effect. Specifically, our study is conducted in two parts. First, we examine the nonlinear relationship between financial development and innovation. Second, we study the role of financial development on the innovation-growth relationship. To this end, we use two different methods to explore the possible nonlinearities. Initially we qualitatively split the sample into different subgroups by the level of financial development and income and apply a system-GMM to estimate the effect of financial development on innovation for each group. The system-GMM methodology allows us to use the lagged value of dependent and independent variables to account for potential endogeneity issues. However, this method may not give precise estimation on the threshold value at which the effect changes, if any. For this reason, we also employ a novel GMM model developed by [Seo and Shin, 2016]. This model extends the [Hansen, 1999] and [Caner and Hansen, 2004] static panel threshold model and the [Kremer et al., 2013] dynamic panel threshold model by allowing for the transitional variable and other covariates to be endogenous. The [Seo and Shin, 2016]'s method requires the use of balanced panel with large n and small T. We curtail the data to fit the model using five years non-overlapping average data, which is also consistent with the related growth literature (see for example [Asimakopoulos and Karavias, 2016] and references therein). To guarantee that our data contains roughly equal proportion of developing and developed countries, we consider only the financial development in credit market. Thus, we end up with a balanced panel of 50 countries from 1990 to 2016, including 22 developing and 28 developed countries.

Our results can be summarized as follows. First, we find that the overall effect of financial development on innovation is positive. However, this effect is lower when financial development exceeds a certain level. Second, the overall effect of innovation on growth is positive and heterogeneous across the various levels of financial development. Third, the dynamic panel threshold method shows the existence of non-linear relationship between innovation and growth with a threshold value around 60% of GDP. Our threshold value reflects the difference between the threshold model used in our paper, dealing with monotonicity and endogeneity simultaneously compared to previous studies, as well as the impact of global financial integration. Financial integration may enhance the positive effect of financial development on innovation and growth leading to a smaller threshold value of financial development.

Credit expansion may lead to banking crisis or economic crisis and the innovation activities may be dampened during the crisis ([Döner, 2017], [OECD, 2012], [Comin and Gertler, 2006] and [Francois and Lloyd-Ellis, 2008]). Therefore, the observed vanishing effect may be caused by banking crisis. To check whether the threshold effects are affected by crisis, we interact the crisis dummy with the variable of interest and estimate the difference in the effect between crisis and tranquil period. Our findings indicate an insignificant negative effect on the interaction term.

The 2007-2008 financial crisis may have a long run negative effect on innovation. In our sample, 39.2% of the high income countries' innovation never recover to their pre-crisis level and 22.7% of middle income countries' innovation sink after the financial crisis. The subsequent European sovereign debt crisis continually depresses the innovative activities for many countries in Euro Zone (EZ) and probably countries outside the EZ since 2010. We find that 67.86% of high income countries experienced a reduction in innovation after 2010 and 50% of middle income countries have seen a sluggish recovery in innovation. The situation does not get ameliorated even for countries with high quality of governance. During the same period, however, we find that the level of credit is higher in high income countries and in countries with high governance quality. The documented non-linearity using full sample may be contaminated by the ongoing European sovereign debt crisis and the long run negative effect of the recent financial crisis. Using a sub-sample from 1990 to 2009, we find a robust non-linearity between finance, innovation, and growth.

Our paper relates and contributes to several strands of theory relating growth, innovation and financial-market development. Our findings provide consistent results with several theoretical predictions and recent empirical studies. Regarding the finance-innovation nexus, [Tobin, 1984] mentioned that too many financial activities may misallocate resources, both physical and human capital, from production sector to less productive financial sector. [Cecchetti and Kharroubi, 2015] and [Borio et al., 2016] elaborate this idea by showing that less productive but more pledgeable projects are easily financed during financial sector expansions. When credit inflates, workers, especially the talented STEM workers, are lured into low productivity gains sectors due to high finance compensation ([Axelson and Bond, 2015], [Boustanifar et al., 2017] and [Célérier and Vallée, 2017]). Both channels hurt real sector by reducing the innovation capacity. [Weinstein and Yafeh, 1998], using firm level data, show that close firm-bank ties may facilitate firms to access credit, but it may also prevent firms from involving risky and high return projects such as R&D activities. [Morales, 2003] introduces financial sector in an endogenous growth model and shows that financial activity may have two opposite external effects on research productivity. On one hand, the positive effect of financial activity will spill over to other sectors of the economy and promote productivity. On the other hand, this positive externality would induce creative destruction process and discourage the incentives to invest in R&D. Inspired by the work of [Klette and Kortum, 2004] and [Akcigit and Kerr, 2018], where different types of innovations are introduced in a growth model, [Philippe et al., 2018] argue that the introduction of financial development into these models may result in two competing effects. First, potentially good innovators may face less financing constraints to enter the market due to the development of financial market, which in turn is beneficial to aggregate innovation and growth. Second, less credit constraints may make it easier for less efficient firms to remain in the market and prevent more efficient innovators from entering the market. This in turn may be harmful to aggregate innovation and growth. As financial sector continues to expand in modern economy and credit constraints are alleviated for many firms, it is uncertain whether the overall effect of financial development on innovation is monotonic or not.

In terms of the finance-growth relationship, our results are consistent with several recent empirical papers showing that "too much finance" may hurt economic growth. Using country- and industry-level panel data, [Arcand et al., 2015] test the non-linearity between private credit and growth by including both the private credit and its square term into the growth equation, deriving a threshold point of around 100% of GDP. Private credit tends to promote growth in the lower regime, while the effect turns negative in the upper regime. In a similar fashion, [Cecchetti and Kharroubi, 2012] estimate the threshold to be nearly 100% of GDP. The baseline models used in these two studies, however, may suffer from endogeneity and multicollinearity issues (see [Law and Singh, 2014] for discussions). In an attempt to control for these issues, [Law and Singh, 2014] use a panel threshold model proposed by [Kremer et al., 2013] to re-estimate the possible threshold effect of private credit on growth and they obtain a threshold of around 88% of GDP. Using both a dynamic panel threshold approach and an autoregressive distributed lag ARDL(p,q) model, [Samargandi et al., 2015] establish the non-monotonic effect of financial development and growth among middle income countries, suggesting a turning point around 91% of GDP. However, most of these studies do not explicitly or directly explore the sources of non-linearity between financial development and growth.

The above discussions may generate two implications. First, financial development may have a diminishing effect on the rate of innovation, such effect transmits to productivity and slows down aggregate growth. Second, financial development may also make innovations per se less effective in promoting growth. For an innovation to be effective in promoting productivity and aggregate growth, necessary complementary inventions and follow-up investment in productive capital is required. However, as credit market expands, banks may also prevent firms from involving risky projects such as R&D activities, causing less productive but more pledgeable projects to be easily financed. The relatively less investment of productive capital may prolong the implementation and restructuring lags and reduce the contribution of innovation on productivity and economic growth.

Most related to our work are studies by [Law et al., 2018] and [Xiao and Zhao, 2012]. [Law et al., 2018] document an inverted U-shaped relationship between financial development and innovation using a panel of 75 countries over 1996-2010. Their analysis is embodied in the context of institution quality where the effect of finance on innovation depends upon the quality of institutions. Our study does not consider the context of institution quality because there is high overlapping between countries with high quality of governance, high income countries and countries with high level of financial development. [Xiao and Zhao, 2012] find that credit market development significantly enhances firm innovation in countries with lower government ownership of banks, while the effect turns to insignificant or even negative when government ownership increases.

Our study contributes to the related literature in three ways. First, we provide direct evidences that finance-innovation-growth nexus follows a non-linear relationship as credit expands. The findings show that the threshold effect between finance and innovation serves as a possible channel through which too much finance may harm growth. Second, we also find that the effect of innovation on growth is weakened by too much finance. Finally, this empirical work is conducted using a novel GMM method developed by [Seo and Shin, 2016]. This model extends the [Hansen, 1999] and [Caner and Hansen, 2004] static panel threshold model and the [Kremer et al., 2013] panel threshold model by allowing for the transitional variable and other covariates to be endogenous. Therefore, this new dynamic panel threshold model accounts for the endogeneity issue that is ignored by previous studies.

The rest of this paper is organized as follows. Section 2 specifies the empirical models and describes the data. Section 3 presents and discusses the results. Section 4 concludes.

2. Empirical Specifications and Data

2.1. Empirical strategies

The empirical analysis consists of two parts. First, we examine the non-linear relationship between financial development and innovation. Second, we estimate how financial development affect the innovation-growth relationship. To this end, we employ two different methods: linear system GMM and a dynamic panel threshold.

2.1.1. Linear system-GMM

In the linear system-GMM method, we qualitatively split the sample into two groups by the level of financial development. We initially sort the countries by their level of financial development. Then we define the top 25 countries as high financial development countries and the bottom 25 countries as the low financial development countries. This strategy may not give a precise estimation of the threshold level of financial development, but it enables us to build an intuition about the possible nonlinearity between finance, innovation and growth. In our sample, high income countries are typically associated with high level of financial development. As a robustness check, we also split the sample into two groups by their level of GDP per capita: high income countries and middle incomes[1]. For each of the five groups, we consider the following specification for the innovation equation:

$$innovation_{it} = \rho innovation_{it-1} + \alpha_j FD_{it} + \beta \mathbf{X}_{it} + u_i + v_t + e_{it} \qquad (1)$$

where $innovation_{it}$ and $innovation_{it-1}$ are the current and lagged indicator of innovation. $\mathbf{X}_{it}$ denotes the control set including FDI, schooling, population, GDP per capita, and the protection for intellectual property right. FD_{it} denotes the financial development indicators. u_i is the country fixed effect that absorbs the effect of country level variation, v_t captures the time fixed effect, which controls for possible cross-sectional dependences. e_{it} captures the stochastic error term. j is an indicator of high and low level of financial development or high and middle income countries. System-GMM use the lagged dependent variable and regressors to instrument for possible endogeneity issues. In our setting, there are two possible causes of endogeneity: the omitted variable issue and reverse causality between financial development and

[1]In our sample, there are no low income countries due to the unavailability of data in indicators of financial development, innovation indicators, and other variables

innovation. First, if $innovation_{it-1}$ is correlated with e_{it}, then in the first-difference transformed equation, $\Delta innovation_{it-1}$ would correlate with Δe_{it}. Second, technology change relating to communication and data processing have greatly promoted the development of financial services ([Frame et al., 2014]). As instruments we lag our variables twice for the difference equation and once for the level equation. All the variables used are five years non-overlapping average data.

Next, we consider how financial development affect the innovation-led growth. In a similar spirit, we split the sample by the level of financial development and GDP per capita. Specifically, we consider the effect of innovation on growth for the high level financial development countries, low level financial development countries, high income countries and middle income countries. For each group we consider the following growth regression:

$$y_{it} = \rho y_{it-1} + \alpha innovation_{it} + \gamma \mathbf{Z}_{it} + u_i + \tau_t + e_{it} \tag{2}$$

where y_{it} and y_{it-1} represent current and lagged growth rate of GDP per capita, respectively. $innovation_{it}$ is the same as in the innovation regression. $\mathbf{Z}_{it}$ is the control set including government expenditure (%GDP), trade (%GDP), investment (%GDP), inflation rate (%), Schooling and initial GDP per capita. u_i, τ_t and e_{it} refer to country fixed effects, time fixed effects, and stochastic error term, respectively. Notice that our specification is different from conventional regression specified in growth literatures, where y_{it} usually refers to GDP per capita. In our sample, GDP per capita is quite persistent and the Harris-Tzavalis test([Harris and Tzavalis, 1999]) shows that GDP per capita is not stationary[2]. Using growth rate of per capita GDP instead of the level does not change our interpretation of the coefficient on variables of interest (see also [Asimakopoulos and Karavias, 2016]).

[2]We use H-T test because our sample contains relatively larger panel and smaller time period, Harris-Tzavalis test best fit sample structure like this.

As a robustness check, we also consider the interaction between financial development and innovation. The specification is as follow:

$$y_{it} = \rho y_{it-1} + \alpha innovation_{it} + \beta FD_{it} * innovation_{it} + \gamma \mathbf{Z}_{it} + u_i + \tau_t + e_{it} \tag{3}$$

The marginal effect of innovation on growth is $\hat{\alpha} + \hat{\beta} * FD_{it}$. According to the theoretical prediction, higher level of financial development reduces productivity via brain drain or misallocation in physical capital and the effect of innovation on growth is lower in countries with higher level of financial development. Therefore, if there exists any "diminishing effect" for the innovation-growth nexus due to financial development, α is expected to be greater than zero, while β is expected to be negative.

2.1.2. Dynamic panel threshold model with endogenous threshold variable

Although the linear system-GMM method helps us to build an intuition about the non-linearity, it gives neither a rigorous test on the linearity nor the estimated threshold value at which the effect begins to change. For this reason, we examine the above two questions using a novel GMM method developed by [Seo and Shin, 2016]. This model extends the [Hansen, 1999] and [Caner and Hansen, 2004] static panel threshold model and the [Kremer et al., 2013] panel threshold model by allowing for the transitional variable and other covariates to be endogenous. To estimate the coefficients, they propose a First Difference GMM (FD-GMM) transformation. This algorithm relaxes the exogeneity assumption on regressors and threshold variable and guarantee that the estimators follow a normal distribution asymptotically, which validates the use of Wald test for standard statistical inference on threshold and other parameters. For the innovation equation, we extend equation (1) to:

$$innovation_{it} = \rho innovation_{it-1} + \alpha_L FD_{it} I(FD_{it} \leq \gamma) + \alpha_H FD_{it} I(FD_{it} > \gamma) + \beta \mathbf{X}_{it} + u_i + \tau_t + e_{it} \quad (4)$$

Note that, the financial development is treated as regime dependent variable as well as transitional variable. $I(\cdot)$ is an indicator of the regime. γ is a hypothetical threshold value. The subscripts L and H on α refer to lower and upper regime, respectively. The instrument variables include the exogenous variables, the lagged dependent variable and other covariates.

In a similar spirit we estimate our growth equation using a dynamic panel threshold model. In particular, we treat financial development as the threshold variable, while innovation is the regime dependent variable changing according to the estimated threshold of financial development. The notation used here is similar to the innovation equation (1). Therefore, the growth model presented in equation (2) becomes:

$$y_{it} = \rho y_{it-1} + \beta_L innovation_{it} * I(FD_{it} \leq \gamma) + \beta_H innovation_{it} * I(FD_{it} > \gamma) + \theta \mathbf{Z}_{it} + u_i + \tau_t + e_{it} \quad (5)$$

For equations (4) and (5), we use the non-linearity test $supW = supW_n(\gamma)$ statistics upon the null of $\alpha_L - \alpha_H = 0$ and $\beta_L - \beta_H = 0$, where $W_n(\gamma)$ is the standard Wald statistic for each fixed γ.

2.2. Data and summary statistics

A complete picture of financial development includes the development in both credit and equity markets. Due to the limitation of stock market data in developing countries plus the fact that firms financing in developing countries is mainly through internal retained profits and external credit market, we constraint our study to credit markets. The private credit by banks and other financial institutions as a share of GDP is preferred in finance-growth literature ([Levine et al., 2000a]). As robustness checks, we also consider credit issued to private sector by money deposite banks (%GDP), demostic credit to private sector (%GDP) and liquidity liability (%GDP). All the indicators are obtained from World Bank Financial Structure Database.[3] The banking crisis data is obtained from [Laeven and Valencia, 2013] Systemic Banking Crises Database (1970-2011). Inspired by [Baker et al., 2016], the data of banking crisis are extended to 2016 by searching for keywords that indicate a banking crisis for each country between 2012 and 2016. The keywords used include bank run, bank crisis and illiquidity.[4]

The innovation is measured by patent applications per 100 billion USD obtained from World Intellectual Property.[5] This indicator is measured as total equivalent counts by applicant's origin. We use patent application as an indicator of innovation to account for the truncation issue, since there are typically two to three years grant lags between application and grant year. For example, the mean years of grant lags for USPTO fluctuates between 26 months and 32 months and the distribution of grant lags varies across fields of inventions ([Squicciarini et al., 2013]). Another reason is that the application year better captures the actual effective time of innovation ([Griliches et al., 1986]) and an invention starts to affect the real economy since its inception ([Hsu et al., 2014]). We have the following considerations when constructing this variable. First, the selection of countries and period of time is based on the availability of annual observations on patent applications. Second, countries with

[3]In our sample, New Zealand missed the indicators of financial development between 2012 and 2016 . To fill the gaps, we use data for Broad Money, Private sector credit, Domestic credit, Exchange rate between New Zealand Dollar and US Dollar, and Gross Domestic Product from Reserve Bank of New Zealand(https://www.rbnz.govt.nz/statistics) to construct the missing indicators in World Bank Financial Structure Database. In New Zealand, the private credit by deposit banks and Private credit by banks and other financial institution are identical.

[4]Using this method, we detected several banking crisis for the following countries: China in 2014; Greece in 2015; Portugal in 2014; Spain between 2012 and 2014

[5]We also consider using patent applications per million population as indicator of innovation, the correlation between these two indicators is 0.9554 and the results are quite similar.

many zeros or very small amount of patents and missing values are not considered. Third, countries in our sample are expected to exhibit different stages of development.

We also use the number of utility models as another measure of innovation. This indicator is obtained from WIPO. The major differences between patents and utility models are as follows. First, the requirements for acquiring a utility model are less stringent than for patents. Second, utility models are cheaper to obtain and to maintain. Third, the term of protection for utility models is shorter than for patents. Therefore, in many countries, utility models are sometimes referred to as "second-class patents". Thus, patents and utility models represent different quality of innovation.[6] Throughout this paper, patents are used as the primary indicator of innovation in the regressions. However, we provide the estimation results for utility models in the dynamic threshold regression as an additional robustness check. The last indicator of innovation we use as a robustness check is R&D expenditure (%GDP)[7], which is collected from OECD and UNESCO. We drop four countries due to missing values, reducing our sample reduces to 46 countries. However, our threshold estimations remain robust even with the reduced sample size.

For controls in innovation regression, we include net inflow of foreign direct investment (%GDP) measuring the technology diffusion effect; population, which accounts for possible scale effects in the process of innovation; mean years of schooling; GDP per capita; and protection for intellectual property right. Regarding the growth regression, the dependent variable is the growth rate of GDP per capita and the variables of interest are innovation and financial development. We consider innovation as regime dependent variable and take financial development as the threshold variable. The controls include general government final consumption (%GDP), capital forma-

[6]This strategy can also be seen at [Cai et al., 2018]

[7]Some studies think that R&D indicator does not capture innovation very well because it belongs to input and provides insufficient information on the output of R&D activities. Despite this, we think R&D indicator is still useful as an alternative indicator to check the robustness of our results because it retains some predictive power about the innovative output.

tion (%GDP), CPI-based inflation rate (%), trade openness (%GDP), mean years of schooling, and initial GDP per capita. To remove the influence of cyclical components of data, we use five years non-overlapping averages. The final panel consists of 50 countries from 1990 to 2016, among which, 28 are high income countries and the rest are upper and lower middle income countries. Table (1.A7) provides the definition, construction and source of each variable. Summary statistics are shown in Table indicating a significant heterogeneity in innovation and financial development across countries.

3. Results

As a starting point, we build an intuition about the relationship between financial development and innovation by qualitatively splitting the sample into two groups: high financial development countries and low financial development countries. Specifically, the countries are ranked by the level of financial development in an ascending order. Then we define the top half of the sample as countries with high level of financial development, while the other half is defined as countries with low level of financial development. Figure (1.1) shows that as financial development continues to expand, its effect on innovation tends to decrease. This illustration seems to match the prediction of existing theories, but possible non-linearities might exist via other sources. Next, we present the empirical results.

3.1. Results for linear system-GMM

3.1.1. Financial development and innovation

Table (1.2) reports the basic results for equation (1). In this table, we use private credit as a proxy for financial development and the percentage change in patent application as dependent variable. We implement a two step system-GMM estimation for equation (1). Due to the downward bias in the computed standard errors of two-step estimation, the Windmeijer correction is applied. In each regression, we take population as an exogenous variable, while considering the rest as endogenous variables. The full sample results show that the overall effect of private credit on innovation is positive and significant. Population, FDI and GDP/capita exhibit a non-negative but insignificant effect on innovation. In addition, schooling and protection for intellectual property right have a negative but insignificant effect.

Next, we consider the effect of private credit change as the level of financial development increases. We find that the effect of private credit on innovation for middle income countries is higher than that of high income countries and that the overall effect lies between 0.183 and 0.394. Moving to the low and high financial development countries, we find a similar pattern that the effect in low financial development countries is greater than that of high financial development countries. Again, the overall effect lies between the two estimated effects. The p-value of the AR(2) test and Hansen J-test are reported at the bottom of Table (2.2). The AR(2) test show no significant correlation between the error term and the lagged dependent variable, which indicates that the use of two lags for the dependent variable serve as valid instruments. The Hansen test shows that the specifications do not suffer from over-identification issues. This exercise is consistent with the intuition in Figure (1.1) and confirms our hypothesis that "too much finance" would hurt innovative activities. In Table (1.A1) of appendix, we provide robustness checks for regression (1) using other indicators of financial development and we find a similar pattern as in Table (2.2).

We also provide a robustness check on how banking crisis affects rate of innovation, the purpose of this exercise is to exclude the potential negative shock of banking crisis. Under the 5 year average context, the dummy of banking crisis is taken as 1 if there is at least one crisis during the five years interval, and zero if otherwise. The result in Table (1.A8) can be interpreted as the mid- or long-term effect of banking crisis as we are using five year average values. We can see that banking crisis per se exerts negative yet non-significant effect on innovation. The positive and significant effect of financial development stays there. The coefficient on the interaction term between financial development and crisis dummy is nonsignificant. This result suggests that the diminishing effect of finance on innovation is independent of the external banking crisis shock. More detailed information can be found in Appendix 2.

3.1.2. Financial development, innovation, and growth

This part studies how financial development affects the innovation-growth relationship. Results in Tables (2.2) and (1.A1) show that innovation may be regime dependent upon the level of financial development, since innovation is a determinant factor for long-run growth, it is possible that the effect of innovation on growth is conditional on the level of financial development. Our hypothesis is that higher level of financial development hurts innovation and related investment in complementary inventions and structure, reducing its effect on growth. We estimate equation (3) under: i) full sample; ii) middle and high income groups; and iii) high and low level of financial development groups. Table (1.3) provides the results using private credit by banks and other financial institutions (%GDP) as a proxy for financial development (similar to Table (1.2)), and patent per 100 billion USD as an indicator of innovation. Table (1.3) shows that the overall effect of patent on growth is positive and significant. When we split the sample into middle and high income countries, the effect of innovation for middle income countries is larger than that of high income countries. The same pattern appears when we split the sample into low and high level of financial development countries. The effect is positive and significant for low financial development countries, while it is positive and non-significant for high financial development countries. Also notice that the overall effect lies between the effects of the two subgroups.

In terms of the coefficients of other covariates, government consumption affects negatively economic growth, which is consistent with the related literature. High income and high financial development countries benefit from international trade, while middle income and low financial development countries do not. Developing countries are featured with unsound laws and regulations, less efficient financial market and low level of human capital. These may impede its capacity to attract foreign investment and to absorb the frontier technologies. Moreover, the negative coefficient of initial GDP per capital captures the convergence effect. Table (1.3) also reports AR(2) and Hansen J-test indicating valid specifications. We further check the robustness of our estimations using alternative indicators of financial development and we find that the results reported in Table (1.3) remain valid (see Table ()1.A2) in the appendix).

3.1.3. Interaction analysis

The results in the previous sub-sections deliver a signal that the effect of innovation on growth may be heterogeneous across countries. Based on this observation, we extend equation (2) to:

$$y_{it} = \rho y_{it-1} + \alpha_i innovation_{it} + \gamma \mathbf{Z}_{it} + u_i + \tau_t + e_{it} \qquad (6)$$

where the parameter α_i is country specific parameter and depends on financial development

$$\alpha_i = \alpha + \beta FD_{it} \qquad (7)$$

As discussed in introduction, countries with higher level of financial development may hurt innovation and its effect on growth. We therefore expect a negative sign on β. Combining equations (6) and (7) we can get the form of equation (3).

Table (1.4) reports the results of the interaction analysis. For every indicator of financial development we find consistent results that the coefficient on interaction term is negative and that the effect of patent is positive and significant. The average marginal effect of patent on growth is $\alpha + \beta * FD_{it}$, since $\alpha > 0$ and $\beta < 0$ the overall effect of patent is a decreasing function of financial development. In Figure (1.A2) in the appendix we simulate the average marginal effect of patent on growth for all the indicators of financial development. Our findings suggest that the marginal effect is a downward trend line and mainly positive. This is consistent with the results reported in Table (1.3).

3.1.4. Credit expansion, Banking crisis, Innovation, and Growth

A number of recent empirical studies have documented a "too much finance" pattern using both aggregrate and industrial level data. Major explanations to this evidence include credit expansion, induced financial instability and economic volatility ([Rajan, 2006], [De la Torre et al., 2011]), as well as misallocation of resources ([Tobin, 1984], [Cecchetti and Kharroubi, 2015]). We find that, in our sample, banking crisis follows closely the credit expansions. Figure (1.A1) in the appendix shows the evolution of private credit for U.S., UK, Japan, Malaysia, and China. For each country, a banking crisis takes place when credit tends to expand. For example, Malaysia experienced a banking crisis between 1997-1998. During this period the private credit level is at the highest level in our sample. Table (1.5) shows the difference in financial development between crisis and tranquil period. On average, the level of private credit is significantly higher than in tranquil period. Banking crisis may affect innovation performance and investments via several mechanisms ([Döner, 2017], [OECD, 2012]). For example, a crisis causes a reduction in the demand for products dampening the incentives to innovate. In addition, firms may suffer from credit constraints and difficulties in accessing financing during banking crisis causing a reduction in riskier activities such as R&D expenditurers. This pro-cyclical pattern of R&D and innovation has been observed over various business cycles and for a variety of countries (e.g. [Comin and Gertler, 2006], [Francois and Lloyd-Ellis, 2008]).

The "diminishing effect" documented in Tables (1.3) and (1.4) may be attributable to the potential negative effect of banking crisis on innovation. Therefore, we consider the interaction between innovation and banking crisis in the following equation:

$$y_{it} = \rho y_{it-1} + \alpha innovation_{it} + \beta BC_{it} + \delta innovation_{it} \times BC_{it} + \gamma \mathbf{Z}_{it} + u_i + \tau_t + e_{it} \tag{8}$$

where BC_{it} is the dummy for banking crisis for country i at year t. The value of this dummy is 1 if there is a banking crisis at year t and 0 for tranquil periods. δ measures the difference effect of finance on innovation between crisis and tranquil period. [Arcand et al., 2015] show that economic volatility does not play a major role in the vanishing effect of financial development. Thus, we expect that banking crisis does not impose a significant impact on innovation-growth nexus. The results in Table (1.6) show that banking crisis and patent have the expected signs. Regarding the interaction term, we do not find a significant negative effect which means that the vanishing effect of innovation on growth is not a result of banking crisis.

3.1.5. The European sovereign debt crisis and long run impact of financial crisis since 2009

The 2007-2008 financial crisis may have a long term negative impact on innovative activities and innovation-led growth. The potential long-term negative effects on innovation and growth, if any, can transmit through the negative effects on human capital, future investment on R&D activities, technological leadership and public support systems for innovation ([OECD, 2012]).

In order to assess the heterogeneous impact of post financial crisis on innovation for different types of countries, we divide our sample into four groups: high income countries, middle income countries, countries with high quality of governance and countries with low quality of governance. We consider the quality of governance because the potential negative effect on innovation may depend on the soundness of the quality of governance.[8] We use the index of quality of governance (QOG), proposed by [Teorell et al., 2018], to measure the quality of government. A country is considered as high QOG if the index is above the 50^{th} percentile of all countries.

Panel A of Table (1.7) provides a brief summary of the innovation resilience after the 2007-2008 financial crisis. To assess how financial crisis affects the innovation in the long run, we construct three indicators to measure the innovation recovery after the financial crisis. The first indicator is called Sinking Ratio, which is defined as the ratio of countries whose innovation level does not recover to its pre-crisis level through the whole post financial crisis period examined in our sample. We use the average level of innovation in year 2005 and 2006 as the pre-crisis level of innovation. Meanwhile, year 2009 is set as the initial year after the financial crisis. The sinking ratio shows that 39.2% of high income countries never recover to its pre-crisis level of innovation between 2009-2016. Similarly, 38.4% of high QOG countries do not fully recover to its pre-crisis level of innovation. However, the sinking ratio is lower for middle income and low QOG countries. Next, we consider how long does it take for a country to recover from crisis. The average years of recovery is defined as the average years needed to return to pre-crisis level for those recovered countries. We find that middle income and low QOG countries take longer to recover to pre-crisis level than that of high income and high QOG countries. The average years needed

[8] The literature on the effect of Basel Core Principles for Effective Bank Supervision (BCP) show that better supervisory governance and supervisory unification were generating a positive impact on financial sector stability and banking soundness pre-2008 financial crisis. However, these conclusions do not hold when the period examined covers the 2007-2008 financial crisis. [Quintyn et al., 2011] find a negative relationship between supervisory governance and economic resilience using a panel of 100 countries. Countries with a solid supervisory governance system hurt more during the 2007-2008 crisis. If this evidence is reliable, then one possible explanation is that innovation recovers slowly or is unable to return to pre-crisis level for countries with high quality of governance.

to recover for high income and high QOG countries is between 0.43 and 0.5, however, this time is around 1.4 for middle income and low QOG countries. We also take a look at the years needed for the first positive growth of innovation after crisis, which is defined as the average years of first turning point. We find that for each of the four groups, countries tend to recover in a quarter after 2009. Overall, middle income and low QOG countries take longer to recover to pre-crisis innovation level, but the sinking ratio is lower than that of high income and high QOG countries. This indicates that the self-healing ability after crisis in middle income and low QOG countries is stronger. These facts are consistent with the pattern in [Quintyn et al., 2011].

The financial crisis may have a significant role on the ongoing European sovereign debt crisis (ESDC) started in late 2009 and early 2010 through international financial linkages, but ESDC should not be simply taken as the consequence of the recent financial crisis. Many factors contribute to the ESDC.[9] In our sample, there are 17 European countries, which are among the high income countries. Although 12 out of 17 countries tend to recover to its pre-crisis level of innovation very quickly, most of these European countries are affected during the ESDC. To measure how ESDC may affect countries' innovation after 2010,[10] we construct a simple indicator measuring the ratio of countries with negative average growth rate of innovation since 2010. As shown in row 4 of panel A in Table (1.7), 67.86% of high income countries experience negative growth of innovation, while this figure is 50% for middle income countries. For high QOG countries, 69.23% of them show negative growth rate of innovation. This indicator is 50% for low QOG countries. Regarding the European countries in our sample, 14 out of 17 show a negative trend in innovation during this course. Over

[9]For example, the globalization of finance; easy credit conditions during 2002-2008 period that encouraged high-risk lending and borrowing practices; international trade imbalance; the inaccordance between unified Euro Zone monetary policy and independent fiscal policy of individual sovereign country; and possibly the inability of the macroeconomic model employed by European Central Bank

[10]Notice that, we cannot attribute a country's declination of innovation after 2010 simply to the impact of ESDC, for example, we find that Argentina and Brazil show a negative trend. This, however, could be a compound effect of both long-run effect of financial crisis and other domestic factors.

the same period, the level of financial development, as shown in panel B of Table (1.7), is higher for high income and high QOG countries.

Table (1.8) provides a test on the impact of post financial crisis and ongoing European sovereign debt crisis on innovation. We define the dummy $LC = 1$ for the years after 2009 and $LC = 0$ if otherwise. The interaction term between financial development and LC is negative. This indicates that the ongoing European sovereign debt crisis and post financial crisis impose a significant negative effect on innovation.

Combining these facts, it is possible that the diminishing effect of finance on innovation-led growth is caused by the ongoing ESDC and long run negative effect of financial crisis. To check the robustness of our results, we delete the sample after 2010 to rule out the influence of post financial crisis and European Debt Crisis. The results in Table (1.9) use private credit as indicator of financial development[11] and show that the pattern is quite similar to that of the full sample. In the growth regression, the overall effect of patent is positive and higher for middle income and low level of financial development countries. This shows that the non-linearity between finance, innovation and growth is robust and independent of the financial crisis and European sovereign debt crisis.

3.1.6. Brief summary

The results illustrated in this sub-section reveal the existence of possible non-linearity between financial development, innovation and growth. Countries with higher level of financial development tend to have a lower rate of innovation and growth. The results are robust under a series of robustness checks. However, in the above analysis we slpit our sample using qualitative characteristics and the threshold at which the non-linearity occurs is not rigorously estimated. To quantitatively measure whether there is a threshold for the finance-innovation-growth nexus, we use a dynamic panel

[11] We also use other indicators of financial development for robustness check, and the results are similar.

threshold methodology developed by [Seo and Shin, 2016].

3.2. Dynamic Panel Threshold Result

[Seo and Shin, 2016]'s model extends [Hansen, 1999] and [Caner and Hansen, 2004] static panel threshold model and [Kremer et al., 2013] dynamic panel threshold model by allowing for the transitional variable and other covariates to be endogenous and for unobserved individual heterogeneity. To estimate the coefficients they propose a First Difference GMM (FD-GMM) transformation. This algorithm relaxes the exogeneity assumption of regressors and threshold variable and guarantees that the estimators follow normal distribution asymptotically, which validates the use of Wald test for standard statistical inference on threshold and other parameters. The GMM estimators are obtained through a two-step procedure.[12]

3.2.1. Innovation regression

In innovation regression, equation (4), we consider financial development as a threshold variable as well as a regime dependent variable. Financial development could be endogenous due to omitted variables and due to the reverse causality between technological progress and financial services. Technology changes relating to telecommunications and data processing have greatly spurred financial innovations and services in commercial banking that have facilitated secondary markets for retail loans, such as credit card debt and mortgages. For example, the introduction of Automated Teller Machines (ATMs), Debit Cards, Online Banking and Prepaid Cards have significantly enhanced the banking account access and amount of credits ([Frame et al., 2014]). It is hence necessary to take the endogeneity issue of financial development into account. Previous panel threshold methods cannot handle the endogeneity issue of the threshold variable and other covariates. [Seo and Shin, 2016]'s model construct the set of

[12] For details see [Seo and Shin, 2016]

instrumental variables using the lagged dependent variable, the threshold variable and other covariates.

Table (1.10) shows the results for every indicator of financial development using dynamic panel threshold method. For private credit in column (1), the effect of FD is positive and significant in the lower regime, while it becomes insignificant in the upper regime. The estimated threshold value of banking credit is 48% and the linearity test indicates an overall significant non-linear relationship. In addition, the over-identification test (J-test) indicates no over-identification issues. Moving from column (2) to (4), we find consistent results with that of private credit and with estimated threshold values at around 50%.

3.2.2. Growth regression

In growth regression, equation (5), we consider the financial development as the threshold variable and innovation as the regime dependent variable. The endogeneity role of financial development in the finance-growth relationship is undetermined. Evidences from country cross-section, time series and panel data studies provide mixed signals on the causality between financial development and growth. Using cross sectional data, [King and Levine, 1993a], [Levine et al., 2000a] and [Levine et al., 2003] show evidence of one-way causation, that financial development leads to growth. Subsequent studies cast doubts on the cross-section country evidences. Cross-sectional data may cause spurious correlation arising from nonstationarity. To overcome this potential issue, [Demetriades and Hussein, 1996] use time series data for 16 countries and conduct cointegration test, they find evidence of bi-directionality and even evidence of reverse causality. Also, they find that the causal relationship between financial development and growth is country-specific. However, time series evidence may also be unreliable due to the short time span of data. A good option may be the use of panel data. Using panel data for ten developing countries [Christopoulos and Tsionas, 2004] apply a panel cointegration analysis and find evidence in support of the cross-section country studies. [Calderón and Liu, 2003] use a panel of 105 countries from 1960 to 1994 and find that, in general, financial development leads to growth. However, the effect is heterogeneous across countries and larger in developing countries. Moreover, they find that Granger causality test shows a bi-directional causality between financial development and growth.

In sum, the above evidence reveal the possibility of reverse causality between financial development and growth. This leads us to consider the threshold variable (the indicator of financial development) as endogenous. Regarding the endogeneity issue of other covariates, innovation may also be endogenously determined by economic development. High income countries typically invest more in R&D activities and hence promote innovation. Government spending, trade, inflation, schooling and investment may also be endogenous due to reverse causality and omitted variable issues. To account for the endogeneity issues, we use the lagged threshold variable, regime dependent variable, dependent variable and other covariates as instruments.

Table (1.11) summarizes the basic results of the dynamic panel threshold regression for every financial development indicator, estimating equation (5). Column 1 shows the results from the use of private credit as financial development indicator. The coefficient of patent is positive and significant for the lower regime, while it is negative at the upper regime. The estimated threshold value is 58.4% of GDP. The p-value of the linearity test shows a significant non-linearity between the two regimes. Using alternative indicators of financial development, we obtain similar results, except for liquidity. Specifically, banking credit and domestic credit generate a threshold value of 58.5% and 57.7%, respectively. However, for liquidity liability both lower and upper regime show negative effect, while the estimated threshold is 136.7%. One possible reason for the high estimated threshold value for liquidity liability is that the tail of liquidity density is longer than the others. The Kernel density of the four indicators are plotted in Figure (1.A3) in the appendix. Obviously, the density of liquidity liability is significantly right-skewed, which may explain the relatively larger threshold value.

3.2.3. Robustness checks

As a robustness check we re-examine our threshold estimations taking into account the R&D spending as an alternative indicator of innovation. Tables (1.A3) and (1.A4) report the innovation and growth threshold estimations, respectively. The results indicate that the key non-linear relationship and estimated threshold values, reported in the previous subsections, remain consistent.

We also provide an additional robustness check taking into account the utility models, as an additional indicator of innovation. In this case we re-estimate the results for the growth threshold equation (see Table (1.A5)) and we find that the estimated threshold remains around the level of 60% as a share of GDP, which is consistent with the results we obtained using patents (see Table (1.11)) and the results we obtained using R&D spending (see Table (1.A4)). Therefore, these robustness checks indicate the validity and consistency of our baseline results.

3.2.4. Discussion on the smaller threshold level

Most of the estimated threshold values in finance-growth literature are between 53% and 100%. For example [Cecchetti and Kharroubi, 2012] and [Arcand et al., 2015] estimate a threshold of around 100%, [Masten et al., 2008] between 53% and 70%, [Law and Singh, 2014] at 88%, and [Samargandi et al., 2015] at 91%. In our sample, the estimated threshold values are at about 60%. While this value is towards the smaller value of the range reported in the related literature, we argue that this is not due to the sample selection issue, rather the econometric method employed and the potential impact of financial integration across Europe and the world. As a comparision, we apply the quadratic regression by including the square term of financial development indicators and the [Kremer et al., 2013]'s panel threshold model to our current sample. To find out the optimal value, the quadratic regression use Lind and Mehlum U-shape test to decide whether the nonlinear effect exists or not and where the threshold value lies. All the quadratic regressions are estimated using system-GMM. [Kremer et al., 2013]'s panel threshold model includes lagged dependent variable as the only instrument variable, without taking into account the endogeneity of threshold variable, regime dependent variable, and other covariates. The results in table (1.A6) show that both methods give very large threshold values, which is consistent with the threshold documented in previous studies. In this sense, the large threshold value documented in previous studies may be biased.

In addition, our sample contains 17 European countries from 1990 to 2016. Therefore, our threshold value cannot be completely attributed to the differences in the econometric tools, but it also relates to financial integration across European countries and the rest of the world. Financial integration may enhance the positive effect of financial development on innovation and growth, thus may lead to a smaller threshold value of financial development. One direct evidence is from [Masten et al., 2008], where using data from European countries they document a credit-to-GDP threshold between 53-70%, which is similar to our work.

In Table (1.12) we provide an additional test by re-estimating equation (5) considering the financial development as both the threshold variable and the regime dependent variable. This way we test the threshold effect between finance and growth.

Therefore, equation (5) becomes:

$$y_{it} = \rho y_{it-1} + \beta_L FD_{it} * I(FD_{it} \leq \gamma) + \beta_H FD_{it} * I(FD_{it} > \gamma) + \theta \mathbf{Z}_{it} + u_i + \tau_t + e_{it} \tag{9}$$

The results indicate an estimated threshold value of about 60%, which is very close with the results from the previous sub-section presented in Tables (1.11) and (1.A3). This shows that the results we obtained in the previous sub-section, where we allowed for innovation to switch according to the financial indicator, remain valid even if we do not consider innovation as a regime dependent variable. Therefore, innovation does not affect significantly the estimated threshold of financial development, but it seems to be significantly affected by the level of financial development.

3.2.5. Theoretical explanation

Evidences in Tables (1.10), (1.11), and (1.12) reveal two important economic implications. First, we show that financial development imposes diminishing effect on rate of innovation, such a diminishing effect may slow down economic growth. In this sense, our findings provide a channel through which "too much finance" may harm growth. There may exist three channels through which this diminishing effect works. First, financial development reduces the rate of innovation and thus the productivity growth. In [Rajan and Zingales, 1998], they show that financial development causes the productivity growth in a unidirectional way. [Levine et al., 1998] also shows that productivity growth is the main channel linking financial development to growth. These studies indicate productivity growth as a major channel through which financial development affects growth. Therefore, the negative effect of financial development on growth may be attributed to its potential negative effect on productivity growth. Follow this logic, [Aghion et al., 2018] has documented an inverted U-shaped relationship between financial development and productivity growth. We show explicitly that the diminishing effect of financial development on rate of innovation could be the source of inverted U-shape relationship between financial development and productivity growth. In this sense, we close the FD-innovation-productivity-growth chain. Second, FD may reduce both the quantity and quality of innovation. This also causes a decline in productivity growth and aggregate growth. Finally, high level of financial development induces volatility in firm sales growth ([Wang and Wen, 2009]), signalling a downward expectation on the returns of investment. This may reduce the investment in risky projects such as R&D activities. Lower R&D expenditure may slow down the rate of innovation output, and thus the innovation-led growth.

The second implication is that financial development may make innovations less effective in promoting economic growth. In other words, given a unit increase in innovation, the contribution of innovation is smaller in countries with higher level of financial development. Why? We think that an innovation will not be effective in promoting productivity and aggregate growth until necessary complementary inventions and follow-up investment in productive capital occurs. As credit market develops, bank and firm develop close ties. This close firm-bank ties may facilitate firms to access credit, but it may also prevent firms from involving risky projects such as R&D activities ([Weinstein and Yafeh, 1998]), causing less productive but more pledgeable projects to be easily financed ([Cecchetti and Kharroubi, 2015]). The results in table (1.A3) also confirm this argument. The relatively less investment of productive capital may prolong the implementation and restructuring lags and reduce the contribution of innovation on productivity and economic growth ([Gordon, 2018]).

3.2.6. Financial development and productivity growth slowdown

The diminishing effect of financial development on innovation and growth lead us to think about the possibility that whether the expansionary financial sector is responsible for the productivity growth slowdown in the U.S. and other developed economies started the early 2000s. For expository convenience, Figure (1.A4) and Table (1.A8) show the annual total factor productivity growth rate for the G7 group from 1985 to 2017. The U.S. TFP growth rate has seen an increase from 0.732% in the 1980s to 1.623% around 2004, then it goes down after 2004 even before the financial crisis. A similar pattern can be found in other G7 countries, with Italy as an exception, whose TFP growth rate keeps declining since the mid-1980s. We can also see a significant drop in the TFP growth rate between 2007-2008, then a recovery to a level of less than 1%. Since the decline already began well before the financial crisis, it is less likely that the crisis-related explanation is an almighty candidate.

Several explanations have emerged to account for the slowdown in productivity growth in the U.S. and other developed countries. For example, "The mismeasurement hypothesis"([Griliches, 1994] and [Byrne et al., 2018])[13], weak business dynamism([Decker et al., 2016], [De Loecker and Eeckhout, 2017], and [Bijnens, 2018]), low interest rate([Gopinath et al., 2017] and [Liu et al., 2019]). The latter two explanations lead to the same end that it is the rise in industry concentration(or falling in the competition) and higher markups that lead to lower productivity growth because lower financial constraints and real interest rates have made it harder for high-productivity firms to crowd out the least efficient ones. Financial development closely relates to credit constraints, capital abundance, and interest rate, accordingly, it is likely that financial development serves as a deep-rooted explanation to the productivity growth decline of developed economies since the 1980s.

4. Conclusions

This paper has empirically tested the hypothesis that an expansion in financial sector would hurt innovation and innovation-led growth, using a panel of 50 countries over

[13][Brynjolfsson et al., 2018] admitted that we cannot completely exclude the possibility of mismeasurement issue, but it is not a major force that drags the productivity growth over the past decade. Similar viewpoint can also be found in [Sichel, 1997] and [Sichel, 2019]

1990-2016. The results from a linear system-GMM shows that countries with higher level of financial development are associated with a relatively low rate of innovation. Furthermore, this vanishing effect between finance and innovation would finally transmit to innovation-led growth. We find that the positive effect of innovation on growth is smaller or even insignificant for countries with developed financial sector. These conclusions are robust to the banking crisis, the long run effect of 2007-2008 financial crisis, the ongoing European sovereign debt crisis and alternative indicators of financial development and innovation. To precisely estimate the threshold value at which the vanishing effect starts, a dynamic panel threshold model is employed. We find that, for our sample of countries, innovation starts to have an insignificant effect on output growth when private credit reaches the level of around 60% of GDP. Finally, we have shown that our threshold value is not driven by our sample size and selection but the difference in the tools employed in our work, compared to the related literature, as well as the ongoing regional and international financial integration process.

This current work can be extended in several ways. First, the currently employed innovation indicator does not reflect the full picture of innovation, future work would be to construct alternative indicators. A potential candidate would be the research quotient(RQ), which measures the research efficiency of R&D. The RQ is considered a better measurement of innovation as it is output- and market-oriented and well captures the marginal contribution of R&D expenditure by controlling for the other factors that affect sales revenue. The conventional output-based measurement of innovation such as patent counts and patent citation suffer from several issues. For example, nearly 50% of firms do not apply for patent protection, that is, the patent data cannot capture the precise output of R&D. The patent citation data suffer from the truncation issue, to properly use it, one needs to adjust it using the estimated citation lag metric. Besides, patent as an outcome of R&D may not necessarily bring practical commercial profits. Accordingly, using patent-based innovation measures may lead to bias conclusions as well as the wrong question.

Second, the effect of financial development on innovation may be sector-specific. For example, the Medical industry R&D may be more reliant on the cost/availability of credit than the Software industry. It is interesting to decompose innovation (patents) by sector and examine how finance affects each and whether passthrough to growth differs by sector of innovation. The disaggregated data can also well account for the heterogeneity and endogeneity issue. Accordingly, it is advisable to use the industrial and firm-level data to re-examine the above hypothesis. Another development would be to construct homogeneous groups using the convergence club technique.

Third, the current analysis framework can be extended to the equity market instead of limiting it to the credit market. the behavior of the stock market may be different from the credit one. We think that there will generate new and comprehensive insights into this issue.

Last but not least, it is interesting to explore how the diminishing effect of FD on innovation and growth has played a role in the convergence between poor and rich economies. If too much finance promotes innovation more efficient in countries with lower FD, then countries with an optimal level of FD may catch up with countries with a higher level of FD.

CHAPTER II

THE NONLINEAR EFFECT OF FINANCIAL DEVELOPMENT ON INNOVATION: THE ROLE OF MARKET STRUCTURE

1. Introduction

This paper studies the nonlinear effect of financial development on innovation. Understanding how financial development affects innovation is important in both theoretical and practical regards. Traditional thoughts on the finance-innovation nexus think that financial development facilitates innovation by relaxing the constraints of financing for innovative activities such as R&D. Further, financial development affects economic growth mainly through its effects on productivity([Rajan and Zingales, 1998]). So theoretically understanding how financial development affects innovation could shed light on the mechanism between finance-growth nexus. In practice, whether financial development promotes innovation may determine the government's policy preference for innovation. For example, if the positive effect holds in any situation, then policies and regulations that promote financial market development may be favored compared to the R&D subsidies.

Studies such as [Hsu et al., 2014] has examined the effect of financial development on innovation, most of these findings in this field support the positive monotonic relationship. However, a few papers have shown that more finance may negatively affect innovation due to the induced macro-volatility([Morales, 2003]), "crowding out effect"([Tobin, 1984], [Cecchetti and Kharroubi, 2015], [Borio et al., 2016], and [Boustanifar et al., 2018]), and "trade-off effect"([Aghion et al., 2019]).

It is hence reasonable to hypothesize that as the financial sector continues to expand, financial development imposes a nonlinear effect on innovative activities, with a positive effect before a certain threshold level and a negative effect post the threshold value.

A few existing papers have examined the nonlinearity between financial development and innovation using country-level data. For example, [Law et al., 2018] find financial development exerts a negative effect on innovation around the threshold value of 100%. The method used to detect nonlinear effect is by including the square term of indicators of financial development. Another paper by [Zhu et al., 2020] has shown that credit market expansion exerts a diminishing effect on innovation. This paper employs a novel dynamic panel threshold model and finds a threshold value between 50% and 60%, which are smaller than the value documented in previous finance-growth literatures.

Several issues emerge in the previous literature on the nonlinear effect of financial development on innovative activities. First, the link between the financial sector and innovation may be sector-specific. For example, Medical R&D may be more reliant on the cost or availability of credit than the software industry. Previous studies using country-level data assigns equal weight on the innovation(measured by patent counts) fail to capture the sector-specific effects. Second, the financial indicators used in the previous works fail to capture the overall picture of a countrys financial development. An overall picture of financial development includes development in both equity and credit market and financial institutions. In Law and [Zhu et al., 2020], they only focus on the credit market. Therefore, the conclusion may not hold if considering a comprehensive measurement of financial development. Third, The measure of innovation such as patent counts and citations each patent received after filing may not precisely reflect the innovation output of firms, because nearly 50% of firms with R&D

activities do not filing a patent due to several considerations([Cooper et al., 2015]). Last but not least, the endogeneity of financial development. Law(2018) uses GMM to account for the endogeneity issue. The spirit of the dynamic panel threshold model used in [Zhu et al., 2020] is similar to GMM because it uses the lagged value of both threshold and regime dependent variables as instrumental variables. Although GMM could solve the endogeneity issue in partial, it suffers from the sensitivity and large instrument issue. A economic-intuitive method instead of the technique-oriented IV is desired to control for it.

In this paper, using a new data set consisting of a large volume of firms from both developing and developed countries, we attempt to provide novel and thorough empirical examinations regarding the potential nonlinear effect of financial development on innovation. In particular, we focus on the innovative activities in the Manufacturing sector. We first identify how financial development affects innovation nonlinearly at the industrial level, then we focus on the channels through which this channel works. Specifically, we seek to answer the following:

- Will there be any negative or diminishing effect as the financial sector expands?
- Are the effects of the equity market and credit market different? And are there any sector-specific effects?
- What could be the potential channel through which the negative or diminishing effect takes place? if any.
- And, will the effect of financial development on innovation differ between developed and emerging economies?

To answer these questions, we first construct cross country industry-level data from the Worldscope Fundamentals Annual. Second, we capture the full picture of financial development by using multi-dimension indicators. The indicators include both the credit and equity markets. We also use the financial development index filed by IMF([Svirydzenka, 2016]). Third, to overcome the shortcomings of current measures of innovation, we construct a unique cross country Research Quotient(RQ) database consists of 48 countries between 1989-2017. The RQ is defined as the firm-specific output elasticity of R&D. it has several advantages over the traditional innovation measures such as patent count, patent citation, R&D input and TFP(See discussions in [Cooper et al., 2015]). Fourth, we twist the RZ specification a little bit to account for the endogeneity of financial development. In this paper, we extend the RZ index([Rajan and Zingales, 1998]) by constructing the External Financing Dependence(EFD) index for each country. This way allows us to account for the heterogeneity of EFD for different industries across different nations. Lastly, the industrial level data allows us to examine the sector-specific effect. We consider the innovative activities in the manufacturing sector and divide the manufacturing sector into high tech and non-high tech sectors. We examine the heterogeneous effects of financial development on innovative activities across sectors.

In the first section, we show that a high level of financial development has a diminishing effect on innovative activities. We use the financial development indexes, which are comprehensive indicators that synthesize both the development in financial markets and financial institutions, as proxies for the overall financial development. The innovation of Industries that rely heavily on external financing benefits more when financial development is lower than a certain level, however, this positive effect diminishes as the level of financial development exceeds that threshold. When decomposing the financial markets into credit markets and equity markets, we find differentiated behavior between these two types of financial markets. Specifically, the diminishing effects hold for the credit markets, while in the equity market, more finance is "always better".

In the second section, we conduct several robustness checks. First, we aggregate the industrial level patent counts and forward citation weighted patent counts as alternative indicators of innovation by merging firm-level data set from Compustat North America Fundamentals Annual, Compustat Global Fundamentals Annual, and USPTO. We find stable patterns. Second, we consider whether the diminishing effects are sector-specific. We classify the manufacturing sector into two sub-sectors: high technology manufacturing industry(SIC 35 and 36) and non-high technology manufacturing industry. The results indicate that the innovative activities of the high tech industry are more likely to be affected by the equity market, and exhibit inverted-U shape between the equity market and innovation. While the credit markets play a major role in the non-high tech sectors and impose a diminishing effect on innovation. Despite the different roles, each market shows an inverted-U effect on innovation in its domain. Third, we use legal rules as instrumental variables to check the robustness and find consistent results.

After establishing the facts, we turn to the potential channel through which financial development affects innovation in a nonlinear manner. [Aghion et al., 2005a] finds that there exists an inverted-U shape between market structure, as measured by the degree of competition, and the innovative activities. In [Liu et al., 2019], lower interest rates enhance the innovation incentives of technological leaders in the various sectors of the economy. This, in turn, increases the average technological gap between leaders and followers, and consequently discourages innovation by followers, causing a rising of market concentration. Because financial development reduces the credit constraints mainly by lowering the interest rate, we hypothesize that financial development affects innovation through its nonlinear effect on market structure. We find that the degree of competition becomes weak as the level of financial development increases in industries rely heavily on external financing. Further, we show consistently that the marginal effect of competition on innovation decreases with the level of financial development.

Realizing that countries with different institutions or stages of development may carry different financing strategies toward the innovation, thus the effects may be heterogeneous, we categorize the country into High-Income Countries and Non-High Income Countries based on the World Bank Country Classification System[14]. We find striking results. Specifically, the high income and non-high income countries that share a similar threshold range exhibit opposite effects. For each indicator of financial development employed in our paper, the diminishing effect of financial development on innovation occurs only in high-income countries. In Non-high income countries, financial development exhibits accelerating effects or kick-in effects. We provide an explanation for this fact. Basically, it relates to the financial development, types of innovation, and market competition. More details will be provided in section 8.

Together, our results not only identify the nonlinear effect of financial development on innovation but also provide novel evidences on the multi-dimensional picture of the effects. While there have been several studies on the nonlinear relationship between finance and innovation, our findings differ from the earlier studies in that we use unique database and novel indicators of innovation, and find differential effects between credit and equity markets, we are also able to identify an explicit channel, which provides a micro-based perspective to understand the transmission pipeline of finance-growth nexus. Lastly, we find heterogeneous effects across sectors and development stages. This finding is important in terms of the cross country study in this field and policy-making for different countries. We also provide an untested

[14]The WB Country Classification System originally divides countries into four groups: High income, Upper Middle income, Lower Middle income, and low income. The number of countries in the Lower Middle and Low-income group is too small that the observation is not sufficient. Therefore, we combine the last three categories into one group: the Non-high income countries.

explanation for future study.

In the rest of the paper, Section 2 reviews related literature and develops our major research hypotheses, Section 3 and 4 presents the major empirical strategies, data, and the detailed procedures on how the indicators are constructed, we present and discuss our main results in Section 5 and 6, Section 7 discusses the potential channels. Section 8 explores the heterogeneous effects across the stage of country development. Section 9 concludes.

2. Literature Review and Hypothesis Development

In this section, we briefly review the literature relevant to our study. Previous studies such as [Xiao and Zhao, 2012], [Brown et al., 2013], [Hsu et al., 2014], and [Acharya and Xu, 2017] have shown that equity and credit market development might impose differential effect on innovation. Given this, we split the reviews into three sections. The first part reviews the studies on the credit market and innovation, then reviews how equity market development affect innovation, finally, we propose a hypothesis on the overall effect of financial development on innovation.

2.1. Credit Markets and Innovation

R&D activities are difficult to finance in a competitive market environment due to both its longer than average maturity horizon and to its high budget requirements. As the financial market develops, the credit constraints of innovative activities are likely to relax and the risks associated with R&D can be diversified. Therefore, firms have more incentives to increase the R&D investment since the potential returns are high. [King and Levine, 1993b] provide country-level evidence and verify this channel. [Hsu et al., 2014] use industry-level data and find a monotonic positive relationship between financial development and innovation. Evidences from the firm-level data also confirm this conventional wisdom([Aghion et al., 2012], [Brown et al., 2009], and [Amore et al., 2013]).

Despite the optimists, several theoretical and empirical studies raised the concern of possible crowding-out effects of financial development on innovation. [Tobin, 1984] raised the concerns that too many financial activities may misallocate resources, both physical and human capital, from the production sector to less productive financial sector. [Cecchetti and Kharroubi, 2015] and [Borio et al., 2016] elaborate this idea by showing that less productive but more pledgeable projects are easily be financed during financial sector expansions. When credit inflates, workers, especially the talented STEM workers, are lured into low productivity gains sectors such as the financial sector due to high finance compensation([Axelson and Bond, 2015], [Boustanifar et al., 2018], and [Célérier and Vallée, 2019]). Both channels hurt real sectors by reducing the innovation capacity.

There may also exist a trade-off effect of financial development on innovation. Evidence from firm-level, such as [Weinstein and Yafeh, 1998], shows that close firm-bank ties may facilitate firms to access credit, but it may also prevent firms from involving risky and high return projects such as R&D activities. [Morales, 2003] introduces the financial sector in an endogenous growth model and shows that financial activity may have two opposite external effects on research productivity. On one hand, the positive effect of financial activity spill over to other sectors of the economy and promote productivity, On the other hand, however, this positive externality would induce creative destruction process and discourage the incentives of incumbent to invest in R&D. Inspired by the works of [Klette and Kortum, 2004] and [Akcigit and Kerr, 2018], [Aghion et al., 2019] think that financial development may result in two competing effects. On the one hand, potentially good innovators may face fewer financing constraints to enter the market due to the development of the financial market, which in turn is beneficial to aggregate innovation and growth. On the other hand, fewer credit constraints may make it easier for less efficient incumbent firms to remain on the market and prevent more efficient innovators from entering the market. This, in turn, may be harmful to aggregate innovation and growth. As the financial sector continues to expand in the modern economy, credit constraints are now not a major concern for many firms, it is even uncertain whether the overall effect of financial development on innovation is monotonic. Collectively, the above discussion leads to our first research hypothesis

H1:*Credit market development has a positive but diminishing effect on innovation.*

2.2. Equity Market Development and Innovation

The studies on the stock market affects firm innovation is mixed. Stock markets differ from the debt markets in that it provides different mechanisms and channels for fundraising, and thus may generate differential effects on innovative activities. Many studies in this area support the idea that the stock market promotes firm innovation. One relevant study by [Moshirian et al., 2018] shows that industries with higher innovation intensity experience a higher level of innovation output given a stock market liberalization shock. Using a matched Chinese firm-level data, [He et al., 2017] shown that after an IPO, firms' innovation, both quantity and quality, improves. A cross-country study by [Xiao and Zhao, 2012] documented that stock market development significantly enhances firm innovation, using World Bank survey of over 28,000 firms from 46 countries.

Some other studies think that the stock market may inhibit innovation. [Bernstein, 2015] compared firms that went public with similar firms that stayed private and found no change in the scale of innovation but a substantial decline of approximately 40 percent in innovation novelty when companies went public. The reason, as suggested by the author, is that the transition to public equity markets leads firms to reposition their R&D investments toward more conventional and safer projects. Similarly, [Wies and Moorman, 2015] found that companies that go public produce more innovations than before but that those innovations are less bold. because going public increases capital which allows more innovations but it introduces "myopic incentives and disclosure requirements" which can inhibit riskier innovation. Another study by [Acharya and Xu, 2017] also shows that public firms in external finance dependent industries are more likely to generate patents of higher quantity as well as quality. Notice that these two research are country-specific as they were built in the context of U.S. private and public firms. A cross country study by [Brown et al., 2013] compared the effect of equity financing and debt financing on innovation. They found that better access to stock market financing is particularly important for investment in research and development (R&D), and credit market access is much less important than stock market access for R&D investment because of the shortcomings of debt for funding R&D. Despite the fact that we have found evidence showing the possibility of a positive and negative effect of stock market development on firm innovation, a diminishing effect is possible, but it is still hard to fix the idea of whether excessive equity financing is good or bad to innovation as a whole. It is likely that the positive effect of stock market development on innovation still dominates, and it is also possible that the effect may vary according to the dimensions of financial development. For example, stock market depth, accessibility, and efficiency may affect innovation differently. Thus, we have

H2: *Equity market development may have a diminishing effect as it continues to expand, but it also depends upon the characteristics of equity markets .*

2.3. Financial development and innovation

As stated above, most of the studies on the effect of financial development on innovation or productivity focus separately on either the credit market or equity market.

To fully understand the effect, a synthesis of both the equity market and the credit market is desired. In [Hsu et al., 2014], they define the overall level of financial development as the sum of a country's stock market capitalization plus domestic credit provided by the banking sector. Despite the fact that both sources of financing will be primarily used for investment relevant activities, this simple lump sum of the depth of two markets fails to distinguish the function of each market, thus may make the aggregation not be feasible. Besides, the overall financial development defined in their paper is only about the depth dimension of financial development, it does not involve efficiency and accessibility of financial development. In this paper, we will use a new set of index developed by [Svirydzenka, 2016]. This set of index provides comprehensive measures of financial development from different dimensions. More details will be given in the following section. Theoretically, it is hard to predict how overall financial development affects the innovation, because it depends on the share of each component, ways of funds raising, and its ways of use. But based on the above two hypothesis, we predict that the overall effect of financial development aligns with the effect of credit and equity market, that is

H3: *The overall effect of financial development on innovation is diminishing.*

3. Empirical Strategy

3.1. Basic Identifications

To establish the intuition about the possible nonlinear effect of financial development on innovation, we first adopt a simple quadratic form regression

$$RQ_{c,i,t} = \sigma_0 + \alpha \text{value\_add}_{c,i,t-1} + \beta FD_{c,t-1} + \gamma FD^2_{c,t-1} + \delta \mathbf{X}_{c,i,t} + \eta_{c,t} + \mu_i + \varepsilon_{c,i,t} \tag{10}$$

where $RQ_{c,i,t}$ is our proxy for innovation for country c, industry i at year t. $\text{value\_add}_{c,i,t-1}$ is the value-added of industry i in country c at time $t-1$. $FD_{c,t-1}$ and $FD^2_{c,t-1}$ are the original and quadratic form of indicators of financial development for country c at year $t-1$, respectively[15]. To capture the overall picture of FD, we consider both the development of equity and credit market. For each category, we use three dimensions trying to exhaust the different characteristics of each market. A detailed description of each indicator will be given in the next section. $\mathbf{X}_{c,i,.}$ is the industrial control variables at time t or $t-1$. $\eta_{c,t}$ is the country-year fixed effect that absorbs time-varying country characteristics, such as the overall level of economic development, government policies, and country-wide reforms. μ_i is the industry fixed effect that absorbs the effects of industrial variation upon which our mechanism variables are constructed. $\varepsilon_{c,i,t}$ captures the omitted variables and is assumed to follow $i.i.d.$

Financial development could be endogenous due to omitted variables and the reverse causality between technological progress and financial services. Technology changes relating to telecommunications and data processing have greatly spurred financial innovations and services in commercial banking that have facilitated secondary markets for retail loans, such as credit card debt and mortgages. For example, the introduction of Automated Teller Machines (ATMs), Debit Cards, Online Banking, and Prepaid Cards have significantly enhanced the banking account access and amount of credits ([Frame et al., 2014]). It is hence necessary to take the endogeneity issue of financial development into account. One way to account for it is to adopt the [Rajan and Zingales, 1998] methodology by interacting with the financial development of country c with the index of external financial dependence. The rationale is that it is plausible to assume that the innovation changes of a specific industry will not affect the financial depth in a country as a whole. We consider the following

[15] There are two major reasons why lagged financial development is included. A primary concern is that there exist lags between financing a R&D project and output. The specific lags are uncertain and dependent upon the industries and countries. Here we adopt the first order lagged value.

specification

$$RQ_{c,i,t} = \sigma_0 + \alpha \text{value\_add}_{c,i,t-1} + EFD_{c,i} * (\beta FD_{c,t-1} + \gamma FD_{c,t-1}^2) + \delta \mathbf{X}_{c,i,t} + \eta_{c,t} + \mu_i + \varepsilon_{c,i,t} \quad (11)$$

where $EFD_{c,i}$ refers to the external financial dependence(EFD) for industry i in country c. The EFD in our specification is different from that of being adopted in [Rajan and Zingales, 1998] and many others in two respects. First, the definition of EFD follows [Brown et al., 2013] and [Hsu et al., 2014] and is given in a broad manner. Second, we construct the index for each country instead of using the EFD from the Compustat's North American and Global Annual Fundamentals. Again, the details will be given below.

3.2. The Endogeneity of Financial Development

Although RZ specification is widely used in empirical studies, the major critique has been the absence of valid instrumental variables for extracting the exogenous component of financial development. [Levine, 1998] proposes to use the legal variables such as creditor right, enforcement, and legal origin([La Porta et al., 1997]) to instrument for the banking development. Similarly, [Brown et al., 2013] also use legal rules and institutions as instruments for the country-level measures of stock market access. Follow the previous literature, we use creditor right as instruments for the credit market, while use Anti-self dealing index as instruments for the stock market development, also we use legal origin and enforceability of contract as instruments for both equity and credit market. To conduct the IV regression, all industry-level variables are averages over the full sample. We do this for two reasons. First, this allows us to see the long-run effect of financial development on innovation while controlling for the endogeneity issue of financial development. Second, Using the cross-section data allows us to reduce the influence of time-aggregation associated with the time-variant IVs([Ahmed, 1998]). The basic specification will be

$$RQ_{c,i} = \sigma_0 + \alpha \text{value\_add}_{c,i} + EFD_{c,i} * (\beta FD_c + \gamma FD_c^2) + \delta \mathbf{X}_{c,i} + \eta_c + \mu_i + \varepsilon_{c,i} \tag{12}$$

where $EFD_{c,i} * FD_c$ and $EFD_{c,i} * FD_c^2$ will be the key endogenous variables.

4. Data, Measurement, and Sample Characteristics

4.1. The Construction of Research Quotient(RQ)

In this paper, We use a novel indicator of innovation, Research Quotient(RQ), as our primary proxy for innovation, the RQ is defined as the firm-specific output elasticity of R&D. The RQ has several advantages over the traditional innovation measures such as patent counts, patent citation, R&D input, and TFP[16]. The currently available version of RQ is constructed based on data from Compustat and the CRSP monthly stock file. One limitation of this database is that it does not allow us to do the cross-country analysis. To overcome this, we construct the RQ index for each firm from different countries using data covering 1980-2018 retrieved from Worldscope Fundamentals Annual. The Worldscope database contains the annual financial report on the world's public and private companies. The total universe of companies contained on the database, both extinct or inactive companies, is 101,400 scatter across 156 countries[17]. These companies represent approximately 95% of global market capitalization, thereby the revenue of firms on the database can well reflect the economic development of the world as a whole. To capture the economic meaning of RQ, we

[16] see [Cooper et al., 2015] for more information on the comparison between RQ and other innovation indicators.

[17] Note that the count of firms is obtained by dropping the 314 firms without country identifier.

start from the growth accounting

$$Y_{cif,t} = A_{cif,} K^{\alpha}_{cif,t} L^{\beta}_{cif,t} R^{\gamma}_{cif,t-1} S^{\delta}_{cif,t-1} AD^{\Theta}_{cif,t} \varepsilon_{cif,t} \tag{13}$$

where $Y_{cif,t}$ is the output of firm f in industry i, country c at year t. $A_{cif,}$ is the firm fixed effect, $K_{cif,t}$ is the capital, $L_{cif,t}$ is the total employees, $R_{cif,t-1}$ is the first-order lagged R&D expenditure, $S_{cif,t-1}$ is the first-order lagged spillover within the 4-digit SIC industry in country c, $AD_{cif,t}$ is the selling and general administrative expense, and $\varepsilon_{cif,t}$ is the stochastic factors that affect firm production. γ can be interpreted as the response of percent change in output to a one percent increase in R&D input, i.e. the elasticity. There is no explicit assumption on the economy scale of production, as firms are in different stages and scale, it could be either CRS, IRS, or DRS.

We derive RQ for each firm-year by estimating Equation (4) using a random coefficients model that allows for heterogeneity in the output elasticity for R&D as well as all other inputs. The utilization of a random coefficient model follows from the need to capture the firm-specific estimates of γ. The coefficient of the random coefficient model consists of two components: the average effect of the full sample and the random component that captures the individual specific effect. We adopt the following three-level specification and the level-1 model for firm f, industry i, and country c is

$$lnY_{cif,t} = a_{ci0} + \alpha_{ci0} lnR_{cif,t-1} + \Delta_{ci0} ln\mathbf{X}_{cif,t} + \varepsilon_{cif,t} \tag{14}$$

to save the notation, we use $\mathbf{X}_{cif,t}$ to denote the control set and Δ_{ci0} representing the corresponding coefficient. The intercept a_{ci0} and slope α_{ci0}, Δ_{ci0} in the level-1 model vary between industries according to the following level-2 models:

$$a_{ci0} = \beta_{c00} + \beta_{c10}x_{ci1,t} + \beta_{c20}x_{ci2,t} + r_{ci0,t} \tag{15}$$

$$\alpha_{ci0} = \beta_{c10} + \beta_{c11}x_{ci1,t} + \beta_{c21}x_{ci2,t} + r_{ci1,t} \tag{16}$$

$$\Delta_{ci0} = \beta_{c20} + \beta_{c12}x_{ci1,t} + \beta_{c22}x_{ci2,t} + r_{ci2,t} \tag{17}$$

where $x_{ci1,t}$ is a continuous predictor and grand-mean centered, and $x_{ci2,t}$ is a dichotomous predictor and uncentered. The intercepts and coefficients in the level-2 models vary between countries according to the following level-3 models:

$$\beta_{mn,c} = \gamma_{mnl} + \gamma_{mnl}w_{1c} + \gamma_{mnl}w_{2c} + u_{mn,c} \quad m, n, l = 1, 2, 3 \tag{18}$$

Substitute (6) through (9) into the (5) we can obtain the reduced form of specification, for illustrative purpose, a parsimonious model for the relationships between firm revenue and R&D lag and control set $\mathbf{X}$ can be obtained by specifying firm-specific random slope ζ_{ci1}, ζ_{ci2} and a firm-specific random intercept ζ_{ci3}:

$$lnY_{cif,t} = (a_0 + \zeta_{ci3}) + (\alpha_0 + \zeta_{ci1})lnR_{cif,t-1} + (\Delta_0 + \zeta_{ci2})ln\mathbf{X}_{cif,t} + \varepsilon_{cif,t} \tag{19}$$

where the a_0, $\alpha_0$and Δ_0: represent the direct effect and $\zeta_{cij}, j = 1, 2, 3$ represents the firm-specific error,respectively.

Follow [Cooper et al., 2015], we conduct the estimation of RQ for each firm-year by estimating regression (10) using rolling 10-years windows of the Worldscope Fundamental Annual from 1980 to 2018. The firm-level variable items include Revenue(U.S.$) (Worldscope item 7240), Capital expenditure as a percent of total assets(Worldscope item 8416), Total assets(U.S.$)(Worldscope item 2999), Employees(Worldscope item 8416), R&D expenditure(Worldscope item 1201), and Selling, general and administrative expense(Worldscope item 1101). The capital expenditure is calculated as the product between item 8416 and item 2999. Notice that Worldscope provides some key items using the U.S. dollar, the Revenue(item 7240) is among them. To manipulate the data under the same unit, we convert all the variables from their national currency into the U.S. dollar using the current exchange rate. Also notice that Worldscope provides two sets of exchange rates for use: the Exchange Rate used in translating balance sheet and the Exchange Rate used in translating income statement/cash flow. We do not use the exchange rate items provided in the database since the series suffer from serious missing value, we obtain the exchange rate used in translating balance sheet by dividing the Total assets(item 2999) by Total assets(item 7230). Similarly, the exchange rate used in translating income statement/cash flow is calculated as the ratio of Revenues(item 1001) to Revenues(item 7240). Then we convert R&D expenditure(item 1201), administrative expense(item 1101), and capital expenditure into the U.S. dollar using the income exchange rate.

A few words on the selling, general and administrative expense. Literatures typically use advertising as a control, the Worldscope database does not split the advertising expense from the Administrative expense. However, it makes a lot of sense to use the general administrative expense because it contains not only the advertising expense but also includes other expenditures in operation provisions such as marketing, product promotion, delivery, etc. These activities cover the up- and down-stream of the whole production, hence are critical to the firms' revenues. In Worldscope, the Selling, general and administrative expense also includes R&D expense(item 1201), we subtract this item to avoid double counting.

4.2. The Construction of Firm-Specific Spillover

Next, we construct the firm-specific spillover as the sum of the differences in knowledge between focal firm f and rival firm j for all firms in the 4-digit SIC industry[18] with

[18]Worldscope provides eight SIC code, we select SIC code 1 because it assigns almost every firm a SIC code.

more knowledge (R&D) than the focal firm[19]:

$$S_{cif,t} = \sum_{j \neq f} R_{cij,t} - R_{cif,t}, \quad \forall R_{cij,t} > R_{cif,t} \tag{20}$$

We drop countries with less than 50 country-year observations, and only keep the firms belong to manufacturing sectors(4-digit SIC code between 2000 and 3999). This treatment is align with that of [Rajan and Zingales, 1998] and [Hsu et al., 2014]. In line with the treatment in [Cooper et al., 2015], we require all firms to have a minimum of six years of non-missing R&D data within each ten-year window[20]. We assign selling and administrative expense a zero if the firm-year observation for it is missing. The random coefficient model gives the fixed effects that are invariant with time, firms, and industries. To predict the firm-year specific effect, we first predict the firm-specific random effects then define the RQ for each firm-year as the sum of the fixed effect and firm-specific random effects in the last year of each window. As a result, our RQ only covers the period between 1989 and 2018.

With the above preparations, we adopt the following procedures to obtain the nation-industry-year data. First, we convert the 4-digit SIC code to the 2-digit SIC code by grouping the 4-digit firms starting with the same first two digits into one club. Second, we find the industry-year value of RQ using the median value of all firms within a 2-digit industry at year t[21] because the median value can exclude the influence of outlier.

Table (2.1)-(2.3) report the statistics of RQ by country, industry, and country-industry average. We also report the relative level of RQ to the U.S. level, denoted

[19]The spillover constructed above measures the technological spillover effect across industries within a national geographic boundary, a broader measure of the spillover would be the spillover between industries by removing the barriers of nations. However, consider that most of the firms do not involve international trade, this index could suffice our purpose.

[20]There is no consensus about the optimal window length for rolling regression, the role of thumb is a 10-year long window for a century data, as sensitivity analysis, we also experiment with 9-year, 8-year window. The results are robust.

[21]We also use firm-size(market capitalization) based weighted average RQ as a measure of each 2-digit industry, the correlation is 0.9870.

as *U.S._ref*. We can see that in Table (2.1) RQ varies across countries. Although the level of RQ is higher in developed economies than the emerging markets, there are several exceptions, such as Brazil, Sri Lanka, and Egypt. The RQ of some emerging economies such as China and India is around 83% of the U.S. level. It means that traditional measures of innovation may not capture the efficiency of intangible capital(R&D input) utilization. Also, it may reflect the trend that emerging markets are becoming more and more efficient and successful in using the capital and taking market share. Some developed countries may have a larger amount of patent filing, but the RQ is smaller, for example, Australia, Belgium, Greece, Italy, Poland, and Isreal. This is also consistent with the macroeconomic fact that these countries are going through declining in productivity growth. In the industry level, Tobacco Products(SIC 21) and Petroleum & Coal Products(SIC 29) sector has the highest RQ, Electronic(SIC 36) and Instruments(38) are among the high RQ group.

Figure (1.1) shows the time series trend of RQ by SIC 20-39. The value of each industry-year pair is calculated as the country average by industry-year. An interesting pattern emerges. For each sector, the RQ has declined since the starting date of our sample and arrived at the trough level of nearly 0.1 around 2000, by around 2009, it bounced back to a level lower than the initial level in 1989, and then slowed down again. Despite the cyclical trend, the RQ has dropped on average by 66.87% in the long run.

4.3. The Construction of External Financial Dependence Index

Existing literature typically follow the [Rajan and Zingales, 1998]'s way of constructing the external financial dependence index, that is, using the public firms listed in major US stock market from the Compustat North America database to calculate the value for each industry in the manufacturing sector. An important assumption is that the dependence of U.S. firms on external finance serves as a good proxy for the demand for external funds in other countries. According to [Rajan and Zingales, 1998], there are two important reasons for this. First, industries' demand for external funds across countries is assumed to be homogenous when responding to technological shocks. Second, the authors cannot access to flow of funds data for other countries due to data limitation. Several important works have shown that the technological gap between poor and rich countries has been widening and this is mainly due to the difference in the development of the financial market in the local country([Aghion et al., 2005b] and [Comin and Nanda, 2019]). Regarding the second concern, the Worldscope database provides variable Funds from operations(Worldscope item 4201), which helps remove the barries for building the external financial dependence for each country alone. The purpose of establishing the EFD is to account for the heterogeneity of the financial dependence among different countries. Follow [Rajan and Zingales, 1998] and [Hsu et al., 2014], we define cash flow from operations as funds from operations(item 4201) plus decreases in inventories(item 4826), decreases in receivables(item 4825), and increases in account payable(item 4827). Capital expenditure and R&D expense are item 4601 and item 1201, respectively. Each firm's dependence on external finance is calculated as capital expenditures plus R&D expenditures minus cash flows from operations, all divided by the sum of capital expenditures and R&D expense. Within a country, the time series of each industry's dependence on external finance is then calculated as the median of all firms' dependence on external finance in a year[22]. We then compute the invariant external dependence of each industry in a country as the time series median of the industry's dependence on external finance during the period 1989-2018. An industry with higher external finance dependence uses more external financing to fund its tangible and intangible investment.

Table (2.19) shows the correlation matrix between the US and other countries

[22]All the values are converted to U.S. dollar.

in terms of the External Finance Dependence. We can see that several developed economies such as Australia, Belgium, Denmark, Finland, France, Germany, Italy, Japan, South Korea, Netherland, Poland, Sweden, and the UK show a significant correlation with U.S.A in terms of the External Financing Dependence. So it is reasonable to use the U.S. index to proxy for the external financing demand of industries in these countries, but still, we can observe that some developed economies such as Austria, Canada, Isreal, and Singapore show no significant correlation with the U.S.A. Regarding the emerging markets, only Brazil shows a very weak correlation with the U.S.A, all else has no significant relation with the U.S.A. In particular, the Philippines even negatively associate with the EFD of the U.S.A. This fact is critical since it shows that industries' dependence on external financing differ across countries, therefore, simply using the U.S. index may work if the study is limited to the industrialized economies, however, it may generate bias estimates if more emerging markets are included. This justifies our construction of cross-country EFD database[23].

4.4. The Construction of Index of Competition

An important control in our specification is the competition among firms within the same industry. The relationship between competition and innovation has been discussed extensively. Competition could be good for innovation but only to a certain extent as indicated by [Aghion et al., 2005a]. Either monopoly or perfect competition tends to dampen innovation. Follow [Nickell, 1996] and [Aghion et al., 2005a], we use the Lerner Index as the measure of product market competition as it has several advantages over indicators such as market share or the Herfindahl concentration index. To measure it, we first calculate the price-cost margin by dividing the net operating

[23] In unreported results, using Compustat North America and Global database, we find a similar pattern in the Worldscope database. The results are available upon request.

profit by net sales,

$$li_{cif,t} = \frac{\text{Net operating profit}}{\text{net sales}}$$

Notice that, the above formula is the definition of operating profit margin(Worldscope item 8316). With this, the competition measure is defined as 100 minus the median value of $li_{cif,t}$ across firms within the industry at year t in a country. A value of 100 indicates perfect competition while values below 100 indicate some degree of market concentration.

Column (3) of Table (2.1) shows the country average index of competition. Most of the level of competition is above 0.9, which means a country's market is relatively competitive. Some countries such as Brazil, China, and Egypt have a level below 0.9, this is an indication of the relatively concentrated market.

4.5. Measurements of Financial Development

In this paper, we investigate how financial development affects innovation. A complete picture of financial development includes the development in both credit and equity markets. For the equity market, we use stock market capitalization to GDP (%) and stock market total value traded to GDP (%) to measure the depth of equity market of country i at yeat t. The stock market turnover ratio (%) is used to measure the efficiency of the equity market. For the credit market, we use private credit by deposit money banks and other financial institutions to GDP (%), private credit by deposit money banks to GDP (%), and liquid liabilities to GDP (%) as measures for credit market depth. These country-level series are available at the World Bank Global Financial Development Database.

Due to data limitation in accessibility and efficiency of the credit market and equity market in some countries, as a robustness check, we complement this by using a comprehensive financial development index from the IMF Financial Development Index database. The index takes into account the complex multidimensional nature of financial development, it summarizes how developed financial institutions and financial markets are in terms of their depth, access, and efficiency using nine indices for over 180 countries with annual frequency from 1980 onwards. Each index is a weighted linear average of the underlying series, where the weights are obtained from principal component analysis, reflecting the contribution of each underlying series to the variation in the specific index. For more information on how the indices are defined and constructed, see [Svirydzenka, 2016]. Table (2.3) gives the descriptive statistics for each indicator used.

5. The results

5.1. The Differential Behavior Between Equity and Credit Market

Notice that the results may be biased and mixed when estimating the effect of the equity market on innovation without isolating the contribution of the credit market, and vice versa. Given this consideration, we present the results in Table (2.4) and (2.5) by controlling for the credit market when estimating the effect of the equity market. The indicator of credit market employed is private credit(% GDP), we also use the other two indicators of the credit market as a robustness check and find the results are consistent[24].

In Table (2.4), we capture the intuition by looking at whether financial development(thereafter, FD) has a nonlinear effect on innovation. The results show that equity and credit market exhibits differential effects. Specifically, the stock value traded and turnover ratio indicate a kick-in effect on innovation. That is, the equity market will not effectively promote innovation until it reaches a certain level, a larger

[24]A similar treatment holds when examining the effect of credit market by controlling for the equity market, we employ stock capitalization as control variable

and more efficient equity market means more opportunities for innovative activities because it makes it easier for firms to raise funds and use it for their risky and long-cycle projects. Since we have not considered the overall effect of the equity market on innovation, this result is partially consistent with the prediction of hypothesis 2 is the part that the effect depends upon the characteristics of the equity market. On the contrary, the development of the credit market has a diminishing effect on innovation. That is, the expansion of credit market depth may impede the innovative activities. This preliminary result on credit market is consistent with hypothesis 1.

Notice that these results do not distinguish the potential heterogeneous effect of financial development on innovation across sectors, so it is necessary to re-examine the results considering how the effects vary within sectors that have similar external financing demands. Empirically, we make the interaction between FD and EFD, and the square of FD and EFD. The results in column (1)-(3) of Table (2.5) show that both stock market depth, as measured by capitalization, and turnover ratio imposes a kick-in effect on innovation, despite the fact that the coefficient on value traded is not significant. The estimated threshold value is 95.8% and 130% of GDP, respectively. For the credit market, the inverted-U shape retains for all three indicators of credit market development, and the estimated threshold value of the credit market is between 66.7% and 90.6% of GDP. The estimated threshold values are not very large compared to most of the value documented in FD-Growth literatures, which are above 90%. In sum, Table (2.4) and (2.5) present evidence that is consistent with hypothesis 1, but partially inconsistent with hypothesis 2.

5.2. The Overall Effect of FD on Innovation

Above we distinguish the effect of credit from the equity market on innovation, but what would be the overall effect of financial development on innovation? To do this, we use the index of financial development developed by [Svirydzenka, 2016]. The broad index of financial development is constructed by synthesizing the development of the financial market and financial institutions. As shown in Table (2.6), the overall effect of FD on innovation follows an inverted-U shape. Notice that the optimal threshold value of FD bears no economic or policy implication as it is an index value rather raw number. Moving to the index of financial markets(FM), which is a weighted linear combination of equity market depth, access, and efficiency, we also find a significant diminishing effect of equity market development on innovation. This result is consistent with the prediction of hypothesis 2. We also consider three different sub-index of financial markets, i.e. depth, accessibility, and efficiency. The financial market depth synthesizes stock market capitalization to GDP, the stock traded to GDP, total debt securities of financial corporation to GDP, etc. we find significant inverted-U shape. A similar pattern is detected in the financial market access, which measures the percent of market capitalization outside of the top 10 largest companies and the total number of issuers of debt (domestic and external, fin. and nonfat. corporations) per 100,000 adults. A higher access index indicates that more firms can raise funds through the stock market. This makes it easier for firms to increases the R&D investment, on the other hand, however, firms are more inclined to allocate their R&D toward more conventional and mediocre projects, thus may reduce the quantity and quality of innovation.

Moving to the index of Financial Institution(FI), which is a weighted index of financial institution depth, access, and efficiency. We find significant inverted-U shape between the credit market and innovation. Financial institution depth is measured as the synthesis of private-sector credit to GDP, pension fund assets to GDP, Mutual fund assets to GDP, and insurance premiums to GDP. We find a significant diminishing effect on innovation. The financial institution access is defined as bank and ATM branches per 100,000 adults. This index is an indication of the scale of banking credit. We also find a clear inverted-U shape. There is no clear nonlinear effect in FI efficiency, which comprises the net interest margin, lending-deposits spread, etc. While the threshold value of these index means no clear policy implication, the turning points center around 0.5. In sum, we find results consistent with the hypotheses that financial development imposes an inverted-U effect on innovation.

6. The Robustness Checks

In this section, we design three methods to check the robustness of the results. First, we adopt the convention measures of innovation such as industry level patent counts and forward citation weighted patents by merging database Compustat North America Annual, Compustat Global Annual, and USPTO. Second, We consider how financial development affects the technology-intensive manufacturing industries. We conduct This examination for two major reasons. 1) If financial development affects innovation nonlinearly, then this effect should be more evident in the technology-intensive sector. 2) This step also serves as a way to explore the potential channel through which financial development affects innovation nonlinearly, although this is likely not a deep-rooted channel. Third, We account for the endogeneity of financial development, using legal origin, the enforceability of the contract, creditor right, anti-self dealing as instrumental variables.

6.1. Using Patent Counts and Citation weighted Patents as Measures of Innovation

Even though Research Quotient could overcome several limitations in conventional innovation measures, there are shortcomings in itself. For example, it is a market-oriented measure, which may ignore the influence of law on innovation such as intellectual property rights protection. So it is necessary to employ the conventional indicators of innovation to examine the robustness of the above results. An ideal way of doing this is to provide the Worldscope-USPTO matched patent data for each firm-year pair. However, USPTO provides GVKEY code for each firm, while Worldscope provides non-GVKEY code. A potential approach would be Fuzzy Matching by the name of assignees, but this may generate significant bias and measurement error. An alternative solution is to use data from Compustat Global Fundamentals Annual, which matches with USPTO patent database.

Notice that Compustat Global Fundamentals Annuals database does not include the Compustat North America, so we first merge the two separate databases into one. Since we focus on the innovations in the manufacturing sector, we drop the 4-digit SIC code beyond 2000 and 3999. We also drop firms with missing GVKEY because we are unable to assign the patent to these anonymous firms. In the next step, we match the USPTO patent with the firms in the merged Compustat database. USPTO provide the filing date of each patent in a D/M/Y format, we first convert this date format into the year format only. Then, we calculate the total patent application of a firm for a given year and aggregate them into the 2-digit SIC industrial level according to the concordance table between SIC 2-digit and 4-digit code. Pure patent counts do not measure the quality or importance of innovation, a better measure is to use the citation weighted patent. Similar procedures can be applied to generate the forward citation weighted patent[25]. To account for the truncation issue, we adopt a method different from Hall(2005)'s citation lag weight matrix.

1. we first generate the maximum value of patent citation within the same technology class at a given application year.

2. then generate the portion of each patents citation to the maximum citation. This step gives the relative forward citations each patent receives.

[25]We do not use pure citation data to avoid the citation lag issue

3. Find the total citation of patent that each firm has issued given an application year.

4. Aggregate the industry citation-weighted patent by summing up the value of each firm within the same 2 digit SIC industry.

The Compustat Global Fundamentals Annual database starts from the year 1987[26], so our final data comprise of 98 countries from 1987-2017[27].

Table (2.7) reports the nonlinear effect of financial development on innovation as measured by the log value of industrial-level patent counts. In this table, we remove data from the US to control for the home-bias effect because we are using the patent and citation data from USPTO. We also control for the credit market when estimating the effect of equity market development on innovation, and vice verse. The results show that there exists a significant kick-in effect in the equity market, while in the credit market, we find a diminishing effect. Specifically, the coefficient on the square term of capitalization is negative, while it is positive on the value traded and turnover ratio. Regarding the credit market, the coefficient on the square term of total private and liquidity are negative, but no significant effect on deposit credit. In particular, the threshold value of value traded and turn over ratio is 44.4% and 63.3% of GDP, respectively. In the credit market, the threshold value of liquidity is around 31% of GDP. The small threshold value of financial development using patent as an innovation measure may be attributed to the zero industrial patents in many countries. The agglomeration of zero samples may compress the threshold.

Notice that the coefficient on the square term of competition is negative while the coefficient is positive on the competition. It means both lower and higher degrees of competition may not be good for innovative activities. The optimal level of the

[26] The starting date is another important consideration why we do not use Compustat data to construct the Research Quotient database because using a 10-year rolling window significantly reduces our data coverage

[27] The third reason why use the Compustat database is that it contains more countries spanning across high income, middle income, and lower-income countries.

degree of competition is between 0.59 and 0.70.

In Table (2.8), we use the forward citation weighted patent count and the results reconfirm the patterns in previous tables. Specifically, in the equity market, value traded and turnover ratio show a kick-in effect on innovation, the coefficient on capitalization*EFD is negative, which indicates excessive stock expansion may not be good to innovation. In the credit market, however, we find a diminishing effect on innovation for total private and liquidity, but not in the deposit.

To examine the overall effect of financial development on innovation, we again use the index of FD. The indicator of innovation employed is forward citation weighted patent counts. The results in Table (2.9) show that financial development imposes a diminishing effect on innovation and is consistent with the pattern documented using RQ. In particular, the threshold value of the index is relatively smaller compared to using RQ as the independent variable, as this may due to the many zero patent samples. In unreported results, we use the patent counts as a measure of innovation and find similar results.

Combining Table (2.7), (2.8), and (2.9) we can show that credit market expansion not only hurts the quantity but also the quality of innovation. This pattern has important implications for economic growth. In recent years, several empirical studies have documented that too much finance may harm economic growth(e.g. [Arcand et al., 2015]). These studies do not explicitly explore the channels through which too much finance(or more specifically, the credit market expansion) harms the growth. Since innovation is the driving factor of growth, it is thus possible that too much finance harm growth through its diminishing effect on innovation. In [Zhu et al., 2020], we show that this diminishing effect of credit market expansion on innovation serves as a channel for too much finance phenomenon, one question remains unsettled in that paper is that we also find that the contribution of innovation on growth decreases with the level of financial development. We explain that an innovation will not be effective in promoting productivity and aggregate growth until necessary complementary inventions and follow-up investment in productive capital occurs. As the credit market develops, banks and firms develop close ties. This close firm-bank ties may facilitate firms to access credit, but it may also prevent firms from involving risky projects such as R&D activities ([Weinstein and Yafeh, 1998]), causing less productive but more pledgeable projects to be easily financed ([Cecchetti and Kharroubi, 2015]). The relatively less investment of productive capital may prolong the implementation and restructuring lags and reduce the contribution of innovation on growth. The basic idea is that credit market expansion reduces the quality of innovation and thus the growth. Our results in Table (2.8) and (2.9) confirm this hypothesis. Another note is about the equity market, we find that different dimensions of equity market may have differentiated effects, but the overall effect of equity market development has a diminishing effect on innovation, as in the credit market. Overall, this aligns with the arguments in hypothesis 2.

6.2. High Technology VS. Non-high Technology Manufacturing Sectors

In this section, we examine the differential effect of financial development on sectors with different technology intensity. [Kile and Phillips, 2009] classify 3-digit SIC code industry 283, 357, 366, 382, 384, 481, 482, 489, 737, and 873 as the high technology industries[28]. Mapping to the 2-digit SIC code, it roughly classifies 2-digit code 35(Industrial Machinery & Equipment), 36(Electronic & Other Electric Equipment), 38(Instruments & Related Products), and 48(Communications) as high technology industries. Since these studies consider the innovation in the manufacturing sector,

[28] The distribution of these codes are: Computer Hardware Manufacturing(357,367), Software Development(737), Medical Technology(283, 873), Communications(366, 481, 482, 489), Electronic Manufacturing(367), and Internet& IT Service(737). More classification details can be found at [Kile and Phillips, 2009]

we exclude SIC code 48, which belongs to the Transportation & Public Utilities sector.

To give an idea about the importance and evolution of innovation in high technology industries, we generate the share of total patents listed above to the total industry patents as a measure of the relative importance of high technology industries in terms of innovation from the merged Compustat Database. Figure (1.2) depicts the time series trends of innovation share in high technology-intensive manufacturing industries for several selected countries such as China, Japan, Canada, and France. We can see that the contribution of the high tech sector to innovation in China amount to nearly 100%, meaning that most of the innovations in China come from these two sectors, and the share tends to slow down in China since 2010. In Japan, this share increases stably but with a small speed since the late 1980s. The naked eye metric shows that the share of high technology innovation is not significantly affected by the financial crisis between 2007 and 2008. The picture is different for Canada and France. It clearly shows that, in Canada, the share of high technology industry innovation keeps climbing up and it reaches a peak by the year 2007, then suddenly fell to a level equivalent to the year 2001. The share recovered to the pre-crisis level by the year 2016. The story in France is a little bit different from that of Canada. The share of high technology industry innovation in France arrives at its peak level around mid-1990, then it began to decline since around the year 2000, the financial crisis may give a punch on this declining trend, bringing the share to its lowest level in the period examined. The share then recovers back to a level equivalent to the year 2007 by the year 2015.

The above evidences show that the financial crisis may have a mixed effect on high technology sector innovation. But do we need to worry about that? We construct the global average share of high technology industry innovation and it is presented in

Figure (1.3). We can see that the world-wide share began to increase since the late 1980s, this is largely driven by the internet boom. The share has increased exponentially from less than 20% to more than 45% by the year 2000. The process stagnated even before the financial crisis. We can detect a mild drop in the share during the crisis, but the magnitude of this fall can hardly earn its credit to be a primary concern when comparing to other drops in the entire cycle. In [Zhu et al., 2020], we also consider how the banking crisis, post-financial crisis, and the European Sovereign Debt Crisis has affected the innovation, the results show no significant impact. Another signal is that the share increases since the year 2012, which indicates that the impact of the post-financial crisis on high technology industry innovation comes to an end. Given the above considerations, we think that the impact of the financial crisis is not a major concern.

We use different indicators of financial development testing on how financial development affects high technology manufacturing industries and Non-high technology industries. The results in Table (2.10) shows that financial development has differential effects on innovation in high and non-high technology industries. Panel A of Table (2.10) shows the results for high technology manufacturing industries. We find inverted-U shape between capitalization-innovation nexus, and stock value traded-innovation nexus, the effect for turn over ratio is not significant. Meanwhile, we find that credit markets do not impose any significant effect on innovation for high tech industries. The effect flips when turning to the non-high tech industries. Specifically, we find no significant effect for the equity market, while finding a diminishing effect for the credit market, as shown in column (5) and (6) of Panel B. These indicate that equity market matters more to high technology industries, while credit market means more to non-high technology industries. A possible reason could be that high technology is more likely to access the equity market rather than the credit market due to its high risky nature of its projects. Banks are less likely to make loans to these companies and thus credit market may play a less significant role in affecting its innovative activities. In non-high technology industries, firms are more easier to access the credit market, making credit play a primary role in shaping its innovation.

Despite the differential effects detected, we find that both equity and credit markets impose a diminishing effect on innovation in its domain.

6.3. The Legal Rules as Instruments

The major obstacle to empirical research in this area is that financial development and innovation could be mutually endogenous due to the reverse causality between technological progress and financial services. Technology changes relevant for telecommunications and data processing have greatly spurred financial innovations and services in commercial banking that have facilitated secondary markets for retail loans, such as credit card debt and mortgages. For example, the introduction of Automated Teller Machines (ATMs), Debit Cards, Online Banking, and Prepaid Cards have significantly enhanced the banking account access and amount of credits ([Frame et al., 2014]). Although industry-level data can well account for the endogeneity of financial development, the technological shocks in the specific sector have a significant impact on the entire financial markets. Without addressing this, any results we find are likely to be biased.

In Table (2.12), we follow an extensive literature and rely on predetermined legal variables as instruments for both equity market and credit market development measures. The legal system is considered to be an important determinant of cross-country variations in access to external finance. Different market regulations and laws that protect investors or creditors' rights matter for their access to external finance. In particular, we use creditor right, enforcement, legal origin, and their combinations to instrument for the credit market development. While use anti-self dealing, enforcement, legal origin, and their combinations as IVs for equity market development. In column (1), (5), and (9), we report two-stage least square estimates of equation (3) using an index called Anti-self dealing(ASD, thereafter), which measures the legal protection of minority shareholders. This index is scaled between zero and one with a higher value indicating stronger shareholder protection. The IV estimate on the two interaction terms is not statistically significant at 10% for all three measures of stock market development. We then replace the ASD with a dummy variable equal to one if a country is of common law legal origin to instrument for the stock market. Legal origin is widely used to instrument for financial development because it is arguably exogenous to contemporary economic and financial development. The results are shown in column (2), (6), and (10). Again, we find no significant nonlinear effect of the stock market on innovation in the long run. Next, in column (3), (7), and (11) we consider another index named enforcement, which measures the relative degree to which contractual agreements are honored. This index is scaled from 0 to 10 with higher scores indicating higher enforceability. We find the significant inverted-U effect on innovation for all three indicators of stock market development. Finally, using ASD and legal origin as instruments returns insignificantly effect, as shown in column (4), (8), and (12). Following similar procedures, column (13)-(24) estimates the IV regressions for the credit market. Column (13), (17), and (21) uses creditor right protection as an instrument for credit market development, and show clearly that credit market development has a diminishing effect on innovation. Using legal origin as an instrument for the credit market, we find no significant effect, as indicated in columns (14), (18), and (22). Next, we replace the legal origin with the enforcement index and find a significant inverted-U relationship for all three indicators. Finally, using legal origin and creditor right protection as instruments, we find a similar inverted-U pattern.

As a comparison, we also present the baseline results for the long-run effect of financial development on innovation in Table (2.11). We find that in both the credit and equity markets, there exists a significant inverted-U shape between finance and innovation. Despite the fact that some of the IV estimates for the stock market in Table (2.12) shows no significant nonlinear effect, the overall IV results in Table (2.12) support the baseline results in Table (2.11), indicating that excessive access to the stock market and credit market financing has an important nonlinear effect on innovative activities. [29]

7. Financial Development and Market Structure

In this section, we propose an explanation as to why the overall financial development imposes a diminishing effect on innovation. An important channel through which financial development affects the innovation is altering the market structure, particularly, the market competition within the industry. The basic idea is illustrated in Figure (1.4). The blue line indicates the potential causal relationship between the three variables, while the red line refers to the reserve causal relationships. We want to show that 1) financial development affects the market structure nonlinearly, 2)then it transmits to the industrial level innovation, and 3) this process is not distorted by the potential reserve causality. Our argument consists of two major lines. In the first line, financial development eases the cost of borrowing, facilitating firms' access to credits and funds. There may exist two competing effects in this process([Aghion et al., 2019]). On one hand, it makes it easier for both large incum-

[29] In this note, we consider an alternative way to account for the endogeneity of financial development. Notice that the technologies that promote financial market mainly relate to telecommunications and data processing, which may involve technology in Telecommunications Wiring & Cabling (4-digit SIC code 1623 and 1731), Sound Systems & Equipment(SIC 3651), Security Control Equipment & Systems (SIC 3669-02), Communications Equipment NEC (SIC 3669-98), Audio and Video Equipment (SIC 3679), Wireless Communications Equipment (SIC 3679-01), Cellular and other wireless telecommunications (SIC 4812), Telecommunications except radio (SIC 4813), and Data Processing Supplies (SIC 5112). Since we focus on the manufacturing sector, therefore, the sector that causes reverse causality between financial development and innovation mainly comes from the innovation in Electronic, Electronical Equipment & Components, Except Computer Equipment (SIC 36). One way of controlling for the endogeneity issue is to remove the innovation in industry SIC 36. In unreported results, we find similar patterns.

bents and new innovative entrants to access to the credits and funds and financing the R&D projects. On the other hand, however, it also makes them less productive incumbents easier to stay on the market and depress the new entrants from entering the market using price strategy. The overall effect could be that too many financial activities promote the R&D and innovation up to a certain level, but the effects tend to diminish as the level of FD continues to expand. The key implication here is that financial development may affect the structure of the market, mainly the market competition. Therefore, to account for the nonlinear effect of financial development on innovation, it is interesting to see whether market competition affects innovation nonlinearly. The second line is about the link between market competition and innovation. Conventional thoughts on the effect of competition on innovation is a monotonic one. However, the effect could be nonlinear, as shown in [Aghion et al., 2005a]. Perfect competition and monopoly are both bad for innovation, there exists an optimal degree of market competition. A work by [Liu et al., 2019] documented similar results that market structure becomes more monopolistic as the interest rate declines.

Connecting these two lines, it is natural to reason that financial development imposes a diminishing effect on innovation via its effect on market competition. From [Aghion et al., 2005a] we know that there exists an inverted-U shape between competition and innovation, if the inverted-U between finance and innovation holds, then there may exist an inverted-U shape between finance and competition. A higher level of financial development causes an intensive market concentration, therefore reduces the innovation. The rest part of this section is to test the hypothesis that there exists an inverted-U shape between financial development and market competition. But before proceeding to the empirical part, a few words of caution about the endogeneity. First, market competition and innovation are mutually affected. In [Aghion et al., 2005a], the authors use a set of industrial policy shocks that affect the industry competition as instrumental variables, showing that the causality from competition to innovation holds robustly. Second, financial development and innovation could also be mutually endogenous. We have shown that financial development causally affects innovation. Therefore, if the nonlinear finance-competition nexus is successfully documented, then we will be able to close the transmission chain.

To test the hypothesis, we employ a simple quadratic form and regress competition on financial development and test if there exists a significant inverted-U shape between finance and competition. Notice that the measure of the competition uses the Lerner Index, which accounts for the factors that affect competition such as product differentiation and market share of large firms. In our regression, we include the initial share of value-added for the top 10 largest firms within each industry, the purpose is to control for the *strucutre inertia*. Besides, we include the industry-year fixed effects that account for the time-varying industry characteristics, such as the introduction of policy changes across industries. We also include the country fixed effects.

Table (2.13) shows that both databases give similar results that there exists a significant inverted-U shape between financial development and competition. Using the Worldscope database, we can see that more finance promotes competition in the first stage and then reduces it in industries that are more dependent upon external financing. The turning point is between 96.6%-150% of GDP. Using the merged Compustat Global database, stock value traded and liquidity give a significant diminishing effect on innovation. The threshold is 55% and 50% of GDP, respectively. Collectively, the threshold range is similar to that of in Table (2.5) and (2.7). This indicates that the effect of financial development on competition could serve as a channel for the nonlinear effect of financial development on innovation.

To further test this statement, consider the following specification

$$inno_{cit} = \sigma_0 + \alpha \text{valueadd}_{ci,1989} + EFD_{cit} * (\beta \text{comp}_{cit} + \gamma \text{comp}_{ct} * FD_{ct}) + \delta \mathbf{X}_{cit} + \eta_{c,t} + \mu_i + \varepsilon_{cit} \tag{21}$$

where $inno_{cit}$ is the innovation and comp_{cit} indicates the degree of competition. The interpretation of this specification is that if competition serves as a channel, then the effect of competition on innovation is dependent upon the level of financial development. In industries that rely more on external financing, more finance causes less competition and thus reduce innovation. We expect the coefficient γon the interaction term $\text{comp}_{ct} * FD_{ct}$ to be negative.

Table (2.14) summarizes the results using different measures of innovation from two databases. Panel A uses RQ as an indicator of innovation, we can see that the coefficient on the interaction term between competition and financial development is negative, with stock capitalization as an exception. Meanwhile, the coefficient of competition is positive for most indicators. Combining these two pieces of evidence, it can be induced that the marginal effect of competition on innovation, $EFD_{cit} * (\beta + \gamma * FD_{ct})$, decreases with the level of financial in industries that rely more on external financing. Take total private as a percentage of GDP as an example, the marginal effect of competition on innovation is $EFD * (0.007 - 0.007 * FD)$, if EFD is positive, then the marginal effect turns to negative as the level of private credits exceeds 100% of GDP. The decreasing marginal effects hold as we switch to the Compustat database. Panel B uses patent counts as a measure of innovation, we find a negative coefficient of the interaction term on stock capitalization, total private, liquidity, and deposit credit. Panel C uses the citation weighted patent counts and find that the coefficients on the interaction term for indicators in both equity and credit markets are negative, in particular, the coefficient on competition is positive as well.

8. The Heterogeneous Effects by Stages of Development

To examine whether this effect varies for countries with different development stages, we split the sample into two groups based on the income level by twisting a little bit the World Bank Country Classification System. The upper and lower-middle-income countries are categorized into a middle-income country, the rest countries are high-income country. Grouping the country based on the level of financial development generates similar results since high-income countries overlap with the high level of FD countries. In Table (2.15), we control the effect of the credit market when examining the effect of equity market on innovation, and vice versa. The results in Table (2.15) indicates two patterns. regarding the high-income group, we find that there exists a significant diminishing effect of financial development on innovation in both equity and credit market. While another picture emerges in the middle-income group, for both the credit and equity market, financial development exhibits a clear U-shape effect on innovation. For each indicator of financial development, the estimated threshold values in the high and middle groups are close. For example, the estimated threshold value of stock capitalization is 155.5% of GDP for high-income countries, it is 114.2% of GDP in middle-income countries. For the turnover ratio, it is 100% in the high-income group, and it is 91.6% in the middle-income group. We also examine this using Compustat database and the index of financial development, we find a robust result for this pattern, as shown in Table (2.16) and (2.17). Combine these two patterns we find that in a similar threshold range, the effect of financial development on innovation behaves differently between the high and the middle-income countries. As illustrated in Figure (1.5), after exceeding the threshold range, financial development begins to impede innovation in the high-income group, while it begins to foster innovation in middle-income countries. This evidence contradicts the arguments in the hypothesis, in which it may apply to the developed countries but not the middle-income countries. Why?

We think this relates to the financial development, types of innovation, and market competition. Most firms in emerging markets(or developing countries) are engaged in activities far from the technological frontier, the innovation in these economies is mainly about adopting new ideas and technologies already in use in more developed countries ([Zanello et al., 2016]). This matters for market power because different types of innovation means different impacts on market competition. In emerging markets, using external finance has a significant positive effect on the extent of firm innovation, such as introducing a new product line, upgrading existing product lines, and opening a new plant([Ayyagari et al., 2011])[30]. Most of these innovative activities is not about introducing new products or new inventions, therefore, it has less power to reshape the market structure. While in most developed countries, the firm innovation is about bringing in new products, which may lead to market concentration and the creation of monopolistic power. The intensity of competition relates to innovation is an Inverted-U shape, as shown in [Aghion et al., 2005a], it spurs innovation among the more technologically advanced incumbents and discourages laggard firms from innovating, causing the distance between leaders and followers to increase. Combining these three elements we can depict the timeline of the story. Financial development promotes innovation in both developing countries and developed countries, however, more finance may impede innovation in developed economies because the easier availability of external finance makes it easier to generate new technology frontier, which may lead to further market concentration due to the monopolistic power of new products. While the market structure in an emerging market is less likely to

[30]Notice that in [Ayyagari et al., 2011], the author adopts a more broadly defined measure of innovation based on the World Bank Enterprise Survey

be affected because most of the innovation is by adopting technology in developed countries, this follower-strategy gives less superiority to firms in developing countries.

9. Concluding Remarks

In this paper, we conduct a thorough study on the nonlinear effect of financial development on innovation as well as the potential channels. We construct a unique cross country Research Quotient database from the Worldscope Fundamentals Annual for 48 countries from 1980 to 2017. We also use another database by merging the Compustat North America, Global Annual, and USPTO to check the robustness, this database consists of 98 countries from 1987-2017. We find a significant overall nonlinear effect of financial development on innovation. When examining different characteristics of the credit market and equity market, we find the effect differs. In particular, there exists weak evidence of the kick-in effect in the equity market, but the diminishing effect of the credit market is solid and robust. We also find that equity markets impose an inverted-U effect on innovation in high technology sectors, while credit markets have an inverted-U effect on innovation in non-high technology industries. We then explain the overall diminishing effect. We find that the nonlinear effect of financial development on market competition serves as a potential channel through which finance affects innovation nonlinearly. In the final section, we show that the effect of financial development on innovation may be country-specific. It is heterogeneous across different stages of development. In emerging markets, despite the types of financial markets, there exists a kick-in effect on innovation, however, it is a diminishing effect on innovation for developed countries.

This research calls for a comprehensive measurement of financial development. As mentioned above, the widely adopted indicators of financial development developed by the World Bank provide a single-dimension measure of financial system, reflecting characteristics such as depth, accessibility, and efficiency. One merit of these indicators is that they convey real economic meanings and it enables the researchers to provide specific instructions for policymakers, however, it limits the scholars to view the financial system as a whole. What could be a better way to synthesize different indicators to provide a systematic indicator while preserving economic meaning is a question that remains to be explored.

A possible extension to this current work is to give a thorough study on the possible heterogeneous effects between emerging and developed economies and provide explanations to it.

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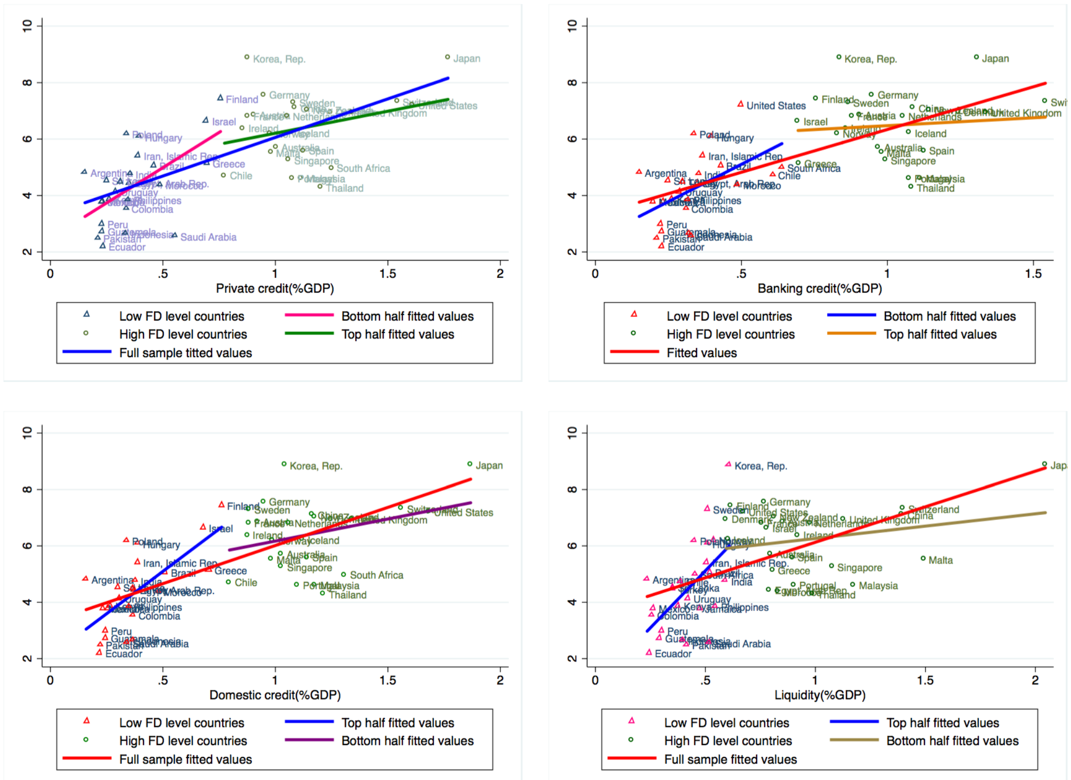
Table 1.1: Summary statistics

Variable	Mean	Median	Std. Dev.	Min.	Max.	N
	Innovation regression					
Patent	5.351	5.353	1.726	1.075	9.169	300
Utility models	3.808	3.747	2.273	-1.531	7.985	294
R&D	1.266	0.892	1.054	0.05	4.26	276
FDI	0.048	0.021	0.169	-0.04	2.691	300
GDP/capita	9.773	9.946	0.851	7.502	11.311	300
Population	17.003	17.096	1.651	12.471	21.039	300
Schooling	8.906	9.06	2.654	2.42	13.4	300
IP	3.435	3.68	1.051	0.2	4.875	300
	Growth regression					
Growth rate	0.023	0.019	0.025	-0.045	0.244	300
Govt	0.163	0.164	0.05	0.055	0.3	300
Trade	0.754	0.601	0.587	0.156	4.109	300
Investment	0.237	0.228	0.058	0.098	0.474	300
Inflation	0.195	0.032	1.365	-0.017	16.672	300
Initial GDP/capita	9.496	9.509	0.877	7.502	10.755	300
	Indicators of Financial Development					
Private credit	0.742	0.685	0.479	0.079	2.223	300
Banking credit	0.674	0.567	0.439	0.066	2.223	300
Domestic credit	0.756	0.651	0.495	0.115	2.359	300
Liquidity	0.690	0.602	0.392	0.137	2.126	300
Banking crisis	0.23	0	0.422	0	1	300

Note: Five year average data reported. Patent: patent per 100 billion dollars. R&D: R&D spending as percentage of GDP. IP: Index of protection for intellectual property right. Obatained from [Park, 2008], the author updated data to 2015. WIPO: World Intellectual Property Organization; WDI: World Development Indicators; UN-HDI: United Nations Human Development Index; WBFSD: World Bank Financial Structure Database. The financial development missing data for New Zealand is filled using data from Reserve Bank of New Zealand(https://www.rbnz.govt.nz/statistics). Banking Crisis is obtained from [Laeven and Valencia, 2013], Systemic Banking Crises Database(1970-2011). The data from 2012 to 2016 are extended by the author by searching key words that indicates a banking crisis for each country between 2012 and 2016. Key words includes bank run, bank crisis and illiquidity.

Figure 1.1: Financial development and innovation



Note: Countries are sorted according to the level of financial development(FD). This figure splits the countries into two groups: low FD countries and high FD countries. Each group contains 25 countries. This figure uses patent as proxy for innovation.

Table 1.2: Financial development and Innovation: 1990-2016

	Dependent var: Percentage change in patents				
	Full	**MIC**	**HIC**	**LFD**	**HFD**
L.Patent	0.024	-0.258*	0.006	-0.273***	-0.021
	(0.073)	(0.145)	(0.049)	(0.088)	(0.064)
Private credit	0.353*	0.394**	0.183	0.837**	0.229
	(0.181)	(0.194)	(0.158)	(0.401)	(0.153)
FDI	0.086	9.877	0.139***	-0.975	-0.118
	(0.082)	(10.310)	(0.048)	(1.229)	(0.344)
Population	0.019	0.161***	0.033	0.121**	0.004
	(0.048)	(0.060)	(0.022)	(0.060)	(0.029)
GDP/capita	0.191	-0.275	0.194	0.452	0.109
	(0.336)	(0.553)	(0.251)	(0.347)	(0.249)
Schooling	-0.115**	0.080	-0.089***	0.015	-0.072
	(0.046)	(0.121)	(0.027)	(0.064)	(0.054)
IP	-0.039	-0.064	-0.092	-0.020	0.072
	(0.133)	(0.181)	(0.074)	(0.137)	(0.121)
Obs	250	110	140	125	125
Countries	50	22	28	25	25
AR(2) test	0.130	0.232	0.392	0.250	0.215
Hansen J test	0.240	0.859	0.365	0.505	0.483

Note: Robust standard errors in parentheses. All variables are five years average values; Windmeijer correction method is applied for each regression; MIC: Middle income countries; HIC: High income countries; LFD: Low financial development countries; HFD: High financial development countries. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.3: Financial development, Innovation, and Growth: 1990-2016

	Dependent var: Growth of GDP per capita				
	Full	**MIC**	**HIC**	**LFD**	**HFD**
L.Growth	0.170	-0.119	-0.246**	0.041	0.097
	(0.366)	(0.189)	(0.098)	(0.381)	(0.183)
Patent	0.004*	0.011**	0.002	0.008**	0.001
	(0.002)	(0.005)	(0.005)	(0.004)	(0.003)
Govt	-0.070	-0.262***	0.001	-0.122*	-0.001
	(0.043)	(0.082)	(0.042)	(0.067)	(0.046)
Trade	0.004*	0.004	0.006**	0.006	0.006***
	(0.002)	(0.010)	(0.003)	(0.010)	(0.002)
Investment	-0.029	-0.012	0.309***	0.057	0.153***
	(0.136)	(0.117)	(0.109)	(0.075)	(0.058)
Inflation	-0.012	-0.001	0.005	-0.006	-0.120
	(0.019)	(0.032)	(0.052)	(0.029)	(0.166)
Schooling	0.000	0.001	0.000	0.000	0.001
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Initial	-0.009**	-0.011	-0.023**	-0.009	-0.013***
	(0.004)	(0.009)	(0.009)	(0.007)	(0.004)
Obs	250	110	140	125	125
Countries	50	22	28	25	25
AR(2) test	0.236	0.120	0.145	0.152	0.433
Hansen J test	0.187	0.667	0.148	0.357	0.126

Note: Standard errors in parentheses. All variables are five years average values; Windmeijer correction method applied for each regression; MIC: Middle income countries; HIC: High income countries; LFD: Low financial development countries; HFD: High financial development countries. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.4: The effect of innovation on growth with level of financial development:1990-2016

	Dependent var: Growth rate of GDP per capita			
	Private credit	**Banking credit**	**Domestic credit**	**Liquidity**
L.Growth	-0.009	0.026	-0.001	-0.011
	(0.113)	(0.287)	(0.104)	(0.153)
Patent	0.012***	0.014**	0.014***	0.010***
	(0.003)	(0.005)	(0.003)	(0.003)
FD*Patent	-0.006**	-0.006*	-0.006**	-0.005*
	(0.003)	(0.004)	(0.003)	(0.003)
Govt	-0.066	-0.028	-0.095*	-0.056
	(0.051)	(0.057)	(0.050)	(0.042)
Trade	0.005	0.009**	0.005*	0.009**
	(0.003)	(0.004)	(0.003)	(0.004)
Investment	0.096	0.078	0.092	0.116
	(0.067)	(0.067)	(0.061)	(0.082)
Inflation	-0.075	-0.056	-0.072	-0.056
	(0.063)	(0.055)	(0.059)	(0.042)
Schooling	0.001	-0.000	0.001	0.000
	(0.002)	(0.001)	(0.002)	(0.002)
Initial	-0.007**	-0.010***	-0.008***	-0.013***
	(0.003)	(0.004)	(0.003)	(0.004)
Obs	250	250	250	250
Countries	50	50	50	50
AR(2) test	0.152	0.173	0.172	0.119
Hansen J test	0.918	0.769	0.956	0.598

Note: Standard errors in parentheses. All variables are five years average values; Windmeijer correction method is applied for each regression; FD is the indicators of financial development, it includes Banking credit, private credit, liquidity liability, and domestic credit. FD*Patent is the interaction between financial development and patent. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.5: Financial development in crisis and tranquil period

Vars	Ave. (BC=1)	Ave. (BC=0)	diff	standard error	t-statistics	p-value
PC1	0.90	0.67	-0.23***	0.056	-4.019	0.000
PC2	0.83	0.61	-0.22***	0.052	-4.217	0.000
LL	0.75	0.64	-0.11**	0.045	-2.204	0.027
DC	0.92	0.71	-0.21***	0.041	-5.037	0.000

Notes: PC1 refers to private credit by banks and other financial institutions(%GDP); PC2 refers to private credit by deposite money banks(%GDP); LL is liquidity liability(%GDP). DC is domestic private credit(%GDP). BC is short for banking crisis, it equals to 1 if there is banking crisis event in that year, and 0 if otherwise. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.6: Banking crisis, innovation, and growth:1990-2016

	Dependent var: Growth rate		
	(1)	**(2)**	**(3)**
L.Growth	0.520	0.363	0.087
	(0.368)	(0.283)	(0.201)
Patent	0.007***	0.006***	0.007**
	(0.003)	(0.002)	(0.004)
BC	-0.002	-0.010	0.000
	(0.031)	(0.032)	(0.030)
BC*Patent	-0.001	0.000	-0.001
	(0.005)	(0.006)	(0.005)
Initial	-0.012***	-0.009***	-0.012***
	(0.004)	(0.003)	(0.004)
Govt		-0.048	-0.070*
		(0.033)	(0.041)
Trade		0.005*	0.006**
		(0.003)	(0.003)
Schooling		-0.001	-0.001
		(0.001)	(0.001)
Investment			-0.041
			(0.066)
Inflation			0.006
			(0.030)
Obs	250	250	250
Countries	50	50	50
AR(2) test	0.618	0.538	0.115
Hansen J test	0.532	0.603	0.152

Note: Standard errors in parentheses. All variables are five years average values; Windmeijer correction method is applied for each regression; BC is short for banking crisis, it equals to 1 if there is banking crisis event in that year, and 0 if otherwise. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.7: Impact of financial crisis and European debt crisis on innovation recovery:2009-2016

	High income	**Middle income**	**High QOG**	**Low QOG**
	Panel A: Innovation resilience post 2007-2008 financial crisis			
Sinking ratio	39.2%	22.7%	38.4%	25%
Ave. years to recover	0.50	1.43	0.43	1.39
Ave. years of first turning point	0.34	0.33	0.28	0.24
Ratio of negative growth since 2010	67.86%	50%	69.23%	50%
	Panel B: Financial development since 2010(mean values)			
Banking credit	94.31%	39.47%	101.93%	39.23%
Private credit	102%	44.05%	112.91%	43.79%
Liquidity	89.18%	52%	92.26%	51.99%
Domestic credit	99.26%	45.71%	112.39%	44.71%

Note: Financial crisis between 2007 and 2008. Take year 2009 as the initial year post crisis. **Sinking ratio** is defined as the ratio of countries whose innovation level do not recover back to its pre-crisis level through the period examined in our sample; **Average years to recover** refers to the average years needed to return back to pre-crisis level for those recovery countries; **Average years of first turning point** calculates the average years needed for the first positive growth of innovation post crisis. **Ratio of negative growth since 2010** measures the ratio of countries with negative average growth rate of innovation since 2010. Pre-crisis innovation level are calculated as the average innovation level of 2005 and 2006.

Table 1.8: The impact of post financial crisis and european sovereign debt crisis on innovation

	Dependent var: Growth of patent			
	Private credit	**Banking credit**	**Domestic credit**	**Liquidity**
L.Patent	-0.116	-0.122	-0.122	-0.028
	(0.100)	(0.109)	(0.098)	(0.055)
LC	0.133	0.104	0.093	0.126
	(0.144)	(0.140)	(0.122)	(0.111)
FD	0.472***	0.425***	0.377***	0.187
	(0.129)	(0.114)	(0.143)	(0.186)
LC*FD	-0.266**	-0.271**	-0.200*	-0.254**
	(0.135)	(0.133)	(0.111)	(0.126)
FDI	0.305	0.365	0.309	-0.386
	(0.427)	(0.418)	(0.421)	(0.573)
Population	0.066	0.088	0.066	0.032
	(0.075)	(0.080)	(0.082)	(0.066)
GDP/capita	0.374	0.395	0.412	0.146
	(0.428)	(0.489)	(0.486)	(0.372)
Schooling	-0.079	-0.065	-0.082	-0.046
	(0.062)	(0.066)	(0.065)	(0.062)
IP	-0.049	-0.054	-0.049	0.024
	(0.090)	(0.092)	(0.094)	(0.090)
Obs	250	250	250	250
Countries	50	50	50	50
AR(2) test	0.121	0.105	0.112	0.118
Hansen J test	0.542	0.670	0.566	0.664

Note: Robust standard errors in parentheses. All variables are five years average values; Windmeijer correction method is applied for each regression; FD is the indicators of financial development, it includes Banking credit, private credit, liquidity liability, and domestic credit. LC is a dummy equals to 1 if after 2009, and it is 0 if otherwise. LC*FD is the interaction between financial development and LC. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.9: Ruling out the the impact of post financial crisis and european sovereign debt crisis on innovation: 1990-2009

	Dependent var: Growth of GDP per capita				
	Full	**MIC**	**HIC**	**LFD**	**HFD**
L.Growth	0.188	-0.013	-0.300**	-0.162	-0.081
	(0.354)	(0.239)	(0.146)	(0.141)	(0.345)
Patent	0.003*	0.014***	-0.006	0.005**	-0.000
	(0.002)	(0.005)	(0.004)	(0.002)	(0.003)
Govt	-0.021	-0.173	0.041	-0.040	0.079
	(0.031)	(0.129)	(0.104)	(0.061)	(0.061)
Trade	0.002	0.007	0.000	0.000	0.004
	(0.002)	(0.008)	(0.004)	(0.008)	(0.004)
Investment	0.092	-0.113	0.693*	0.035	0.265**
	(0.131)	(0.086)	(0.401)	(0.103)	(0.111)
Inflation	-0.002	0.029	-0.027	0.003	-0.058
	(0.015)	(0.025)	(0.088)	(0.019)	(0.096)
Schooling	0.000	0.000	0.003	0.001	-0.000
	(0.001)	(0.002)	(0.003)	(0.001)	(0.002)
Initial	-0.009***	-0.019**	-0.021***	-0.010*	-0.013***
	(0.002)	(0.009)	(0.008)	(0.005)	(0.004)
Obs	150	66	84	75	75
Countries	50	22	28	25	25
AR(2) test	0.236	0.089	0.242	0.106	0.221
Hansen J test	0.183	0.518	0.741	0.543	0.127

Note: Robust standard errors in parentheses. All variables are five years average values; Windmeijer correction method is applied for each regression. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.10: Dynamic Panel Threshold Analysis: Innovation regression

	Private credit	**Banking credit**	**Domestic credit**	**Liquidity**
Threshold($\hat{\gamma}$)	0.480***	0.479***	0.527***	0.496***
	(0.043)	(0.044)	(0.033)	(0.130)
Financial development				
$\hat{\beta}_L(FD \leq \gamma)$	1.339***	1.246***	1.184***	0.329**
	(0.237)	(0.219)	(0.215)	(0.176)
$\hat{\beta}_H(FD > \gamma)$	0.030	0.096	-0.060	-0.345***
	(0.234)	(0.218)	(0.204)	(0.109)
L.Patent	0.632***	0.596***	0.603***	0.570***
	(0.028)	(0.039)	(0.029)	(0.038)
FDI	-0.048*	-0.025***	-0.024*	-0.034
	(0.026)	(0.033)	(0.010)	(0.022)
Population	0.048	0.095	0.230	-0.109
	(0.444)	(0.327)	(0.169)	(0.319)
GDP/capita	0.302***	0.359*	0.069	0.486***
	(0.068)	(0.097)	(0.106)	(0.094)
IP	0.259***	0.237***	0.243***	0.202***
	(0.042)	(0.044)	(0.032)	(0.038)
Schooling	-0.037	-0.031	0.023***	0.032
	(0.025)	(0.025)	(0.007)	(0.028)
Obs	250	250	250	250
Countries	50	50	50	50
Linearity test(p-value)	0.000	0.000	0.000	0.000
m_2	0.497	0.310	0.234	0.14
J(p-value)	0.94	0.94	0.36	0.94

Note: The null of linearity test is H_0: $\hat{\beta}_L = \hat{\beta}_H$. m_2 tests for lack of second order serial correlation in the residuals. If this test rejects the null hypothesis, then the moment restrictions are not valid and the GMM estimator will be inconsistent. The J test is a specification test which means that if it rejects, either the orthogonality conditions, or other assumptions, or both are false. Robust standard errors in the parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.11: Dynamic Panel Threshold Analysis: Growth regression

	Private credit	**Banking credit**	**Domestic credit**	**Liquidity**
Threshold($\hat{\gamma}$)	0.584***	0.585***	0.577***	1.367***
	(0.017)	(0.023)	(0.032)	(0.067)
Innovation				
$\hat{\beta}_L$(FD$\leq\gamma$)	0.010***	0.009***	0.006*	-0.009***
	(0.002)	(0.001)	(0.003)	(0.001)
$\hat{\beta}_H$(FD$>\gamma$)	-0.008***	-0.007***	-0.008***	-0.005***
	(0.002)	(0.001)	(0.002)	(0.001)
L.Growth	-0.440***	-0.479***	-0.380***	-0.392***
	(0.016)	(0.037)	(0.018)	(0.031)
Schooling	0.008***	0.008***	0.009***	0.009***
	(0.000)	(0.001)	(0.001)	(0.001)
Govt	-0.514***	-0.733***	-0.572***	-0.936***
	(0.045)	(0.072)	(0.074)	(0.082)
Investment	0.221***	0.248***	0.256***	0.241***
	(0.019)	(0.018)	(0.013)	(0.017)
Trade	0.013***	0.017***	0.016***	0.015***
	(0.003)	(0.004)	(0.002)	(0.004)
Inflation	0.004	0.005	-0.011	-0.033***
	(0.003)	(0.005)	(0.006)	(0.011)
Obs	250	250	250	250
Countries	50	50	50	50
Linearity test(p-value)	0.000	0.000	0.000	0.000
m_2	0.03	0.05	0.15	0.04
J(p-value)	0.36	0.94	0.36	0.99

Note: The null of linearity test is H_0: $\hat{\beta}_L = \hat{\beta}_H$. m_2 tests for lack of second order serial correlation in the residuals. If this test rejects the null hypothesis, then the moment restrictions are not valid and the GMM estimator will be inconsistent. The J test is a specification test which means that if it rejects, either the orthogonality conditions, or other assumptions, or both are false. Robust standard errors in the parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

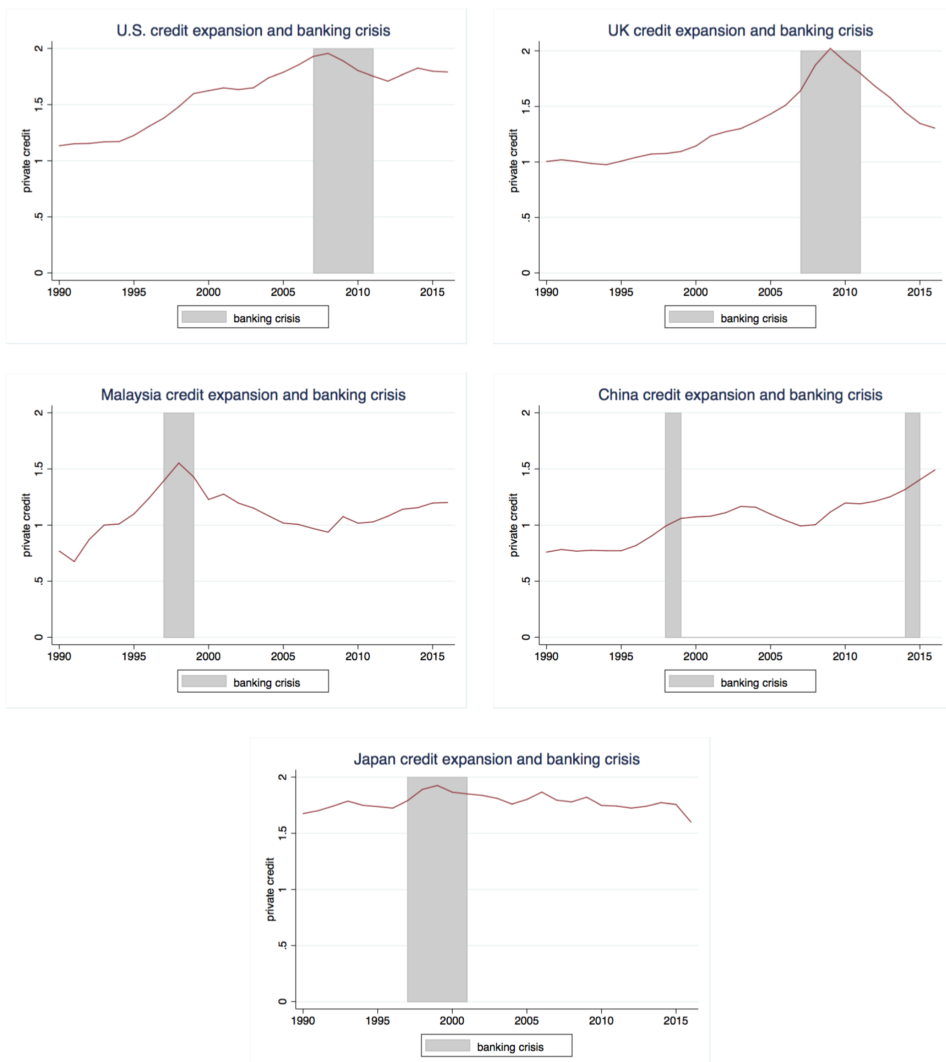
Table 1.12: Dynamic Panel Threshold Analysis: Growth regression without interaction between finance and patent

	Private credit	**Banking credit**	**Domestic credit**	**Liquidity**
Threshold($\hat{\gamma}$)	0.591***	0.598***	0.611***	0.730***
	(0.034)	(0.033)	(0.025)	(0.252)
Financial development				
$\hat{\beta}_L$(FD$\leq\gamma$)	0.034**	0.052***	0.022*	0.086*
	(0.015)	(0.008)	(0.010)	(0.047)
$\hat{\beta}_H$(FD$>\gamma$)	-0.056***	-0.039***	-0.048***	0.012
	(0.015)	(0.006)	(0.008)	(0.027)
L.Growth	-0.271***	-0.381***	-0.312***	-0.034
	(0.027)	(0.055)	(0.043)	(0.103)
Schooling	0.005***	-0.002	-0.002	-0.009*
	(0.001)	(0.005)	(0.002)	(0.005)
Govt	-0.004***	0.001	-0.001	-0.005
	(0.000)	(0.004)	(0.026)	(0.006)
Investment	0.069***	0.061***	0.072***	0.109
	(0.012)	(0.014)	(0.019)	(0.075)
Trade	-0.006	0.025***	0.027	0.004
	(0.005)	(0.005)	(0.004)	(0.023)
Inflation	-0.008***	-0.008***	-0.009***	-0.001
	(0.001)	(0.002)	(0.002)	(0.009)
Obs	250	250	250	250
Countries	50	50	50	50
Linearity test(p-value)	0.000	0.000	0.000	0.000
m_2	0.07	0.05	0.08	0.029
J(p-value)	0.36	0.94	0.94	0.03

Note: The null of linearity test is H_0: $\hat{\beta}_L = \hat{\beta}_H$. m_2 tests for lack of second order serial correlation in the residuals. If this test rejects the null hypothesis, then the moment restrictions are not valid and the GMM estimator will be inconsistent. The J test is a specification test which means that if it rejects, either the orthogonality conditions, or other assumptions, or both are false. Robust standard errors in the parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

APPENDIX

Figure 1.A1: Credit Expansion and Banking Crisis



Note: Shaded area indicates a banking crisis in that year. Original database on Banking Crisis is obtained from [Laeven and Valencia, 2013], Systemic Banking Crises Database(1970-2011). The data from 2012 to 2016 are extended by the author by searching key words that indicates a banking crisis for each country between 2012 and 2016. Key words includes bank run, bank crisis and illiquidity.

Table 1.A1: Robustness check for innovation regression 1: 1990-2016

	Dependent var: Percentage change in patents														
	Banking credit					Domestic credit					Liquidity				
	Full	**MIC**	**HIC**	**LFD**	**HFD**	**Full**	**MIC**	**HIC**	**LFD**	**HFD**	**Full**	**MIC**	**HIC**	**LFD**	**HFD**
L.Patent	0.007	-0.327**	0.007	-0.160**	0.051	0.020	-0.274*	0.006	-0.316***	0.090	-0.044	-0.361**	-0.013	-0.610*	-0.120
	(0.062)	(0.165)	(0.035)	(0.065)	(0.084)	(0.072)	(0.153)	(0.050)	(0.073)	(0.068)	(0.066)	(0.150)	(0.044)	(0.371)	(0.181)
FD	0.260*	0.621**	0.152	0.626*	0.176*	0.247**	0.414**	0.133	0.840**	0.123	0.302*	0.536***	0.029	0.545**	0.105
	(0.147)	(0.242)	(0.116)	(0.378)	(0.093)	(0.124)	(0.204)	(0.123)	(0.367)	(0.312)	(0.160)	(0.205)	(0.095)	(0.239)	(0.116)
FDI	0.114	12.374	0.151***	-1.398	0.069	0.097	9.934	0.144***	-0.098	0.048	0.109	16.523	-0.205	-0.488*	-0.123
	(0.077)	(13.534)	(0.043)	(1.846)	(0.058)	(0.077)	(10.829)	(0.047)	(0.678)	(0.116)	(0.381)	(12.646)	(0.194)	(0.266)	(0.157)
Population	0.037	0.174**	0.044*	0.087**	-0.026	0.017	0.163**	0.032	0.108**	-0.084	0.017	0.192**	0.014	0.100	0.068
	(0.043)	(0.079)	(0.024)	(0.034)	(0.045)	(0.047)	(0.064)	(0.021)	(0.054)	(0.089)	(0.064)	(0.084)	(0.027)	(0.095)	(0.077)
GDP/capita	0.197	-0.338	0.184	0.195	-0.010	0.174	-0.279	0.252	0.190	-0.477	0.166	-0.353	0.299*	0.856	0.694
	(0.324)	(0.638)	(0.209)	(0.188)	(0.330)	(0.337)	(0.577)	(0.206)	(0.341)	(0.511)	(0.445)	(0.553)	(0.155)	(0.816)	(0.549)
Schooling	-0.095**	0.095	-0.085***	0.025	-0.121***	-0.108**	0.079	-0.091***	0.061	-0.052	-0.092	0.113	-0.091***	0.004	-0.123***
	(0.046)	(0.139)	(0.022)	(0.060)	(0.044)	(0.045)	(0.125)	(0.026)	(0.067)	(0.066)	(0.057)	(0.135)	(0.020)	(0.196)	(0.037)
IP	-0.029	-0.058	-0.084	-0.073	0.067	-0.010	-0.065	-0.091	0.048	0.245*	0.015	-0.080	-0.024	0.145	-0.070
	(0.130)	(0.191)	(0.064)	(0.108)	(0.181)	(0.126)	(0.185)	(0.074)	(0.160)	(0.135)	(0.134)	(0.197)	(0.074)	(0.499)	(0.191)
Obs	250	110	140	125	125	250	110	140	125	125	250	110	140	125	125
Countries	50	22	28	25	25	50	22	28	25	25	50	22	28	25	25
AR(2) test	0.113	0.270	0.360	0.095	0.339	0.116	0.236	0.348	0.365	0.105	0.119	0.295	0.302	0.690	0.130
Hansen J test	0.190	0.818	0.464	0.868	0.362	0.293	0.846	0.365	0.632	0.556	0.143	0.800	0.564	0.814	0.382

Note: Robust standard errors in parentheses. All variables are five year average values; Windmeijer correction method applied for each regression; For each indicator the high and low financial development group are classified using 50 percentile as cutoff. MIC: middle income countries; HIC: high income countries; LFD: low level of financial development countries; HFD: high level of financial development countries. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.A2: Robustness checks for growth regression (2): 1990-2016

	Dependent var: Growth rate of GDP per capita					
	Banking credit		**Domestic credit**		**Liquidity**	
	LFD	**HFD**	**LFD**	**HFD**	**LFD**	**HFD**
L.Growth	-0.097	0.218	0.041	0.097	-0.135	0.080
	(0.252)	(0.194)	(0.381)	(0.183)	(0.276)	(0.252)
Patent	0.010***	-0.006	0.008**	0.001	0.008**	0.003
	(0.003)	(0.008)	(0.004)	(0.003)	(0.003)	(0.004)
Govt	-0.078	-0.010	-0.122*	-0.001	-0.091*	-0.037
	(0.066)	(0.085)	(0.067)	(0.046)	(0.052)	(0.067)
Trade	0.008	0.002	0.006	0.006***	0.001	0.006
	(0.007)	(0.003)	(0.010)	(0.002)	(0.011)	(0.004)
Investment	0.072	0.075	0.057	0.153***	0.089	0.156
	(0.054)	(0.112)	(0.075)	(0.058)	(0.067)	(0.114)
Inflation	-0.019	-0.222	-0.006	-0.120	-0.026	0.113
	(0.040)	(0.262)	(0.029)	(0.166)	(0.038)	(0.095)
Schooling	-0.001	0.002	0.000	0.001	-0.000	0.001
	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)
Initial	-0.011*	-0.014***	-0.009	-0.013***	-0.010**	-0.011*
	(0.006)	(0.004)	(0.007)	(0.004)	(0.005)	(0.006)
Obs	125	125	125	125	125	125
Countries	25	25	25	25	25	25
AR(2) test	0.154	0.413	0.152	0.433	0.127	0.239
Hansen J test	0.512	0.151	0.357	0.126	0.268	0.102

Note: Standard errors in parentheses. All variables are five years average values; Windmeijer correction method applied for each regression; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1.A2: Kernel density of four indicators of financial development

Note: Estimated density of indicators of financial development using Epanechnikov kernal density

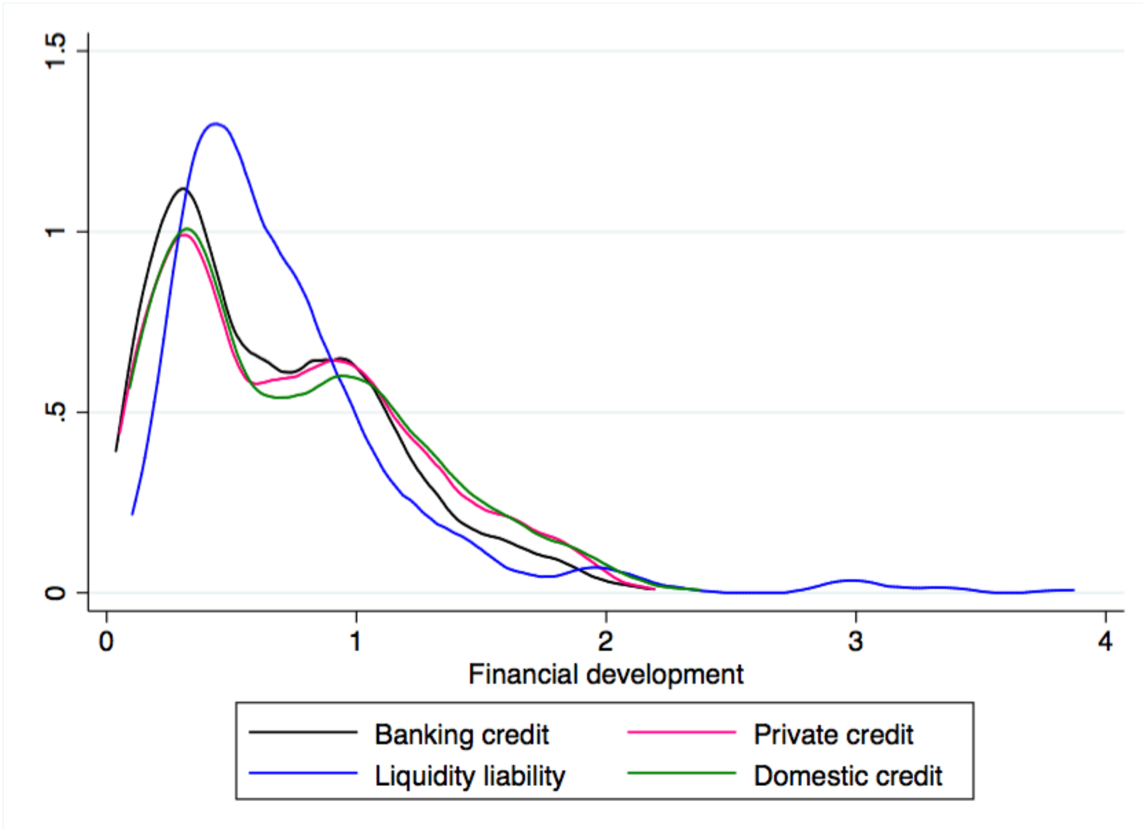


Table 1.A3: Dynamic Panel Threshold Analysis: Innovation regression (R&D)

	Dependent var: R&D (% of GDP)			
	Private credit	**Banking credit**	**Domestic credit**	**Liquidity**
Threshold($\hat{\gamma}$)	0.443***	0.441***	0.389***	0.610***
	(0.113)	(0.095)	(0.085)	(0.156)
Financial development				
$\hat{\beta}_L(FD \leq \gamma)$	1.157***	0.879***	1.319***	0.837***
	(0.210)	(0.159)	(0.367)	(0.092)
$\hat{\beta}_H(FD > \gamma)$	-0.054	0.145	0.196	0.016
	(0.039)	(0.149)	(0.352)	(0.160)
L.R&D	0.398***	0.435***	0.294***	0.415***
	(0.057)	(0.055)	(0.066)	(0.033)
FDI	-0.016	-0.274	-0.034*	-0.001
	(0.282)	(0.265)	(0.018)	(0.026)
Population	0.171	-0.140	0.569*	-0.254
	(0.126)	(0.263)	(0.322)	(0.226)
GDP/capita	-0.012	0.164	0.029	0.127**
	(0.026)	(0.109)	(0.106)	(0.065)
IP	0.036	-0.214	0.015	0.072***
	(0.024)	(0.260)	(0.019)	(0.024)
Schooling	0.119**	0.026	0.061***	0.019
	(0.054)	(0.027)	(0.017)	(0.019)
Obs	230	230	230	230
Countries	46	46	46	46
Linearity test(p-value)	0.000	0.000	0.000	0.000
m_2	0.13	0.12	0.1	0.16
J(p-value)	1	1	0.99	0.99

Note: The null of linearity test is H_0: $\hat{\beta}_L = \hat{\beta}_H$. m_2 tests for lack of second order serial correlation in the residuals. If this test rejects the null hypothesis, then the moment restrictions are not valid and the GMM estimator will be inconsistent. The J test is a specification test which means that if it rejects, either the orthogonality conditions, or other assumptions, or both are false. Robust standard errors in the parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.A4: Dynamic Panel Threshold Analysis: Growth regression (R&D)

	Private credit	**Banking credit**	**Domestic credit**	**Liquidity**
Threshold($\hat{\gamma}$)	0.531***	0.600***	0.511***	0.316***
	(0.026)	(0.047)	(0.029)	(0.010)
R&D				
$\hat{\beta}_L$(FD≤γ)	0.058***	0.023***	0.030***	0.413***
	(0.007)	(0.005)	(0.007)	(0.076)
$\hat{\beta}_H$(FD>γ)	-0.014**	-0.011***	-0.012**	-0.007
	(0.006)	(0.005)	(0.005)	(0.076)
L.Growth	-0.365***	-0.468***	-0.313***	-0.375***
	(0.031)	(0.041)	(0.041)	(0.037)
Schooling	0.0027***	0.0037***	0.0034***	0.0012
	(0.001)	(0.001)	(0.001)	(0.001)
Govt	-0.193***	-0.4471***	-0.411***	-0.494***
	(0.086)	(0.092)	(0.116)	(0.087)
Investment	0.193***	0.248***	0.213***	0.231***
	(0.021)	(0.013)	(0.022)	(0.023)
Trade	0.0066	0.013***	0.015***	0.013***
	(0.005)	(0.003)	(0.004)	(0.004)
Inflation	-0.026***	-0.015***	-0.0058	-0.077***
	(0.005)	(0.005)	(0.009)	(0.008)
Obs	230	230	230	230
Countries	46	46	46	46
Linearity test(p-value)	0.000	0.000	0.000	0.000
m_2	0.06	0.03	0.12	0.17
J(p-value)	0.98	0.98	0.99	0.99

Note: The null of linearity test is H_0: $\hat{\beta}_L = \hat{\beta}_H$. m_2 tests for lack of second order serial correlation in the residuals. If this test rejects the null hypothesis, then the moment restrictions are not valid and the GMM estimator will be inconsistent. The J test is a specification test which means that if it rejects, either the orthogonality conditions, or other assumptions, or both are false. Robust standard errors in the parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.A5: Dynamic Panel Threshold Analysis: Growth regression (Utility models)

	Private credit	**Banking credit**	**Domestic credit**	**Liquidity**
Threshold($\hat{\gamma}$)	0.592***	0.601***	0.572***	0.986***
	(0.032)	(0.027)	(0.268)	(0.067)
Innovation				
$\hat{\beta}_L$(FD≤γ)	0.019***	0.017***	0.006*	-0.023***
	(0.001)	(0.002)	(0.002)	(0.005)
$\hat{\beta}_H$(FD>γ)	-0.007***	-0.011***	-0.007***	-0.005***
	(0.003)	(0.002)	(0.002)	(0.003)
L.Growth	-0.502***	-0.511***	-0.418***	-0.301***
	(0.032)	(0.037)	(0.029)	(0.075)
Schooling	0.005***	0.006***	0.007***	0.015***
	(0.000)	(0.001)	(0.001)	(0.002)
Govt	-0.532***	-0.710***	-0.515***	-0.236
	(0.087)	(0.079)	(0.071)	(0.195)
Investment	0.202***	0.197***	0.171***	0.289***
	(0.021)	(0.018)	(0.022)	(0.092)
Trade	0.013***	0.010***	0.016***	-0.021
	(0.004)	(0.005)	(0.005)	(0.017)
Inflation	0.012**	0.011	-0.007	-0.013
	(0.006)	(0.007)	(0.012)	(0.010)
Obs	245	245	245	245
Countries	49	49	49	49
Linearity test(p-value)	0.000	0.000	0.000	0.000
m_2	0.02	0.04	0.12	0.11
J(p-value)	0.95	0.95	0.99	0.14

Note: The null of linearity test is H_0: $\hat{\beta}_L = \hat{\beta}_H$. m_2 tests for lack of second order serial correlation in the residuals. If this test rejects the null hypothesis, then the moment restrictions are not valid and the GMM estimator will be inconsistent. The J test is a specification test which means that if it rejects, either the orthogonality conditions, or other assumptions, or both are false. Robust standard errors in the parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 1.A6: Threshold estimation using quadratic and [Kremer et al., 2013] method: Innovation regression

	Private credit	**Banking credit**	**Liquidity**	**Domestic credit**
	Nonlinear test using quadratic regression			
L.Patent	-0.092	-0.084	0.020	-0.118
	(0.070)	(0.074)	(0.099)	(0.080)
FD	1.906**	1.303**	1.407**	2.137***
	(0.855)	(0.506)	(0.694)	(0.822)
FD^2	-0.774*	-0.513**	-0.810*	-0.939**
	(0.416)	(0.214)	(0.463)	(0.418)
FDI	-0.035	-0.010	0.089	-0.102
	(0.084)	(0.079)	(0.291)	(0.159)
Population	0.004	0.005	0.038	0.006
	(0.054)	(0.044)	(0.084)	(0.056)
GDP/capita	0.119	0.191	0.231	0.308
	(0.220)	(0.218)	(0.343)	(0.315)
Schooling	-0.147***	-0.178***	-0.152*	-0.210***
	(0.044)	(0.039)	(0.086)	(0.063)
IP	0.123	0.157	0.125	0.232*
	(0.151)	(0.163)	(0.187)	(0.133)
_cons	-0.576	-0.915	-2.502	-2.201
	(2.378)	(2.327)	(4.007)	(3.179)
Obs	250	250	250	250
Country	50	50	50	50
AR(2) test	0.140	0.137	0.116	0.132
Hansen J test	0.411	0.409	0.435	0.930
	Lind and Mehlum U-shape test			
$dY/dFD = 0$	1.231	1.268	0.868	1.137
P-value	0.065	0.022	0.062	0.028
	Threshold test using Kremer et al(2013) method			
Threshold estimates				
$\hat{\gamma}$	1.378	1.333	1.649	1.660
95% CI	[1.207 3.057]	[1.207 1.646]	[1.289 1.782]	[1.219 1.717]
Impact of FD				
$\hat{\beta}_L$	0.664**	0.854**	0.326	0.341**
	(0.334)	(0.359)	(0.24)	(0.147)
$\hat{\beta}_H$	0.038	0.019	-0.008	0.044*
	(0.027)	(0.026)	(0.049)	(0.025)
Impact of covariates				
L.Patent	0.065**	0.041	0.028	0.04
	(0.032)	(0.031)	(0.031)	(0.03)
FDI	0.031	0.037	0.042	0.035
	(0.067)	(0.063)	(0.063)	(0.064)
GDP/capita	-0.105*	-0.073	-0.061	-0.085*
	(0.055)	(0.053)	(0.054)	(0.051)
Population	0.064	0.113	0.092	0.052
	(0.147)	(0.152)	(0.158)	(0.156)
Schooling	-0.045***	-0.042***	-0.032***	-0.039***
	(0.011)	(0.009)	(0.011)	(0.009)
IP	0.067***	0.059***	0.056***	0.066***
	(0.016)	(0.014)	(0.017)	(0.015)
$\hat{\delta}$	-0.116	-0.151	-0.074	-0.035
	(0.093)	(0.088)	(0.106)	(0.064)
Obs	300	300	300	300
Country	50	50	50	50

Note: Robust standard errors in parentheses. All variables are five years average values; Windmeijer correction method is applied for each regression; FD is the indicators of financial development, it includes Banking credit, private credit, liquidity liability, and domestic credit. * (p<0.1), ** (p<0.05), *** (p<0.01).

Table 1.A7: Variable Definitions and Sources

Variables	Definition	Source
Patent	Resident applications per 100 billion USD GDP(2011 PPP)(by applicant's origin), natural log of patent	WIPO
Utility models	Resident applications per 100 billion USD GDP(by applicant's origin), natural log of utility models	Authors' construction from WIPO
R&D	Gross domestic spending on R&D as percentage of GDP	OECD&UNESCO
FDI	Foreign direct investment, net inflows (% of GDP)	WDI, World Bank
GDP/capita	GDP per capita(2011 PPP), natural log of GDP per capita	WDI, World Bank
Population	Total population ages 15-64, natural log of total population	WDI, World Bank
Schooling	Average number of years of education received by people ages 25 and older	UN-HDI
IP	Intelectual property right protection index (five years average)	Park's IP database
Growth rate	GDP per capita growth (annual %)	WDI, World Bank
Govt	General government final consumption expenditure (% of GDP)	WDI, World Bank
Trade	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product(% of GDP).	WDI, World Bank
Investment	Gross capital formation (% of GDP)	WDI, World Bank
Inflation	Inflation as measured by the annual percentage change in consumer price index reflects(%)	WDI, World Bank
Initial GDP/capita	Initial GDP per capita, natural log of GDP per capita	WDI, World Bank
Private credit	Private credit by deposit money banks and other financial institutions to GDP.	WBFSD, World Bank
Banking credit	The financial resources provided to the private sector by domestic money banks as a share of GDP.	WBFSD, World Bank
Domestic credit	Domestic credit to private sector refers to financial resources provided to the private sector((% of GDP)).	WBFSD, World Bank
Liquidity	Ratio of liquid liabilities to GDP. Liquid liabilities are also known as broad money, or M3.	WBFSD, World Bank
Banking crisis	A dummy variable is defined as 1 if there is banking crisis in the year, and 0 otherwise	Laeven et al.(2013) and authors' construction

Note: Index of protection for intellectual property right is obatained from [Park, 2008], the author updates the data to 2015. WIPO: World Intellectual Property Organization; UNESCO: United Nations Educational, Scientific and Cultural Organization; WDI: World Development Indicators; UN-HDI: United Nations Human Development Index; WBFSD: World Bank Financial Structure Database. The financial development missing data for New Zealand is filled using data from Reserve Bank of New Zealand(https://www.rbnz.govt.nz/statistics). Banking Crisis is obtained from [Laeven and Valencia, 2013], Systemic Banking Crises Database(1970-2011). The data from 2012 to 2016 are extended by the author by searching key words that indicates a banking crisis for each country between 2012 and 2016. Key words includes bank run, bank crisis and illiquidity.

This appendix provides a robustness check on the diminishing effect of credit expansion on innovation. In our sample, banking crisis follows closely the credit expansions. Figure A1 in the appendix shows the evolution of private credit for U.S., UK, Japan, Malaysia, and China. For each country showed here, banking crisis occurred when credits expand. For example, Malaysia experienced banking crisis between 1997-1998, during which period the private credit level is the highest of all the period in our sample. Table 5 gives the difference in financial development between crisis and tranquil period. On average, the level of private credit is significantly higher than in tranquil period. Banking crisis may affect innovation performance and investments via several mechanisms([Döner, 2017],[OECD, 2012]). Crisis causes a reduction in the demand for products, this would dampen the incentives to innovate. Firms may suffer from credit constraints and difficulties in accessing finance during banking crisis. Risky Activities such as R&D are seriously affected. Another dark side is the increased uncertainties as to future developments. This pro-cyclic pattern of R&D and innovation has been observed over various business cycles and for a variety of countries(e.g. [Comin and Gertler, 2006], [Francois and Lloyd-Ellis, 2008]). It is therefore necessary to examine whether the diminishing effect of financial development on innovation is independent of the negative effect of banking crisis.
We consider the following DID strategy

$$\text{innovation}_{it} = \rho\text{innovation}_{it-1} + \alpha BC_{it} + \beta FD_{it} + \delta BC_{it} * FD_{it} + \gamma \mathbf{X}_{it} + \mu_i + \tau_t + v_{it}$$

where BC_{it} is the dummy for banking crisis for country i at year t. The value is 1 if there is banking crisis at period t, and equals to 0 for tranquil period. δ measures the differential effect of finance on innovation between crisis and tranquil period. The expected sign of δ is non-negative.

Table A8 shows the results using different indicators of financial development. For all four indicators, the overall effect of financial development on innovation is positive. As expected, the sign on banking crisis is negative, although not significant. The coefficient of interest is the interaction term between financial development and banking crisis, which measures the differential effect of financial development on innovation between crisis and tranquil period. Our results show that the effects of financial development do not make any differences between the two states. This suggests that the diminishing effect of financial development is not caused by banking crisis.

Table 1.A8: Credit expansion, banking crisis, and innovation:1990-2016

	Dependent var: Percentage change in patents			
	Banking credit	**Private credit**	**Liquidity**	**Domestic credit**
L.Patent	-0.377**	-0.295*	-0.280**	-0.334**
	(0.165)	(0.162)	(0.121)	(0.135)
BC	-0.085	-0.089	-0.053	-0.087
	(0.099)	(0.088)	(0.084)	(0.092)
FD	0.565**	0.472*	0.467*	0.483*
	(0.254)	(0.261)	(0.277)	(0.259)
FD*BC	-0.116	-0.012	-0.221	-0.019
	(0.232)	(0.209)	(0.394)	(0.260)
FDI	0.007	0.005	-0.005	0.006
	(0.005)	(0.005)	(0.004)	(0.006)
Population	0.130**	0.069	0.108**	0.071
	(0.059)	(0.062)	(0.049)	(0.051)
GDP/capita	0.146	0.129	0.835**	0.095
	(0.302)	(0.329)	(0.390)	(0.282)
Schooling	0.396	-0.062	-0.807	0.165
	(0.925)	(0.833)	(0.588)	(0.735)
IP	0.338	0.457	0.083	0.510
	(0.553)	(0.545)	(0.727)	(0.471)
Obs	250	250	250	250
Countries	50	50	50	50
AR(2) test	0.192	0.120	0.151	0.145
Hansen J test	0.435	0.372	0.695	0.452

Note: Robust standard errors in parentheses. All variables 5 years average values; Windmeijer correction method is applied for each regression; FD is the indicators of financial development, it includes Banking credit, private credit, liquidity liability, and domestic credit. BC is the dummy of banking crisis. FD*BC is the interaction between financial development and banking crisis. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 1.A3: The Multi-factor Productivity Growth Rate in G7 Group: 1985-2017

Note: Annual trend growth rates are obtained using HP filter, the smooth parameter is set as 6.25. Data source: OECD (2019), Multifactor productivity (indicator).

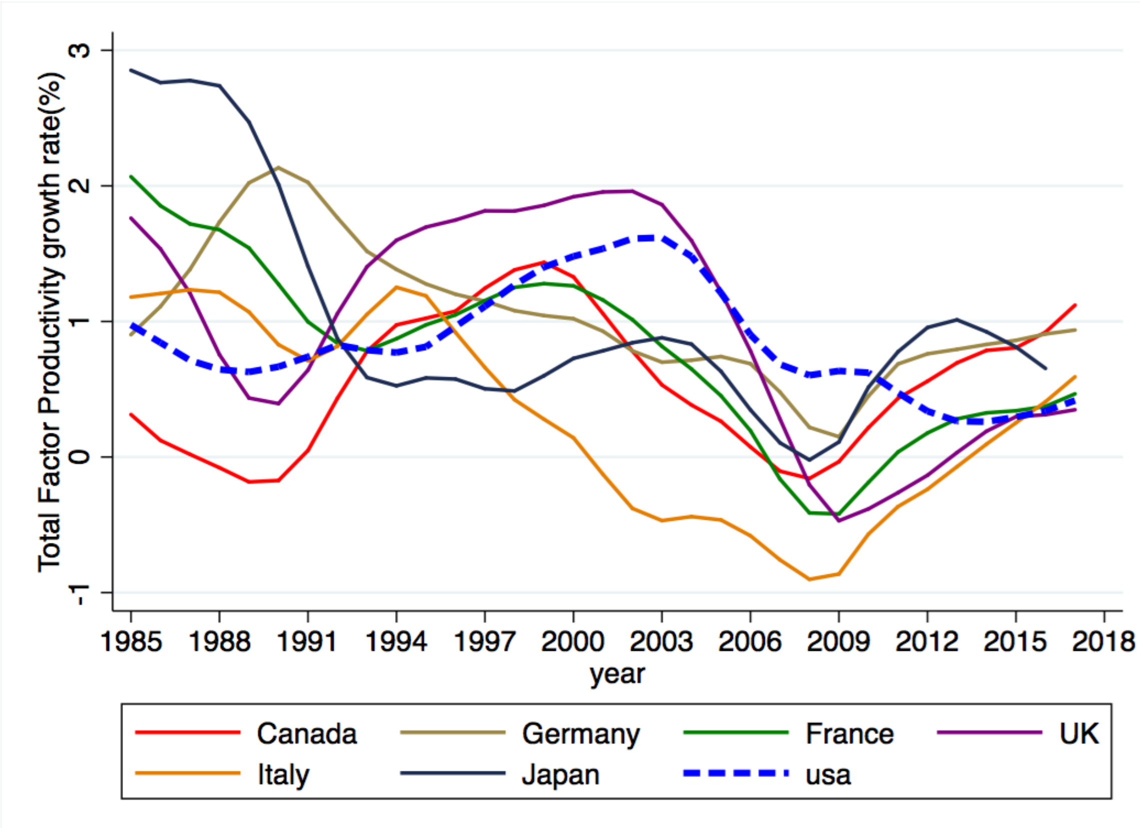
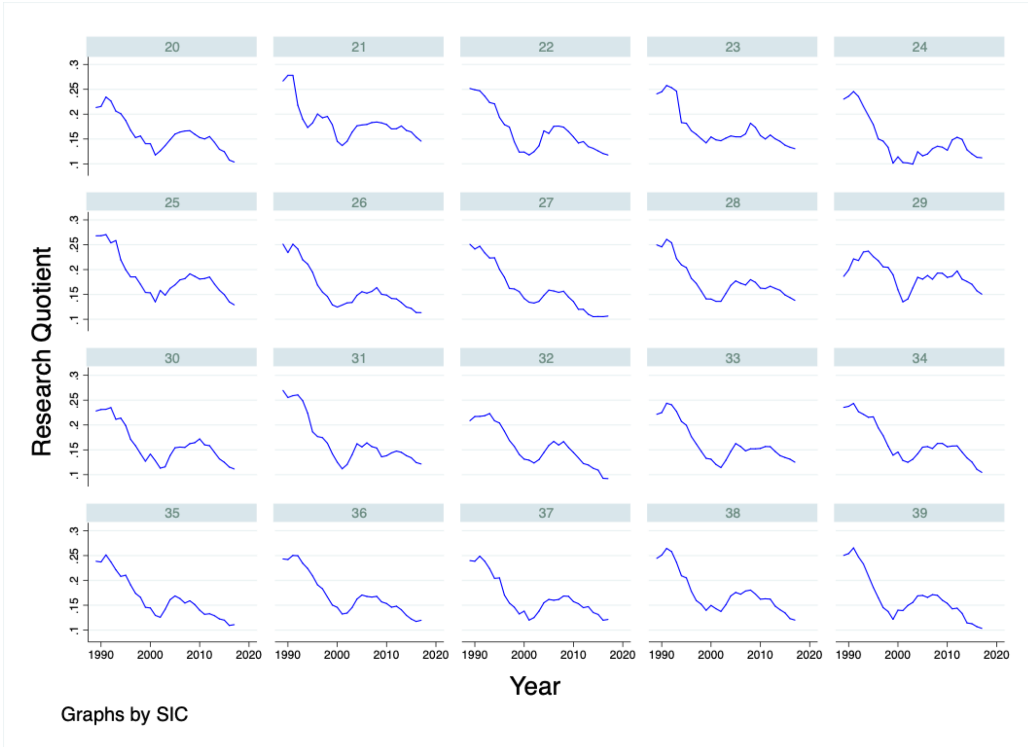


Table 1.A9: The Multi-factor Productivity Growth Rate in G7 Group: 5 years average

	Years					
	1985-1989	**1990-1994**	**1995-1999**	**2000-2004**	**2005-2009**	**2010-2017**
Canada	0.158	.477	1.045	0.697	-0.077	0.820
Germany	1.378	1.821	1.041	0.814	0.029	1.116
France	1.925	0.744	1.142	0.997	-0.347	0.422
UK	1.151	1.072	1.657	1.992	-0.151	0.300
Italy	1.452	0.731	0.448	-0.128	-1.103	0.285
Japan	2.780	0.787	0.672	1.008	-0.370	1.177
USA	0.732	0.842	1.091	1.623	0.580	0.446

Note: Data source: OECD (2019), Multifactor productivity (indicator).

Figure 2.1: Time series trend of Research Quotient by SIC



Note: Figure 2.1 shows the country average RQ trend by SIC code. The value in each industry-year pair is calculated as the average of all countries. 20 Food & Kindred Products; 21 Tobacco Products; 22 Textile Mill Products; 23 Apparel & Other Textile Products; 24 Lumber & Wood Products; 25 Furniture & Fixtures; 26 Paper & Allied Products; 27 Printing & Publishing; 28 Chemical & Allied Products; 29 Petroleum & Coal Products; 30 Rubber & Miscellaneous Plastics Products; 31 Leather & Leather Products; 32 Stone, Clay, & Glass Products; 33 Primary Metal Industries; 34 Fabricated Metal Products; 35 Industrial Machinery & Equipment; 36 Electronic & Other Electric Equipment; 37 Transportation Equipment; 38 Instruments & Related Products; 39 Miscellaneous Manufacturing Industries.

Table 2.1: Descriptive statistics:country-level averages

Country	RQ	U.S_ref	Competition	EFD
Australia	0.145	79.23%	0.971	-0.641
Austria	0.161	87.97%	0.959	0.098
Belgium	0.140	76.50%	0.942	-0.290
Brazil	0.193	105.46%	0.891	-1.877
Canada	0.157	85.79%	0.967	0.477
Chile	0.085	46.44%	0.934	-0.887
China	0.154	82.51%	0.895	-0.138
Denmark	0.161	87.97%	0.922	-0.665
Egypt	0.177	96.72%	0.884	-1.557
Finland	0.173	94.53%	0.942	-0.321
France	0.177	96.72%	0.934	-0.279
Germany	0.163	89.07%	0.953	-0.432
Greece	0.138	75.41%	0.962	0.221
Hong Kong	0.144	78.68%	0.936	-0.667
India	0.153	83.60%	0.921	-0.174
Indonesia	0.138	75.41%	0.904	-0.309
Isreal	0.146	79.78%	0.954	-0.009
Italy	0.148	80.87%	0.948	-0.616
Japan	0.167	91.25%	0.955	-0.151
Jordan	0.173	94.53%	0.939	-0.991
Korea	0.127	69.39%	0.941	-0.156
Malaysia	0.149	81.42%	0.917	-1.115
Mexico	0.132	72.13%	0.927	-1.939
Netherland	0.173	94.53%	0.936	-0.057
Norway	0.175	95.62%	0.958	0.031
Pakistan	0.113	71.03%	0.925	-1.048
Philippines	0.137	74.86%	0.936	-1.698
Poland	0.137	74.86%	0.931	0.008
Romania	0.106	57.92%	0.970	-0.059
Russia	0.120	65.57%	0.956	-0.184
Saudi Arabia	0.165	90.16%	0.893	-1.396
Singapore	0.174	95.08%	0.961	-0.205
South Africa	0.151	82.51%	0.920	-0.726
Spain	0.121	66.12%	0.936	-1.033
Sri Lanka	0.180	98.36%	0.926	-0.882
Sweden	0.166	90.71%	0.925	-0.546
Switzerland	0.171	93.44%	0.932	-0.101
Thailand	0.156	85.24%	0.945	-1.073
Turkey	0.138	75.41%	0.927	-0.630
United Kingdom	0.172	93.98%	0.924	-0.631
United States	0.183	100%	0.934	-0.476

Table 2.2: Descriptive statistics: industry-level averages

Industry	**RQ**	**Competition**	**EFD**
20 Food & Kindred Products	0.152	0.931	-0.616
21 Tobacco Products	0.175	0.849	-2.704
22 Textile Mill Products	0.156	0.948	-0.483
23 Apparel & Other Textile Products	0.157	0.932	-0.727
24 Lumber & Wood Products	0.135	0.942	-0.285
25 Furniture & Fixtures	0.171	0.946	-0.618
26 Paper & Allied Products	0.151	0.939	-0.465
27 Printing & Publishing	0.141	0.928	-1.450
28 Chemical & Allied Products	0.169	0.928	-0.261
29 Petroleum & Coal Products	0.184	0.943	-0.489
30 Rubber & Miscellaneous Plastics Products	0.151	0.938	-0.573
31 Leather & Leather Products	0.157	0.936	-0.689
32 Stone, Clay, & Glass Products	0.148	0.908	-0.593
33 Primary Metal Industries	0.153	0.950	-0.322
34 Fabricated Metal Products	0.158	0.927	-0.570
35 Industrial Machinery & Equipment	0.153	0.942	-0.371
36 Electronic & Other Electric Equipment	0.162	0.955	0.082
37 Transportation Equipment	0.156	0.952	-0.154
38 Instruments & Related Products	0.167	0.938	0.413
39 Miscellaneous Manufacturing Industries	0.153	0.946	-0.775

Table 2.3: Descriptive statistics: country-industry-year averages

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
RQ	0.158	0.059	0.05	0.278	9288
Competition	0.937	0.063	0.811	1.085	11676
EFD	-0.466	1.181	-3.693	1.561	12190
Value Added(log)	21.644	2.476	17.136	26.041	11802
Capitalization(%GDP)	73.226	49.08	14.857	200.384	12900
Total Value(%GDP)	55.191	52.577	3.321	197.175	13079
Turnover Ratio	74.419	52.356	10.889	198.901	13022
Private Credit(%GDP)	92.47	45.115	21.037	175.307	12733
Liquid Liabilities (%GDP)	83.328	44.026	31.702	195.965	12651
Deposit Credit(%GDP)	81.755	40.376	20.755	163.847	12723
Financial Development Index	0.611	0.186	0.126	1	13745
Financial Market Index	0.551	0.21	0.014	1	13745
FM Depth Index	0.554	0.279	0.018	1	13745
FM Access Index	0.487	0.235	0.001	1	13745
FM Efficiency Index	0.608	0.314	0.002	1	13742
Financial Institution Index	0.657	0.199	0.155	1	13745
FI Depth Index	0.588	0.268	0.051	1	13745
FI Access Index	0.545	0.267	0.043	1	13745
FI Efficiency Index	0.732	0.127	0.107	0.935	13745

Table 2.4: Effect of FD on RQ: Capturing the intuition

	Financial Development Measured As					
	Capitalization	**Value traded**	**Turn over**	**Total Private**	**Liquidity**	**Deposit credit**
FD	-0.023***	-0.028***	-0.036***	0.032***	0.072***	0.047***
	(0.007)	(0.005)	(0.006)	(0.012)	(0.014)	(0.012)
FD^2	-0.001	0.010***	0.012***	-0.008	-0.023***	-0.011**
	(0.003)	(0.002)	(0.002)	(0.005)	(0.006)	(0.006)
Competition	-1.867***	-1.826***	-1.858***	-1.867***	-1.814***	-1.815***
	(0.250)	(0.246)	(0.246)	(0.250)	(0.250)	(0.249)
Competition^2	0.964***	0.945***	0.961***	0.964***	0.937***	0.935***
	(0.131)	(0.127)	(0.130)	(0.131)	(0.132)	(0.131)
Value add	0.003***	0.003***	0.002***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
_cons	6.484***	6.492***	6.725***	6.484***	6.764***	6.637***
	(0.256)	(0.258)	(0.242)	(0.256)	(0.275)	(0.244)
N	8254	8425	8385	8254	8174	8250
adj. R^2	0.244	0.238	0.240	0.244	0.237	0.248
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
Control credit market	yes	yes	yes			
Control equity market				yes	yes	yes

Table 2.4 reports Panel fixed effect regressions with industrial level research quotient as dependent variable. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. The industrial level RQ is calculated as the median of all values among all firms within an industry at a given year. All measures of financial development used are first order lagged value; Value added is the first order lagged value. The credit market controlled is the total percentage of private credit to GDP. The equity market controlled is the percentage of stock market capitalization to GDP. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.5: Effect of FD on RQ: RZ specification

	Financial Development Measured As					
	Capitalization	**Value traded**	**Turn over**	**Total Private**	**Liquidity**	**Deposit credit**
FD*EFD	-0.023***	0.003	-0.013***	0.009**	0.029***	0.012**
	(0.006)	(0.004)	(0.005)	(0.004)	(0.005)	(0.006)
FD^2*EFD	0.012***	-0.003	0.005**	-0.006***	-0.016***	-0.009***
	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Competition	-1.682***	-1.718***	-1.628***	-1.718***	-1.682***	-1.729***
	(0.250)	(0.241)	(0.250)	(0.250)	(0.253)	(0.254)
$Competition^2$	0.869***	0.893***	0.843***	0.893***	0.869***	0.894***
	(0.133)	(0.131)	(0.131)	(0.131)	(0.133)	(0.134)
Value add	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
_cons	6.737***	6.723***	6.677***	6.723***	6.737***	6.759***
	(0.212)	(0.209)	(0.211)	(0.209)	(0.212)	(0.211)
N	8044	8253	8139	8253	8004	8080
adj. R^2	0.233	0.238	0.232	0.238	0.233	0.238
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
Control credit market	yes	yes	yes			
Control equity market				yes	yes	yes
Optimal threshold	0.958		1.300	0.750	0.906	0.667

Table 2.5 reports Panel fixed effect RZ regressions with industrial level research quotient as dependent variable. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. The industrial level RQ is calculated as the median of all values among all firms within an industry at a given year. All measures of financial development used are first order lagged value; Value added is the first order lagged value. The credit market controlled is the total percentage of private credit to GDP. The equity market controlled is the percentage of stock market capitalization to GDP. The control variables are the interaction between equity market(credit market) and external financing dependence, and the interaction between its square term and the external financing dependence. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.6: Effect of Financial Development on RQ

	Financial Development Measured As								
	FD	**FI**	**FI Depth**	**FI access**	**FI Efficiency**	**FM**	**FM Depth**	**FM access**	**FM Efficiency**
FD*EFD	0.026***	0.024***	0.014***	0.013***	0.006	0.026***	0.015***	0.013***	0.011***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)
FD^2*EFD	-0.032***	-0.028***	-0.015***	-0.017***	-0.002	-0.033***	-0.016***	-0.018***	-0.010**
	(0.006)	(0.006)	(0.006)	(0.005)	(0.008)	(0.006)	(0.005)	(0.006)	(0.004)
Competition	-1.807***	-1.813***	-1.812***	-1.822***	-1.808***	-1.790***	-1.801***	-1.820***	-1.792***
	(0.239)	(0.239)	(0.240)	(0.240)	(0.240)	(0.239)	(0.240)	(0.240)	(0.240)
$Competition^2$	0.941***	0.944***	0.943***	0.950***	0.938***	0.932***	0.938***	0.949***	0.931***
	(0.126)	(0.126)	(0.126)	(0.126)	(0.126)	(0.126)	(0.126)	(0.126)	(0.126)
Value add	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***	0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
_cons	6.823***	6.788***	6.785***	6.766***	6.740***	6.810***	6.782***	6.767***	6.746***
	(0.197)	(0.197)	(0.197)	(0.197)	(0.197)	(0.197)	(0.198)	(0.197)	(0.196)
N	8670	8670	8670	8670	8670	8670	8670	8670	8670
adj. R^2	0.238	0.237	0.235	0.235	0.236	0.238	0.236	0.235	0.236
Industry effect	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes	yes	yes	yes

Table 2.6 reports Panel fixed effect RZ regressions with industrial level research quotient as dependent variable. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. The industrial level RQ is calculated as the median of all values among all firms within an industry at a given year. All measures of financial development are one order lagged value; Value added is the first order lagged value. The index of Financial Development is from [Svirydzenka, 2016]. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.7: Effect of FD on Innovation: Using industry level patents

	Industry-level patent counts(log)					
	Capitalization	**Value traded**	**Turn over**	**Total Private**	**Liquidity**	**Deposit credit**
FD*EFD	0.005	-0.015**	-0.019***	0.004	0.024***	-0.006
	(0.006)	(0.007)	(0.005)	(0.004)	(0.006)	(0.006)
FD^2*EFD	-0.007**	0.017**	0.015***	-0.008**	-0.039***	0.002
	(0.003)	(0.007)	(0.004)	(0.004)	(0.006)	(0.006)
Competition	0.409***	0.464***	0.457***	0.363**	0.346**	0.364**
	(0.149)	(0.148)	(0.149)	(0.149)	(0.150)	(0.149)
Competition^2	-0.318**	-0.338**	-0.326**	-0.299**	-0.290*	-0.301**
	(0.150)	(0.149)	(0.150)	(0.151)	(0.152)	(0.151)
Value add	0.919***	0.905***	0.916***	0.918***	0.901***	0.918***
	(0.051)	(0.050)	(0.051)	(0.051)	(0.052)	(0.051)
_cons	-2.216	-5.191	-5.218	-13.004***	-14.941***	-12.846***
	(3.224)	(3.161)	(3.213)	(3.234)	(3.254)	(3.247)
N	14936	15150	15003	14606	14440	14605
adj. R^2	0.465	0.466	0.467	0.478	0.481	0.478
Control credit market	yes	yes	yes			
Control equity market				yes	yes	yes
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
Optimal threshold		0.441	0.633		0.308	

Table 2.7 reports Panel fixed effect RZ regressions with industrial level patent counts(log) as dependent variable. The industrial level data are constructed by combining the Compustat North America and Global Annual Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. All measures of financial development used are first order lagged value; Value added is the first order lagged value. The credit market controlled is the total percentage of private credit to GDP. The equity market controlled is the percentage of stock market capitalization to GDP. The control variables are the interaction between Equity Market(Credit Market) and external financing dependence, and the interaction between its square term and the external financing dependence. Each regression excluds U.S. sample to minimize the home bias. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.8: Effect of FD on Innovation: Using citation-weighted patent

	Industry-level patent counts(forward citation weighted)					
	Capitalization	**Value traded**	**Turn over**	**Total Private**	**Liquidity**	**Deposit credit**
FD*EFD	-0.017**	-0.066***	-0.055***	0.017*	0.078***	-0.028
	(0.008)	(0.011)	(0.009)	(0.009)	(0.017)	(0.018)
FD^2*EFD	-0.004	0.024*	0.027***	-0.030***	-0.121***	0.016
	(0.005)	(0.014)	(0.008)	(0.009)	(0.020)	(0.020)
Competition	0.194	0.183	0.185	0.151	0.104	0.154
	(0.284)	(0.280)	(0.283)	(0.293)	(0.299)	(0.293)
$Competition^2$	0.263	0.286	0.286	0.311	0.336	0.301
	(0.295)	(0.293)	(0.296)	(0.303)	(0.308)	(0.303)
Initial share	0.994***	0.961***	0.989***	1.016***	1.015***	1.020***
	(0.083)	(0.081)	(0.082)	(0.082)	(0.083)	(0.082)
_cons	57.032***	53.071***	54.593***	48.479***	43.096***	49.266***
	(10.411)	(10.087)	(10.376)	(10.698)	(10.875)	(10.866)
N	14936	15150	15003	14606	14440	14605
adj. R^2	0.243	0.243	0.243	0.250	0.251	0.249
Controlling for credit market	yes	yes	yes			
Controlling for equity market				yes	yes	yes
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
Optimal threshold		1.375	1.018	0.283	0.322	

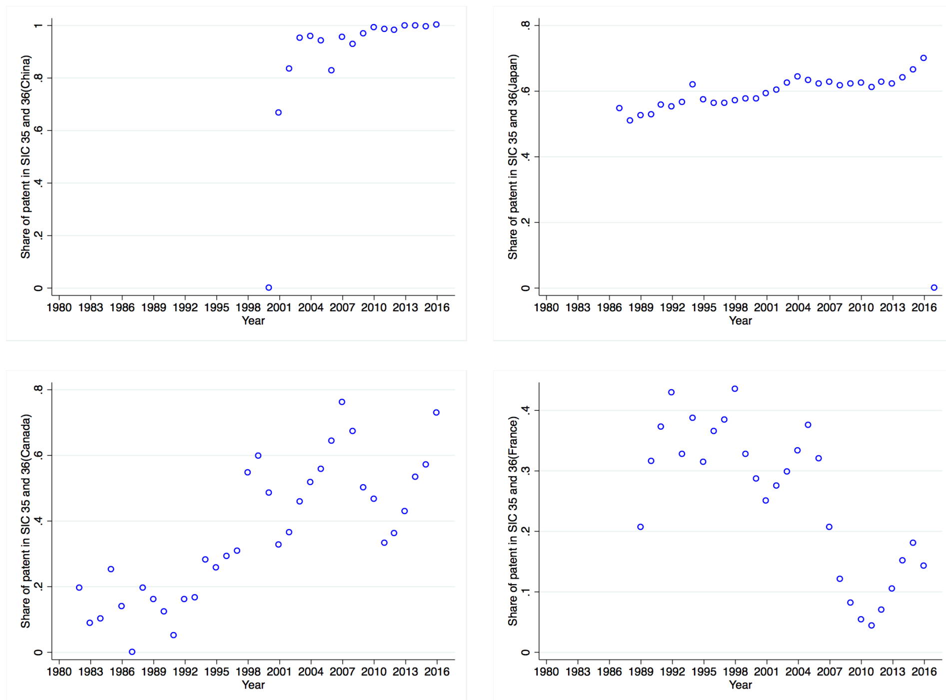
Table 2.8 reports Panel fixed effect RZ regressions with industrial level forward citation weighted patent as dependent variable. The industrial level data are constructed by combining the Compustat North America and Global Annual Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. All measures of financial development used are first order lagged value; Value added is the first order lagged value. The credit market controlled is the total percentage of private credit to GDP. The equity market controlled is the percentage of stock market capitalization to GDP. The control variables are the interaction between Equity Market(Credit Market) and external financing dependence, and the interaction between its square term and the external financing dependence. Each regression excluds U.S. sample to minimize the home bias. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.9: Effect of Financial Development on Innovation: Using citation-weighted patent

	Financial Development Measured As								
	FD	**FI**	**FI Depth**	**FI access**	**FI Efficiency**	**FM**	**FM Depth**	**FM access**	**FM Efficiency**
FD*EFD	0.064***	0.076***	0.018	0.000	0.122***	0.048	0.051*	-0.111***	0.018
	(0.017)	(0.019)	(0.016)	(0.018)	(0.031)	(0.035)	(0.028)	(0.030)	(0.018)
FD^2*EFD	-0.167***	-0.151***	-0.095***	-0.003	-0.178***	-0.150**	-0.151***	0.138**	-0.058**
	(0.036)	(0.034)	(0.028)	(0.027)	(0.043)	(0.064)	(0.045)	(0.063)	(0.026)
Competition	0.190	0.193	0.184	0.191	0.159	0.189	0.198	0.154	0.169
	(0.276)	(0.276)	(0.276)	(0.275)	(0.275)	(0.277)	(0.277)	(0.276)	(0.276)
$Competition^2$	0.312	0.306	0.314	0.301	0.350	0.314	0.305	0.348	0.336
	(0.285)	(0.285)	(0.285)	(0.285)	(0.285)	(0.286)	(0.286)	(0.286)	(0.286)
Value add	0.965***	0.968***	0.967***	0.969***	0.966***	0.967***	0.969***	0.964***	0.968***
	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)	(0.078)
_cons	53.849***	54.728***	54.267***	55.176***	54.890***	53.679***	53.010***	55.159***	54.721***
	(9.202)	(9.305)	(9.297)	(9.324)	(9.310)	(9.085)	(9.155)	(9.247)	(9.254)
N	15526	15526	15526	15526	15526	15526	15526	15526	15526
adj. R^2	0.242	0.242	0.242	0.241	0.242	0.242	0.242	0.242	0.242
Industry effect	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes	yes	yes	yes
Optimal threshold									

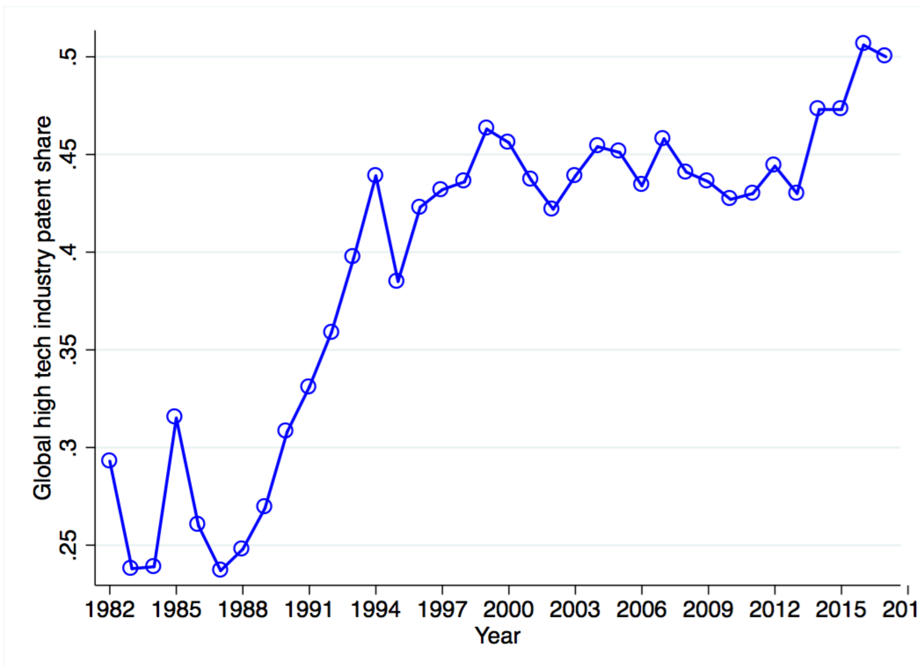
Table 9 reports Panel fixed effect RZ regressions with industrial level citation-weighted patent as dependent variable. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. All measures of financial development used are first order lagged value; Value added is the first order lagged value. The index of Financial Development is from [Svirydzenka, 2016]. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 2.2: Share of patents in high technology manufacturing industry: Selected countries



Note: Figure 2.2 shows the country's share of patent counts in high technology manufacturing industry to the total patents counts in the manufacturing sector at a given year. Based on [Kile and Phillips, 2009], SIC code 35, 36, and 38 are grouped as high technology manufacturing industries. The upper left panel is for China; The upper right panel is for Japan; The bottom left panel is for Canada; and The bottom right panel is for France.

Figure 2.3: Share of patents in high technology manufacturing industry: Global trend



Note: Figure 3 shows the global share of patent counts in high technology manufacturing industry to the total patents counts in the manufacturing sector at a given year. Based on [Kile and Phillips, 2009], SIC code 35, 36, and 38 are grouped as high technology manufacturing industries. This value is calculated as country average.

Table 2.10: Effect of FD on Innovation: High tech VS. Non-high tech manufacturing industry

	Innovation Measured as RQ					
	Financial Development Measured As					
	Panel A: SIC Sector 35, 36, and 38					
	Capitalization	**Value Traded**	**Turn over**	**Total Private**	**Liquidity**	**Deposit Credit**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
FD*EFD	0.027**	0.023***	0.004	-0.014	0.013	-0.014
	(0.012)	(0.008)	(0.007)	(0.011)	(0.013)	(0.011)
FD^2*EFD	-0.009**	-0.011***	0.001	0.004	-0.015*	0.003
	(0.005)	(0.004)	(0.003)	(0.005)	(0.008)	(0.006)
Competition	-0.863	-0.797	-0.954	-0.863	-1.091*	-0.886
	(0.587)	(0.592)	(0.592)	(0.587)	(0.581)	(0.586)
$Competition^2$	0.426	0.401	0.479	0.426	0.540*	0.437
	(0.307)	(0.309)	(0.309)	(0.307)	(0.304)	(0.307)
Value add	0.003*	0.002	0.002	0.003*	0.002*	0.003*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
_cons	8.291***	7.876***	7.992***	8.291***	8.258***	8.314***
	(0.444)	(0.446)	(0.451)	(0.444)	(0.462)	(0.446)
N	1239	1255	1251	1239	1231	1239
adj. R^2	0.406	0.399	0.401	0.406	0.405	0.407
Optimal threshold	1.500	1.045				
	Panel B: Sector Not in SIC 35, 36, or 38					
FD*EFD	0.004	-0.000	-0.000	0.008	0.028***	0.017***
	(0.006)	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)
FD^2*EFD	0.002	-0.001	-0.000	-0.010***	-0.015***	-0.012***
	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)	(0.004)
Competition	-1.748***	-1.710***	-1.719***	-1.748***	-1.655***	-1.713***
	(0.275)	(0.271)	(0.270)	(0.275)	(0.275)	(0.276)
$Competition^2$	0.916***	0.897***	0.901***	0.916***	0.864***	0.894***
	(0.145)	(0.143)	(0.142)	(0.145)	(0.145)	(0.146)
Value add	0.004***	0.004***	0.004***	0.004***	0.004***	0.004***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
_cons	6.578***	6.442***	6.495***	6.578***	6.424***	6.452***
	(0.235)	(0.234)	(0.234)	(0.235)	(0.236)	(0.234)
N	6845	6998	6968	6845	6773	6841
adj. R^2	0.243	0.238	0.239	0.243	0.232	0.239
Optimal threshold					0.933	0.708
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
Control Credit Market	yes	yes	yes			
Control Equity Market				yes	yes	yes

Table 2.10 reports the Panel fixed effect regression by splitting the industries into high-technology and non-high-technology manufacturing industries. The criterion upon which we based is the classification system developed by [Kile and Phillips, 2009]. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. The industrial level RQ is calculated as the median of all values among all firms within an industry at a given year. All measures of financial development used are first order lagged value; Value added is the first order lagged value. The credit market controlled is the total percentage of private credit to GDP. The equity market controlled is the percentage of stock market capitalization to GDP. The control variable is the interaction between credit market(equity market) and external financing dependence, and the interaction between its square term and the external financing dependence. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.11: Effect of FD on Innovation: Cross-section regression

	Financial development measured as					
	Capitalization	**Value traded**	**Turn over**	**Total Private**	**Liquidity**	**Deposit credit**
FD*EFD	0.011*	0.016**	0.015**	0.020**	0.015**	0.014*
	(0.006)	(0.007)	(0.007)	(0.008)	(0.006)	(0.008)
FD^2*EFD	-0.005	-0.011**	-0.009*	-0.014**	-0.008*	-0.009
	(0.004)	(0.005)	(0.005)	(0.006)	(0.004)	(0.007)
Competition	-2.289	-2.138	-2.209	-2.314	-2.088	-2.229
	(1.550)	(1.591)	(1.530)	(1.564)	(1.556)	(1.553)
$Competition^2$	1.187	1.113	1.145	1.201	1.076	1.155
	(0.826)	(0.845)	(0.816)	(0.833)	(0.829)	(0.827)
Value add	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
_cons	1.159	1.085	1.120	1.172	1.071	1.132
	(0.712)	(0.733)	(0.702)	(0.720)	(0.716)	(0.714)
N	436	436	436	436	436	436
adj. R^2	0.198	0.203	0.202	0.205	0.204	0.199
Controlling for credit market	yes	yes	yes			
Controlling for equity market				yes	yes	yes
Industry effect	yes	yes	yes	yes	yes	yes
Country effect	yes	yes	yes	yes	yes	yes
Optimal threshold		0.727	0.833	0.714	0.937	

Table 2.11 reports the Panel fixed effect regression by using the average industry level data. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. The industrial level RQ is calculated as the median of all value among all firms within an industry at a given year. All measures of financial development used are first order lagged value; Value added is the first order lagged value. The credit market controlled is the total percentage of private credit to GDP. The equity market controlled is the percentage of stock market capitalization to GDP. The control variable is the interaction between credit market(equity market) and external financing dependence, and the interaction between its square term and the external financing dependence. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.12: Effect of FD on innovation: Using legal rules as instruments

Financial development measured as — Stock Market

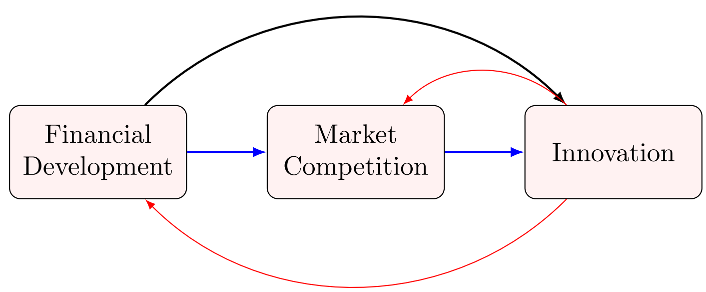
	Capitalization				Value trade				Turn over			
Instruments	**ASD (1)**	**Legal origin (2)**	**Enforcement (3)**	**ASD+Legal (4)**	**ASD (5)**	**Legal origin (6)**	**Enforcement (7)**	**ASD+Legal (8)**	**ASD (9)**	**Legal origin (10)**	**Enforcement (11)**	**ASD+Legal (12)**
FD*EFD	0.014*	0.007	0.087***	0.012	0.014	0.006	0.137***	0.013	0.015	0.020*	0.086***	0.017*
	(0.008)	(0.009)	(0.030)	(0.007)	(0.010)	(0.012)	(0.049)	(0.010)	(0.025)	(0.011)	(0.031)	(0.010)
FD^2*EFD	-0.006	-0.000	-0.079**	-0.005	-0.007	0.001	-0.166**	-0.006	-0.008	-0.014	-0.085**	-0.011
	(0.006)	(0.007)	(0.033)	(0.005)	(0.009)	(0.012)	(0.067)	(0.009)	(0.021)	(0.009)	(0.038)	(0.008)
Competition	-2.095	-2.499*	-6.759	-2.143	-2.188	-2.669*	-7.956	-2.218	-2.049	-2.117	-1.014	-2.011
	(1.468)	(1.420)	(5.905)	(1.460)	(1.496)	(1.487)	(6.702)	(1.488)	(1.525)	(1.427)	(3.708)	(1.467)
$Competition^2$	1.079	1.296*	3.686	1.106	1.132	1.390*	4.345	1.151	1.058	1.092	0.545	1.037
	(0.782)	(0.757)	(3.172)	(0.777)	(0.795)	(0.792)	(3.605)	(0.791)	(0.816)	(0.762)	(1.966)	(0.782)
value add	0.005***	0.005***	-0.005	0.005***	0.005***	0.005***	-0.006	0.005***	0.005***	0.005***	0.004*	0.005***
	(0.001)	(0.001)	(0.005)	(0.001)	(0.001)	(0.001)	(0.006)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
_cons	1.078	1.253*	3.288	1.098	1.116	1.330*	3.851	1.127*	1.051	1.080*	0.540	1.033
	(0.674)	(0.651)	(2.777)	(0.670)	(0.688)	(0.682)	(3.145)	(0.684)	(0.697)	(0.654)	(1.758)	(0.673)
Obs	434	436	102	434	434	436	102	434	434	436	102	434
adj. R^2	0.196	0.191	-0.168	0.196	0.195	0.175	-0.445	0.194	0.199	0.200	0.254	0.200
Endogeneity test	0.435	0.262	0.151	0.248	0.2180	0.110	0.105	0.184	0.379	0.568	0.311	0.360
Industry fixed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country fixed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Financial development measured as — Credit Market

	Private credit				Liquidity				Deposit credit			
Instruments	**Creditor (13)**	**Legal origin (14)**	**Enforcement (15)**	**Creditor+Legal (16)**	**Creditor (17)**	**Legal origin (18)**	**Enforcement (19)**	**Creditor+Legal (20)**	**Creditor (21)**	**Legal origin (22)**	**Enforcement (23)**	**Creditor+Legal (24)**
FD*EFD	0.029**	0.006	0.067***	0.016	0.019**	0.010	0.066***	0.019**	0.025**	0.011	0.074***	0.024**
	(0.014)	(0.013)	(0.019)	(0.011)	(0.008)	(0.010)	(0.019)	(0.008)	(0.011)	(0.014)	(0.022)	(0.011)
FD^2*EFD	-0.023*	-0.001	-0.059***	-0.010	-0.012*	-0.004	-0.059***	-0.012**	-0.020*	-0.005	-0.067***	-0.019**
	(0.013)	(0.012)	(0.018)	(0.009)	(0.007)	(0.008)	(0.020)	(0.006)	(0.010)	(0.013)	(0.022)	(0.009)
Competition	-2.291	-2.346*	-6.063	-2.325	-1.901	-2.291	-6.633	-1.910	-1.949	-2.325	-5.762	-1.981
	(1.493)	(1.425)	(4.761)	(1.430)	(1.456)	(1.441)	(5.001)	(1.455)	(1.454)	(1.446)	(4.821)	(1.456)
$Competition^2$	1.190	1.215	3.255	1.206	0.974	1.186	3.557	0.977	1.004	1.204	3.106	1.019
	(0.794)	(0.760)	(2.537)	(0.761)	(0.774)	(0.769)	(2.667)	(0.774)	(0.774)	(0.771)	(2.571)	(0.775)
value add	0.005***	0.005***	0.001	0.005***	0.005***	0.005***	0.001	0.005***	0.005***	0.005***	-0.001	0.005***
	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)
_cons	1.163*	1.186*	2.952	1.176*	0.990	1.158*	3.202	0.996	1.012	1.177*	2.814	1.028
	(0.688)	(0.655)	(2.251)	(0.658)	(0.671)	(0.660)	(2.358)	(0.670)	(0.669)	(0.662)	(2.279)	(0.669)
Obs	436	436	102	436	436	436	102	436	436	436	102	436
adj. R^2	0.199	0.190	0.104	0.203	0.201	0.200	0.019	0.201	0.192	0.197	0.106	0.194
Endogeneity test	0.660	0.267	0.107	0.797	0.598	0.682	0.115	0.626	0.237	0.515	0.105	0.168
Industry fixed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country fixed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Table 2.12 reports the Panel fixed effect regression by using the average industry level data. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. The industrial level RQ is calculated as the median of all value among all firms within an industry at a given year. All measures of financial development are one order lagged value; Value added is the first order lagged value. The credit market controlled is the total percentage of private credit to GDP. The equity market controlled is the percentage of stock market capitalization to GDP. The control variable is the interaction between credit market(equity market) and external financing dependence, and the interaction between its square term and the external financing dependence. The endogeneous variables are $FD * EFD$ and $FD^2 * EFD$, respectively. The equity market is instrumented with Anti-self Dealing index(ASD), Legal Origin, Law Enforcement, and their combinations. The instruments for credit market are Creditor Protection Index, Legal Origin, Law Enforcement, and their combinations. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 2.4: Financial development, market competition, and innovation



Note: Figure 2.4 illustrates the potential channel through which Financial Development affects Innovation in a nonlinear manner. The basic idea is that as financial system develops, it imposes a nonlinear effect on market competition, thus generating nonlinear effect on innovation.

Table 2.13: Financial development and market competition

	Capitalization	Value traded	Turn over	Total Private	Liquidity	Deposit credit
	Panel A: Worldscope database					
FD*EFD	0.024***	0.027***	0.023***	0.020***	0.026***	0.029***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
FD^2*EFD	-0.008***	-0.009***	-0.009***	-0.007***	-0.012***	-0.015***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Initial share	-0.042***	-0.041***	-0.045***	-0.036***	-0.037***	-0.038***
(top 10 firms)	(0.006)	(0.006)	(0.007)	(0.007)	(0.007)	(0.007)
_cons	-0.887***	-1.164***	-1.035***	-0.564***	-0.495***	-0.487***
	(0.151)	(0.154)	(0.156)	(0.155)	(0.156)	(0.154)
N	8211	8370	8331	8200	8120	8191
adj. R^2	0.238	0.232	0.227	0.219	0.217	0.220
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
Optimal threshold	1.500	1.500	1.278	1.428	1.083	0.967
	Panel B: Merged Compustat Global Fundamentals Annual database					
FD*EFD	0.002*	0.011***	0.004***	-0.000	0.003**	-0.002
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
FD^2*EFD	-0.000	-0.010***	-0.001	0.001	-0.003*	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Initial share	-0.007	-0.007	-0.007	-0.012	-0.013	-0.012
(top 10 firms)	(0.008)	(0.008)	(0.008)	(0.008)	(0.009)	(0.008)
_cons	-21.607***	-20.747***	-20.806***	-22.838***	-23.293***	-22.816***
	(0.437)	(0.440)	(0.441)	(0.455)	(0.462)	(0.455)
N	14936	15150	15003	14606	14440	14605
adj. R^2	0.546	0.547	0.551	0.539	0.540	0.539
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
Optimal threshold		0.550			0.500	

Table 2.13 reports the Panel fixed effect regression investigating how financial development affects market competition in the industry level. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.14: Financial development, market competition, and innovation

	Capitalization	Value traded	Turn over	Total Private	Liquidity	Deposit credit
	Panel A: Research Quotient from Worldscope					
comp*EFD	-0.002	0.005***	0.005***	0.007***	0.004***	0.003
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
$comp * FD * EFD$	0.004*	-0.006***	-0.004***	-0.007***	-0.005***	-0.003
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Initial share	0.007	0.013	0.015*	0.013	0.010	0.013
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
_cons	6.191***	6.188***	6.193***	6.353***	6.334***	6.284***
	(0.165)	(0.165)	(0.164)	(0.166)	(0.167)	(0.166)
N	6645	6790	6756	6673	6593	6669
adj. R^2	0.284	0.283	0.284	0.281	0.271	0.278
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
	Panel B: Patent counts from merged Compustat					
comp*EFD	0.002	-0.000	-0.002	0.007***	0.016***	0.006***
	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)	(0.002)
$comp * FD * EFD$	-0.013***	-0.004	0.001	-0.017***	-0.038***	-0.017***
	(0.004)	(0.007)	(0.005)	(0.004)	(0.005)	(0.004)
Initial share	0.919***	0.908***	0.919***	0.918***	0.898***	0.918***
	(0.051)	(0.050)	(0.050)	(0.051)	(0.052)	(0.051)
_cons	-6.764**	-10.652***	-10.413***	-16.938***	-17.945***	-16.941***
	(2.903)	(2.874)	(2.916)	(2.891)	(2.914)	(2.896)
N	14936	15150	15003	14606	14440	14605
adj. R^2	0.465	0.466	0.466	0.478	0.480	0.478
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes
	Panel C: Citation weighted Patent counts from merged Compustat					
comp*EFD	0.014***	0.011***	0.009**	0.024***	0.049***	0.016***
	(0.004)	(0.004)	(0.004)	(0.006)	(0.009)	(0.005)
$comp * FD * EFD$	-0.050***	-0.080***	-0.036***	-0.048***	-0.104***	-0.035***
	(0.008)	(0.016)	(0.011)	(0.008)	(0.014)	(0.011)
Initial share	0.984***	0.956***	0.985***	1.004***	0.991***	1.006***
	(0.082)	(0.080)	(0.082)	(0.082)	(0.082)	(0.082)
_cons	48.928***	44.810***	46.676***	40.554***	38.046***	40.780***
	(8.528)	(8.393)	(8.585)	(8.608)	(8.806)	(8.693)
N	14936	15150	15003	14606	14440	14605
adj. R^2	0.243	0.242	0.243	0.249	0.250	0.249
Industry effect	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes

Table 2.14 reports the Panel fixed effect regression investigating how the effect of competition affects innovation with the level of financial development. The industrial level data are constructed from the Worldscope Database and are aggregated from the firm level data by the 2-digit SIC code. Only manufacturing industries (SIC 20-39) are included. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.15: Effect of FD on RQ: High income vs. Middle and Low income countries

	Capitalization		Value trade		Turn over		Private credit		Liquidity		Deposit credit	
	HIC	**MLC**	**HIC**	**MLC**	**HIC**	**MLC**	**HIC**	**MLC**	**HIC**	**MLC**	**HIC**	**MLC**
FD*EFD	0.028***	-0.032***	0.011**	-0.014**	0.014***	-0.011*	0.007**	-0.012*	0.014***	0.009	0.013***	-0.010
	(0.005)	(0.007)	(0.005)	(0.006)	(0.005)	(0.006)	(0.003)	(0.007)	(0.004)	(0.006)	(0.004)	(0.008)
FD^2*EFD	-0.009***	0.014***	-0.005**	0.003	-0.007***	0.006**	-0.005***	0.017***	-0.008***	-0.004	-0.009***	0.015**
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.005)	(0.002)	(0.004)	(0.003)	(0.006)
Competition	-2.518***	-0.194	-2.207***	0.209	-2.213***	0.151	-2.231***	0.101	-2.154***	0.231	-2.179***	0.107
	(0.313)	(0.637)	(0.309)	(0.638)	(0.307)	(0.637)	(0.306)	(0.636)	(0.309)	(0.644)	(0.307)	(0.636)
$Competition^2$	1.283***	0.118	1.127***	-0.093	1.131***	-0.063	1.141***	-0.036	1.098***	-0.108	1.112***	-0.037
	(0.165)	(0.338)	(0.162)	(0.338)	(0.162)	(0.338)	(0.161)	(0.337)	(0.162)	(0.341)	(0.161)	(0.337)
Initial share	0.033***	0.016	0.041***	0.009	0.041***	0.010	0.041***	0.015	0.038***	-0.004	0.041***	-0.020
	(0.011)	(0.036)	(0.011)	(0.037)	(0.011)	(0.037)	(0.011)	(0.037)	(0.011)	(0.036)	(0.011)	(0.037)
CM*EFD	-0.014***	0.022***	-0.004**	0.015***	-0.005***	0.011***						
	(0.002)	(0.004)	(0.002)	(0.003)	(0.002)	(0.003)						
EM*EFD							-0.001	0.002	-0.004***	0.001	-0.003**	0.002
							(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
_cons	7.934***	4.663***	7.598***	5.191***	7.716***	5.069***	7.751***	4.846***	7.768***	5.280***	7.741***	4.993***
	(0.243)	(0.651)	(0.240)	(0.652)	(0.240)	(0.655)	(0.241)	(0.655)	(0.243)	(0.661)	(0.240)	(0.657)
N	5309	972	5464	972	5430	972	5430	972	5350	972	5430	968
adj. R^2	0.325	0.331	0.315	0.323	0.317	0.321	0.316	0.323	0.306	0.314	0.317	0.317
Industry effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-year effect	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Optimal thresold	1.555	1.142	1.100		1.000	0.916	0.700	0.35	0.875		0.722	

Table 2.15 reports the results for the heterogeneous effects of financial development on innovation, measured as Research Quotient. Countries are grouped into two clubs based on the World Bank Country Classfication System.Standard errors calculated with clustering at the country level are reported in parentheses.
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.16: Effect of FD on innovation: High income vs. Middle and Low income countries

	Capitalization		Value trade		Turn over		Private credit		Liquidity		Deposit credit	
	HIC	**MLC**	**HIC**	**MLC**	**HIC**	**MLC**	**HIC**	**MLC**	**HIC**	**MLC**	**HIC**	**MLC**
FD*EFD	0.107***	-0.005***	0.117***	-0.009	0.093***	-0.001	0.027	-0.005***	0.149***	-0.009***	0.021	-0.005***
	(0.017)	(0.001)	(0.018)	(0.010)	(0.017)	(0.002)	(0.024)	(0.001)	(0.020)	(0.002)	(0.028)	(0.001)
FD^2*EFD	-0.045***	0.002***	-0.047***	0.011	-0.028***	-0.002	0.021	0.003***	-0.122***	0.008***	0.029	0.003***
	(0.010)	(0.001)	(0.011)	(0.016)	(0.010)	(0.002)	(0.020)	(0.001)	(0.017)	(0.002)	(0.027)	(0.001)
Competition	0.142	0.707***	0.164	0.694***	0.145	0.704***	-0.038	0.807***	-0.070	0.808***	-0.045	0.807***
	(0.178)	(0.146)	(0.176)	(0.143)	(0.178)	(0.147)	(0.181)	(0.146)	(0.183)	(0.146)	(0.181)	(0.146)
$Competition^2$	0.093	-0.653***	0.096	-0.640***	0.142	-0.651***	0.236	-0.729***	0.245	-0.731***	0.237	-0.729***
	(0.196)	(0.150)	(0.194)	(0.147)	(0.195)	(0.150)	(0.200)	(0.150)	(0.202)	(0.150)	(0.200)	(0.150)
Initial share	1.476***	0.340***	1.447***	0.337***	1.465***	0.342***	1.524***	0.342***	1.526***	0.343***	1.521***	0.342***
	(0.078)	(0.060)	(0.076)	(0.060)	(0.077)	(0.060)	(0.080)	(0.060)	(0.081)	(0.060)	(0.080)	(0.060)
_cons	-0.901	-9.899***	-5.518	-9.489***	-5.415	-9.903***	-14.598***	-13.102***	-20.075***	-12.944***	-15.006***	-13.086***
	(4.397)	(2.206)	(4.278)	(2.160)	(4.369)	(2.206)	(4.310)	(2.514)	(4.360)	(2.483)	(4.335)	(2.516)
Obs	10429	4507	10610	4540	10505	4498	10159	4447	9993	4447	10159	4446
adj. R^2	0.501	0.143	0.501	0.143	0.501	0.144	0.516	0.150	0.520	0.150	0.516	0.150
Controlling credit market	yes	yes	yes	yes	yes	yes						
Controlling equity market							yes	yes	yes	yes	yes	yes
Industry fixed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-year fixed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Optimal thresold	1.188	1.250	1.244		1.661			0.833	0.611	0.563		0.833

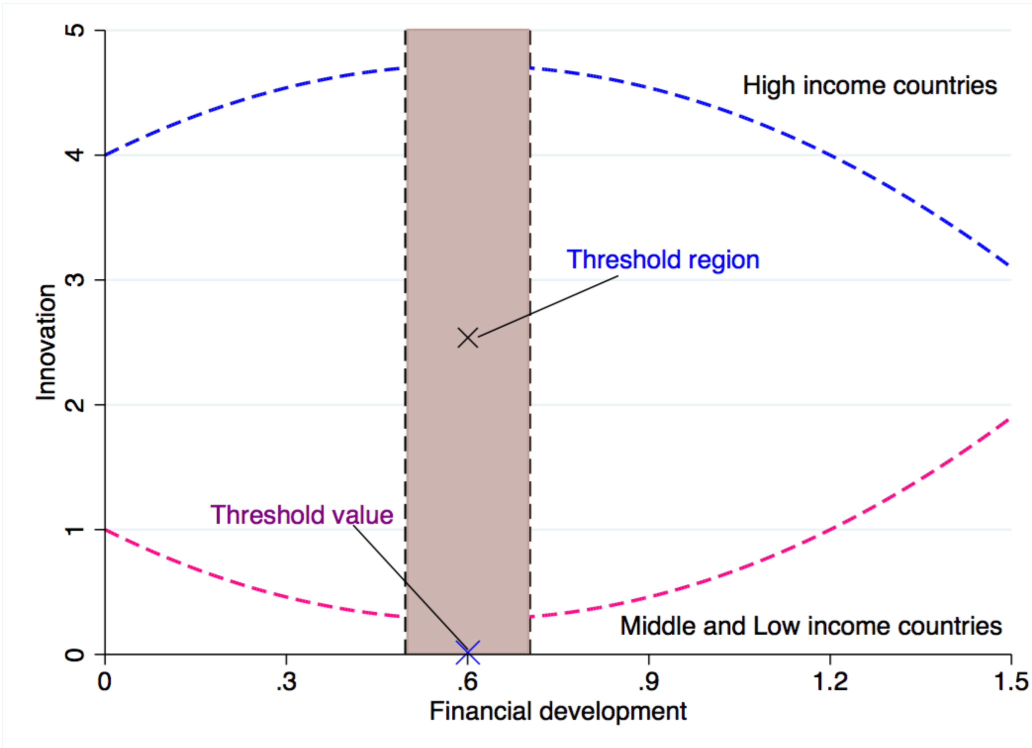
Table 16 reports the results for the heterogeneous effects of financial development on innovation, measured as patent counts and citation weighted patents. Countries are grouped into two clubs based on the World Bank Country Classfication System. Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 2.17: Effect of FD index on innovation: High income vs. Middle and Low income countries

	Industrial Patent counts						Citation weighted Patent counts					
	FD index		FM index		FM Depth		FD index		FM index		FM Depth	
	HIC	MLC	HIC	MLC	HIC	MLC	HIC	MLC	HIC	MLC	HIC	MLC
FD*EFD	0.018	-0.010***	0.094*	-0.026***	0.098**	-0.020 ***	0.251**	-0.000	0.177	-0.002***	0.169*	-0.002***
	(0.046)	(0.002)	(0.055)	(0.004)	(0.048)	(0.003)	(0.111)	(0.000)	(0.135)	(0.001)	(0.101)	(0.001)
FD^2*EFD	0.071	0.014***	-0.029	0.039***	-0.040	0.027***	-0.408***	0.001	-0.337*	0.003*	-0.297**	0.003*
	(0.059)	(0.003)	(0.074)	(0.007)	(0.058)	(0.005)	(0.157)	(0.000)	(0.196)	(0.001)	(0.127)	(0.001)
Competition	0.172	0.795***	0.175	0.790***	0.173	0.799***	-0.155	0.127***	-0.131	0.126***	-0.137	0.127***
	(0.174)	(0.142)	(0.174)	(0.142)	(0.174)	(0.142)	(0.371)	(0.034)	(0.371)	(0.034)	(0.371)	(0.034)
$Competition^2$	0.102	-0.709***	0.100	-0.702***	0.100	-0.713***	1.094***	-0.139***	1.056***	-0.138***	1.062***	-0.139***
	(0.190)	(0.146)	(0.190)	(0.146)	(0.190)	(0.146)	(0.412)	(0.039)	(0.409)	(0.038)	(0.409)	(0.039)
initial share	1.427***	0.326***	1.425***	0.325***	1.424***	0.324***	1.957***	0.002	1.954***	0.002	1.955***	0.002
	(0.076)	(0.058)	(0.076)	(0.058)	(0.076)	(0.058)	(0.145)	(0.010)	(0.144)	(0.010)	(0.144)	(0.010)
_cons	7.159*	-9.725***	6.934*	-9.703***	7.145*	-9.838***	69.747***	-0.885**	69.904***	-0.884**	68.815***	-0.896**
	(3.926)	(2.162)	(3.906)	(2.159)	(3.901)	(2.168)	(12.445)	(0.424)	(12.270)	(0.424)	(12.608)	(0.427)
N	10909	4617	10909	4617	10909	4617	10909	4617	10909	4617	10909	4617
adj. R^2	0.492	0.141	0.492	0.142	0.492	0.141	0.260	0.029	0.260	0.029	0.260	0.029
Controlling credit market	yes	yes	yes	yes	yes	yes						
Controlling equity market							yes	yes	yes	yes	yes	yes
Industry fixed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Country-year fixed	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes

Table 2.17 reports the results for the heteregeneous effects of financial development, measured as the index of FD, on innovation, measured as industry-level patent counts and citation weighted patents. Countries are grouped into two clubs based on the World Bank Country Classfication System.Standard errors calculated with clustering at the country level are reported in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Figure 2.5: An illustration of the heterogeneous effect between emerging and developed economies



Note: Figure 2.5 illustrates the heterogeneous effects of financial development on innovation between developed and emerging economies. The blue curve, red curve, threshold region, threshold value, and the scale of innovation against the vertical axis are all hypothetical ones for illustrative purpose. It shows that for a similar range of threshold of financial development, the effects differ across these two groups.

Table 2.18: Major Variable Definitions and Sources

Variables	Definition	Source
Innovation and control variables		
Research Quotient	Defined as the firm-specific output elasticity of R&D.	Author's Construction from Worldscope
Patent Counts	Aggregation of firm-level number of patent counts by 2-digit SIC code. Mapping the USPTO with the Compustat North and Global Database.	Authors' construction
Weighted Patent	Aggregation of firm-level number of forward citation weighted patents by 2-digit SIC code. Mapping the USPTO with the Compustat North and Global Database.	Authors' construction
Competition	Defined as 100 minus the median value of operating profit margin across firms within the industry at given year in a country.	Author's caculation from Worldscope
External Financing Dependence(EFD)	Calculated as capital expenditures plus R&D expenditures minus cash flows from operations, all divided by the sum of capital expenditures and R&D expense. Within a country, the time series of each industry's dependence on external finance is then calculated as the median of all firms' dependence on external finance in a year	Author's construction
Legal and finance variables		
Legal Origin	A dummy variable equal to one if the country is of co	[La Porta et al., 1997]
Anti-self dealing(ASD)	A measure of legal protection of minority shareholders against expropriation by corporate insiders in 2003, scaled between zero and one with higher values indicating stronger shareholder protection	La Porta's web page
Enforcement	Enforceability of contracts. The relative degree to which contractual agreements are honored. Scaled from 0 to 10 with higher scores indicating higher enforceability	La Porta's web page
Banking credit	The financial resources provided to the private sector by domestic money banks as a share of GDP.	WBFSD, World Bank
Domestic credit	Domestic credit to private sector refers to financial resources provided to the private sector((% of GDP)).	WBFSD, World Bank
Liquidity	Ratio of liquid liabilities to GDP. Liquid liabilities are also known as broad money, or M3.	WBFSD, World Bank
Stock market capitalization	Total value of all listed shares in a stock market as a percentage of GDP., indicator of equity market size	WBFSD,World Bank
Stock market value traded	Total value of all traded shares in a stock market exchange as a percentage of GDP., indicator of equity market activity	WBFSD,World Bank
Stock market turnover ratio	Total value of shares traded during the period divided by the average market capitalization for the period., indicator of equity market efficiency	WBFSD,World Bank

Table 2.19: Correlation of External Financing Dependence Index between US and Other Countries

Country	Corr	Sig.(p-value)
Australia	0.798	(0.0004)
Austria	0.4048	(0.3677)
Belgium	0.7716	(0.0249)
Brazil	0.5625	(0.0905)
Canada	-0.0783	(0.7653)
Chile	0.4011	(0.7373)
China	0.0873	(0.7142)
Denmark	0.6830	(0.0426)
Egypt	0.2876	(0.6389)
Finland	0.6199	(0.0181)
France	0.6905	(0.0044)
Germany	0.5308	(0.0234)
Greece	-0.4346	(0.1580)
Hong Kong	0.3106	(0.2250)
India	0.3122	(0.1802)
Indonesia	0.2217	(0.5977)
Isreal	0.0219	(0.9359)
Italy	0.7795	(0.0010)
Japan	0.7364	(0.0002)
Jordan	-0.3222	(0.7912)
Korea	0.6067	(0.0046)
Malaysia	0.2910	(0.2571)
Mexico	-0.2423	(0.6945)
Netherland	0.5031	(0.0667)
Norway	0.2402	(0.5667)
Pakistan	-0.0561	(0.8860)
Peru	-0.9659	(0.1667)
Philippines	-0.9913	(0.0840)
Poland	1.0000	(0.0000)
Russia	-0.6929	(0.3071)
Saudi Arabia	-0.1252	(0.8132)
Singapore	0.4522	(0.1208)
South Africa	-0.2070	(0.5186)
Spain	0.0437	(0.9110)
Sri Lanka	0.1657	(0.7538)
Sweden	0.5962	(0.0148)
Switzerland	0.2187	(0.4729)
Thailand	0.0153	(0.9587)
Turkey	0.0759	(0.7648)
United Kingdom	0.8254	(0.0000)

Table 2.19 reports the correlation coefficient of external financing dependence index between the U.S. and other countries, with the U.S. as the reference.

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