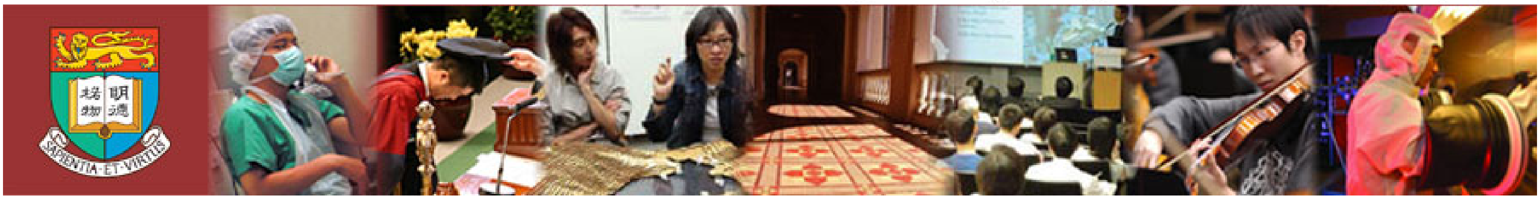

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Financial Development and Innovation: Cross Country Evidence*

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Financial Development and Innovation: Cross Country Evidence

We provide cross-country evidence to examine how financial market development affects innovation. Using a large data set including 34 developed as well as emerging countries, we differentiate the impacts of equity market and credit market development on a country's innovation productivity measured by patenting. We show that, while the development of equity markets encourages innovation, credit market development impedes innovation. A rich set of tests shows that the baseline results are robust to endogeneity and reverse causality concerns. We further examine the effect of financial development on innovation making use of cross-sectional heterogeneity in countries' economic development degrees and investor protections. We find that the effect of financial development on innovation is more pronounced in emerging countries and in countries with stronger shareholder protection and weaker creditor protection. Our evidence is robust to alternative proxies for financial development and innovation.

JEL Classifications: G15; O30; R11

Keywords: financial development; innovation; patent

1. Introduction

Innovation is vital for a country's long-run economic growth and competitive advantage. As suggested in Porter (1992), "To compete effectively in international markets, a nation's businesses must continuously innovate and upgrade their competitive advantages. Innovation and upgrading come from sustained investment in physical as well as intangible assets." Financial markets play critical roles in mobilizing savings, evaluating projects, managing risk, monitoring managers, and facilitating transactions. Therefore the development of financial markets is critical for a nation's innovation (Schumpeter, 1911). Although there is a large economics and finance literature establishing a strong link between financial development and economic growth, empirical studies of channels through which finance affects growth is relatively sparse. The objective of this paper is to fill the gap by identifying a channel, i.e., innovation, and providing cross-country evidence to empirically examine the impact of financial development on innovation. Furthermore, we differentiate the impacts of equity market and credit market development on innovation.

Our basic hypothesis is that credit market and equity market development have different impacts on innovation. As pointed out by Holmstrom (1989), innovation activities involve a very high probability of failure and the whole innovation process is long, idiosyncratic, and unpredictable with many future contingencies that are hard to foresee. Therefore, different natures of credit and equity markets may have different influences on encouraging innovation due to different payoff structures to equity and credit providers. We thus hypothesize that, while equity market development encourages innovation, credit market development impedes innovation.

As suggested by the existing literature, credit markets may discourage innovation. Stiglitz (1985) suggests that the structure of a debt contract is not well suited for innovative firms with uncertain and volatile returns. Hellwig (1991) and Rajan (1992) argue that powerful banks frequently stifle innovation by extracting informational rents and protecting established firms. By acquiring inside information about the firm, powerful banks can extract informational rents and a large share of the profits from firms, which reduces firms' incentives to undertake invest in long-run innovative projects. Weinstein and Yafeh (1998) and Morck and Nakamura (1999) further suggest that credit markets have an inherent bias toward conservative investments, which discourages firms from investing in innovative projects and leads them to be more willing to shut down ongoing ones.

In contrast, equity markets give firms more discretion to invest in innovative technologies and therefore firms have stronger incentive to pursue uncertain but potentially breakthrough innovations. As discussed in Brown, Fazzari, and Petersen (2009) and Brown, Martinsson, and Petersen (2010), equity markets have several advantages relative to credit markets when encouraging innovation. First, unlike bondholders, shareholders share upside returns when innovation turns out to be successful. Second, unlike debt financing, there are no collateral requirements for equity financing, which is especially valuable for innovative firms because these firms typically have large intangible assets with limited collateral value. Third, firms' exposures to financial distress do not increase with additional equity financing, which is valuable for firms investing in innovations.

We collect innovation and financial development data for 34 economies from the World Intellectual Property Organization (WIPO) Patent Report, the U.S. Patent and Trademark Office (USPTO), and the World Development Indicators and Global Development Finance (WDI/GDF) databases. Our sample includes both developed countries such as U.S., U.K., and Japan and emerging nations like China, India, and Brazil. To address concerns regarding endogeneity in financial development and short panel data with auto-correlated variables, we use the Arellano-Bond Generalized Method of Moments (GMM) procedure in our baseline estimation (Arellano and Bover, 1995; and Blundell and Bond, 1998).

Our baseline analysis suggests that a nation's equity market development (measured by the nation's stock market capitalization normalized by GDP) is positively and significantly associated with its subsequent growth in industry-level innovation. Specifically, increasing a country's stock market capitalization by one standard deviation increases its growth in innovation in the following year (measured by the number of filed patents) by 3.01~5.78%. However, a country's credit market development (measured by its domestic credit to private sectors normalized by GDP) is negatively associated with its subsequent growth in industry-level innovation. Our evidence suggests that increasing a nation's credit to private sectors by one standard deviation results in a decrease in its innovation growth rate in the following year by 3.47~5.62%.

While our baseline results support the hypothesis that equity market development encourages innovation and credit market development impedes innovation, an important concern is endogeneity in financial development, which arises because of both reverse causality and omitted variables concerns. First, there is an old debate on the direction of causality between finance and growth (e.g., Schumpeter, 1911; and Robinson, 1952). Although our evidence obtained from the Arellano-Bond GMM procedure seems to suggest that financial development leads to innovation, we cannot completely rule out the possibility that the causality flowing goes from innovation to financial development. For example, one may argue that economies with good innovation prospects develop financial markets to provide the funds necessary to support those good innovation prospects. Then, innovation leads, and finance follows. Second, omitted variables problem may also bias our estimation. Unobservable industry/country characteristics related to both financial development and innovation growth are put in the residual term of the regressions, which biases the estimation and makes statistical inferences hard to draw. Although including country fixed effects in our baseline regression can largely mitigate the omitted variables problem when unobservables are constant over time, endogeneity is still a concern if unobservables are time-varying.

To address the endogeneity concern, we take two different approaches. We start with Granger causality (Granger, 1969) to address the reverse causality problem. Granger causality is an empirical approach to investigate causal effects between time series and has been widely studied and applied in macroeconomics. We find financial development Granger-cause innovation, because a previous increase in financial development is associated with a subsequent increase in innovation but a previous change in innovation is not associated with subsequent change in financial development. Since the concerns and caveats of Granger causality are well understood, we further address the endogeneity issue using the instrumental variable (IV) approach. Following Rajan and Zingales (1998) and Beck and Levine (2002), we use the legal origin and the religious composition of countries as the IVs for the level of financial development. The first-stage regressions of the two-stage least squares (TSLS) regression suggest that the IVs are statistically significantly related to financial development variables and therefore satisfy the relevance condition. In the second-stage regressions, our baseline results continue to hold, suggesting that the relation between financial development and innovation cannot be simply attributed to omitted variables. The evidence from the two approaches addressing endogeneity issues suggests that there exists a causal effect of financial development on innovation.

We then further examine the impact of financial development on innovation relying on the cross-sectional heterogeneity in countries' investor protections and economic development degrees. First, we find that the positive impact of equity market development on innovation is stronger in countries with higher shareholder protection and the negative impact of credit market development on innovation is stronger in countries with weaker creditor protection. Our evidence suggests that stronger protection for investors mitigates the agency problem between firm managers and investors, which encourages innovation. Second, we show that the positive (negative) impact of equity (credit) market development on innovation is stronger in emerging countries than developed countries. Our evidence suggests that relative to developed countries, equity markets play a leading role fostering innovation in emerging countries due to insufficiency and inefficiency of these countries' private sector's technology investment. Meanwhile, since the development of credit markets in emerging nations to some extent reflects the risk aversion of these countries' investors, a more developed credit market discourages risky investments in innovation to a greater degree.

We check the robustness of our findings by constricting alternative proxies and alternative samples. First, we construct alternative proxies for financial development as well as innovation. Our baseline results remain unchanged. Second, besides our baseline setup that is based on country-industry-year observations, we redo all analyses in an alternative sample that is based on country-year observations. The sample size is substantially smaller (which largely reduces the power of our tests), but we find both quantitatively and qualitatively similar results.

Our paper makes contributions to two streams of literature. The primary contribution is to the literature on motivating innovation. There is a fast growing literature, both theoretically and empirically, examining how to promote innovation. Holmstrom (1989), in a simple principle-agent model, shows that innovation activities may mix poorly with routine activities in an organization. Manso (2010) develops a model and argues that managerial contracts that provide tolerance for failure in the short run and reward for success in the long run are best suited for motivating innovation. The model in Ferreira, Manso, and Silva (2010) shows that private instead of public ownership spurs innovation. Empirical evidence using U.S. data shows that laws (Fan and White, 2003; and Acharya and Subramanian, 2009), corporate governance (Sapra, Subramanian, and Subramanian, 2009; and Chemmanur and Tian, 2010), capital structure (Atannassov, Nanda, and Seru, 2007), stock liquidity (Fang, Tian, and Tice, 2010), product market competition (Aghion et al., 2005), investors' attitude towards failure (Tian and Wang, 2010), and institutional ownership (Aghion, Van Reenen, and Zingales, 2009) all affect innovation.

The only paper we are aware of that examines the determinants of firm innovation using international data is Ayyagari, Demirgüç-Kunt, and Maksimovic (2010). Using manager survey data from 47 emerging countries, they show that more innovative firms are large exporting firms characterized by private ownership, highly educated managers with mid-level managerial experience, and access to external finance. Unlike their paper that focuses on emerging countries and uses firm-level survey data, our paper uses data including both emerging and developed countries and studies the different impacts of equity and credit market development on innovation at the aggregate level. To our best knowledge, this is the first paper that shows while the development of equity market encourages innovation, credit market development restrains innovation in an international setting.

Our paper also contributes to the literature on finance and growth. Starting from Schumpeter (1911) and Robinson (1952), a large literature has been developed to understand the relationship between financial systems and growth. Recent theoretical developments have indicated two likely linkages between finance and growth. Bencivenga and Smith (1991) and Jappelli and Pagano (1993) argue that financial markets can matter by affecting the volume of savings available to financial investment, while Greenwood and Jovanovic (1990) and King and Levine (1993a) suggest that financial markets matter by increasing the productivity of investment. Following above theoretical work, empirical evidence linking finance and growth goes back to Goldsmith (1969) and Shaw (1973). More recently, research has shown that the size and depth of an economy's financial system positively affect its future growth in per capital, real income, employment, and output (e.g., King and Levine, 1993b; Jayarathe and Strahan, 1996; Levine and Zervos, 1998; Rajan and Zingales, 1998; Beck, Levine, and Loayza, 2000; Beck and Levine, 2002; and Black and Strahan, 2002). Our contribution to this literature is that we identify a specific channel, i.e., innovation, through which finance affects economic growth.

The closest related paper in this stream of literature to ours is Brown, Fazzari, and Petersen (2009). They argue that the financing of R&D is a channel that links finance and growth, and show significant effects of cash flow and external equity on R&D for young, but not mature firms. Our paper differs from theirs in a couple of dimensions. First, we directly examine the effect of financial development on patents that reflect successful and realized R&D investments. Second, instead of using U.S. firm level data, we rely on cross-country aggregate level data that allow us to differentiate the impacts of credit and equity market development on innovation.

The rest of the paper is organized as follows. In Section 2, we discuss data collection and variable construction, and provide descriptive statistics. Section 3 reports our empirical results and discusses the main findings. Section 4 shows cross-sectional analysis, and Section 5 concludes this paper. Detailed discussions on variable definitions and dynamic panel data model estimation are given in the appendix.

2. Data

We construct our main innovation measure based on the number of patents approved by the U.S. Patent and Trademark Office (USPTO). We measure the innovation growth of industry *j* in country *i* in year *t* as follows:

$$\Delta IndustryTech_{j,i,t} = ln(1 + Patent_{j,i,t}) - ln(1 + Patent_{j,i,t-1}), \quad (1)$$

where $Patent_{j,i,t}$ measures the number of granted patents in industry *j* from country *i* in year *t*. We use the patent data of the USPTO for two reasons: First, due to the territorial principle in U.S. patent laws, any person intending to claim exclusive rights for inventions is required to file U.S. patents. Since the U.S. is the biggest technology consumption market in the world over the past few decades, it is reasonable to assume that all important inventions from other countries have been patented in the U.S. Second, the USPTO adopts a reasonably detailed classification system, 3-digit technology classes, in classifying all U.S. patents.[1] Thus, annual country-industry-level patent counts ($Patent_{j,i,t}$) are actually defined as the number of successful patent applications that are classified in the *j*-th class of 3-digit technology classes and are filed by the residents (patent

[1] There are total 462 groups in the 3-digit technology classes. The detailed definition is available at: http://www.uspto.gov/web/offices/ac/ido/oeip/taf/cbcby.htm.

assignees) of country i in year t, which are collected by the updated NBER patent database.[2] These patents are successful innovation as they are later granted by the USPTO. That database is originally established by Hall, Jaffe, and Trajtenberg (2005) and contains detailed information of all patents approved by the USPTO over the period 1976-2006.

For robustness, we also construct a country-level proxy using a different data source to measure the innovation growth of country i in year t as follows:

$$\Delta CountryTech_{i,t} = ln(1 + Patent_{i,t}) - ln(1 + Patent_{i,t-1}), \quad (2)$$

where $Patent_{i,t}$ denotes the number of patents owned by the residents of country i in year t. To measure $Patent_{i,t}$, we use the number of country i residents' worldwide patent applications filed through the Patent Cooperation Treaty procedure or to country i's national patent office in year t, available from the World Intellectual Property Organization (WIPO) Patent Report.[3] Unlike the NBER patent database that provides information on patent applications that are eventually granted in the U.S., the WIPO database provides information on the number of patent applications in each country. The available sample period of the WIPO database starts from 1985 and ends in 2005.

Some issues about our proxies of innovation are worth discussing: First, using U.S. patent data to measure cross-country innovation performance has been widely adopted in the literature (e.g., Blundell, Griffith, and Van Reenen, 1999; Griffith, Harrison, and Van Reenen, 2006; and Acharya and Subramanian, 2009). Second, we calculate annual country-industry patent counts $Patent_{j,i,t}$ and annual country patent counts $Patent_{i,t}$ based on the patent application year, as inventions start to affect real economy since their inception. As suggested in Hall, Jaffe, and

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[2] The updated NBER patent database is available at: https://sites.google.com/site/patentdataproject/Home.
[3] The data of the WIPO Patent Report are collected from the World Development Indicators (WDI) database and Global Development Finance (GDF) database at: http://data.worldbank.org/data-catalog.

Trajtenberg (2005, P.410), "*Thus, and whenever possible, the application date should be used as the relevant time placer for patents*."

We include a total of 34 economies in our sample: Argentina, Australia, Austria, Belgium, Brazil, Canada, China, Denmark, Finland, France, Germany, Hong Kong, Hungary, India, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Malaysia, Mexico, Netherlands, New Zealand, Norway, Poland, Russia, Singapore, South Africa, Spain, Sweden, Switzerland, U.K., and U.S.[4] Our sample includes a wide arrange of countries, both developed and emerging economies.

Country-level economic variables of these 34 economies are collected from the World Development Indicators and Global Development Finance (WDI/GDF) database on annual basis. The economic variables include GDP, stock market capitalization, stock market traded value, domestic credit to private sectors, aggregate R&D expenditure, import value, export value, and liquid liability (M3) for each sample country in each year during the period of 1976-2006. Moreover, we collect each country's annual economic freedom scores constructed by the Wall Street Journal and Heritage Foundation.[5]

In the existing literature, a country's overall financial development is measured by the ratio of domestic credit plus stock market capitalization to GDP (see, e.g., Rajan and Zingales, 1998). Since our goal is to understand how stock market development and credit market development differently influence a country's innovation productivity, we construct two separate empirical proxies. Following the existing literature (e.g., Beck, Levine, and Loayza, 2000;

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[4] Among 35 top-ranked foreign economies with patent records in the USPTO (http://www.uspto.gov/web/o_ces/ac/ido/oeip/taf/apat.htm), 33 are selected into our sample. Taiwan is not included in our sample because relevant statistics are not available from the WDI/GDF database. Czechoslovakia is not included in our sample as it has been separated into the Czech Republic and the Slovak Republic in 1993.

[5] The economic freedom scores are available at: http://www.heritage.org/index/.

Levine, Loayza, and Beck, 2000; Beck and Levine, 2002; and Djankov, McLiesh, and Shleifer, 2007), our proxy for stock market development of country *i* in year *t* is

$$MKT_{i,t} = ln(Stock\ Market\ Capitalization_{i,t} / GDP_{i,t}), \quad (3)$$

i.e., the natural logarithmic ratio of country *i*'s stock market capitalization in year *t* over its GDP in the same year. The proxy for credit market development of country *i* in year *t* is

$$CREDIT_{i,t} = ln(Private\ Credit_{i,t} / GDP_{i,t}), \quad (4)$$

i.e., the natural logarithmic ratio of country *i*'s domestic credit to private sectors in year *t* over its GDP in the same year. Domestic credit to private sectors includes domestic credit through loans, purchases of non-equity securities, and trade credits and other accounts receivable. For robustness, we also consider the natural logarithmic ratio of all bank credits to GDP as an alternative proxy for credit market development. Since the alternative proxy provides test results similar to those of the primary one, they are omitted in the context in the interest of brevity.

We also include other economic variables that may affect innovation growth in our empirical analysis: (1) aggregate R&D growth, $\Delta R\&D_{i,t}$, which is defined as the natural logarithmic value of country *i*'s aggregate R&D expenditure in year *t* minus the natural logarithmic value of its aggregate R&D expenditure in year $t-1$, i.e. $ln(R\&D_{i,t}) - ln(R\&D_{i,t-1})$;[6] (2) stock market turnover, $Turnover_{i,t}$, which is the natural logarithmic ratio of country *i*'s stock market traded value over its stock market capitalization in year *t*; (3) GDP growth, $\Delta GDP_{i,t}$, which is defined as country *i*'s natural logarithmic GDP in year *t* minus its natural logarithmic GDP in year $t-1$; (4) Economic openness, $Openness_{i,t}$, which is the natural logarithmic ratio of country *i*'s import plus export over its GDP in year *t*, i.e. $ln[(Import_{i,t} + Export_{i,t-1}) / GDP_{i,t}]$; (5) Liquid liability (King and Levine, 1993b), $M3_{i,t}$, which is defined as country *i*'s M3 over its GDP in year *t*, i.e., $ln(M3_{i,t} / GDP_{i,t})$; (6) Economic freedom, $Freedom_{i,t}$, which is country *i*'s overall

[6] Unlike patents, all 34 countries have non-zero reported R&D expenses in the sample period. Therefore, when taking the natural logarithmic transform, we do not add one to R&D expenses.

economic freedom score in year *t*. Detailed definitions of variables used in the following analyses are provided in Appendix A.

Table 1 reports the descriptive statistics of variables. The top panel of Table 1 shows the summary statistics of variables. Industrial innovation growth (Δ*IndustryTech*) has a mean value of 0.007 with a standard deviation of 0.543, while country-level innovation growth (Δ*CountryTech*) has a mean value of 0.028 and a standard deviation of 0.227. Both innovation growth measures are negatively auto-correlated, suggesting a reasonable mean-reversion in technological progress. Stock market development (i.e., *MKT*) and credit market development (i.e., *CREDIT*) have mean values of –0.720 and –0.551 with standard deviations of 1.204 and 0.694, respectively. Their negative mean values are attributed to the logarithmic linearization. Not surprisingly, both financial development measures are highly auto-correlated (i.e., 0.709 and 0.948, respectively), mainly due to slow evolution of economic systems. Both aggregate GDP and R&D reveal steady growth: they increase by 4.7% and 3.8% on average per year, with standard deviations of 7.0% and 3.5% and autocorrelation coefficients of 0.403 and 0.330, respectively. Stock market turnover (i.e., *Turnover*), economic openness (i.e., *Openness*), and liquid liability (i.e., *M3*) have mean values of –0.833, –2.648, and –0.547 with standard deviations of 1.007, 1.484, and 0.541, respectively. Again, the negative mean values are due to the logarithmic linearization. Finally, an average country has an economic freedom index (i.e., *Freedom*) of 67.924 with a standard deviation of 10.091.

The bottom panel of Table 1 shows the correlation coefficient among country-level innovation and other economic variables. We find that country-level innovation correlates with financial development variables: The correlation coefficient between Δ*CountryTech* and *MKT* is 0.141 (*p*-value = 0.012), while the correlation coefficient between Δ*CountryTech* and *CREDIT* is

0.091 (p-value = 0.106). Not surprisingly, $\Delta R\&D$ and ΔGDP are two economic variables that have the highest correlation coefficients with $\Delta CountryTech$ (0.204 and 0.192, respectively) with statistical significance because $\Delta R\&D$ captures the necessary input of innovation and ΔGDP reflects the size of an economy. Economic openness and freedom are two economic variables that have the lowest correlation coefficients with $\Delta CountryTech$ (0.012 and 0.041, respectively), both without statistical significance. These statistics suggest that innovation growth is related to many aspects of the economy and call for further analysis with appropriate econometric methods.

3. Empirical analysis

In this section, we present our empirical tests and discuss the main findings of the paper. We start with presenting model specification and estimation in Section 3.1. In Section 3.2, we report our baseline results based on country-industry-level analysis. In Section 3.3, we discuss our identification strategy and present empirical tests dealing with endogeneity concerns. We provide robustness check results with country-level analysis in Section 3.4 and with alternative proxies for innovation growth in Section 3.5.

3.1. Model specification and estimation

To investigate the effect of financial development on country-industry-level innovation growth, we estimate the following model:[7]

$$\Delta IndustryTech_{j,i,t} = \alpha + \beta_0 \Delta IndustryTech_{j,i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Industry_j + Country_i + Year_t + e_{j,i,t}. \qquad (5)$$

[7] Following the previous literature (e.g., Rajan and Zingales, 1998; and Acharya and Subramanian, 2009), our baseline specification is to regress country-industry-level innovation variables on country-level financial market development as well as economic variables. .

where $\Delta IndustryTech_{j,i,t-1}$ is the lagged value of $\Delta IndustryTech_{j,i,t}$, $Industry_j$ denotes industry dummies, $Country_i$ denotes country dummies, $Year_t$ denotes year dummies, and all other country-level economic variables are the same as we describe in Section 2.

It is well known that the traditional least squares dummy variable (LSDV) method is biased in the above dynamic panel data models with individual effects. To address this potential bias, we adopt the Arellano-Bond GMM procedure following Beck, Levine, and Loayza (2000) for the country-industry-year panel (Equation (5)). The dynamic panel is estimated using the one-step GMM system estimator (Arellano and Bover, 1995; and Blundell and Bond, 1998), which employs two moment conditions to jointly estimate the regressions in transforms of the variables and regressions in levels. Following the existing literature (e.g., Arellano and Bover, 1995; Beck, Levine, and Loayza, 2000; and Levine, Loayza, and Beck, 2000), we use the past three available lagged regressors as instruments in "transformed regressions" and one lagged transforms of regressors in "level regressions." Detailed procedures of dynamic panel data model estimation are discussed in Appendix B.

3.2. Baseline results

Table 2 reports the GMM system estimation results of estimating Equation (5). The *t*-statistics reported in parentheses are based on heteroskedasticity-robust standard errors clustered by country-industry. It shows the results of our baseline regressions of country-industry-level analysis, in which the dependent variable is patent growth in each industry in each country. The coefficient estimates of $MKT_{i,t-1}$ and $CREDIT_{i,t-1}$ are 0.025 (*t*-statistic = 1.98) and –0.050 (*t*-statistic = –2.13), respectively, in the basic model setting (column (1)), in which we include only lagged innovation, stock market development, credit market development, industry dummies, country dummies, and year dummies in the regression. The results suggest that increasing a country's stock market capitalization by one standard deviation increases its industry-level innovation growth by 3.01%, while increasing its credit to private sector by one standard deviation decreases its industry-level innovation growth by 3.47%.[8] In the second specification, we add R&D growth, stock market turnover, and GDP growth to the regression. The coefficient estimate of $MKT_{i,t-1}$ continues to be positive and significant and the magnitude rises to 0.048 (*t*-statistic = 4.37). The coefficient estimate of $CREDIT_{i,t-1}$ is still negative and significant, and the magnitude drops to –0.081 (*t*-statistic = –4.52). In the complete model setting in which economic openness, liquid liability, and economic freedom are all included, we find that the coefficient estimates of $MKT_{i,t-1}$ and $CREDIT_{i,t-1}$ are 0.045 (*t*-statistic = 3.14) and –0.059 (*t*-statistic = –1.75), respectively. Based on the coefficient estimates reported in the complete model in column (3), increasing a country's stock market capitalization by one standard deviation increases its industry-level innovation growth by 5.42%, while increasing the country's credit to private sector by one standard deviation results in a decrease in its industry-level innovation growth by 4.10%. The evidence reported in this panel provides support for our hypothesis that while stock market development has a positive effect on innovation, credit market development negatively affects innovation.

As reported in Table 2, we also show that R&D growth, GDP growth, and liquid liability are positively related to industry-level innovation growth, which are consistent with economic intuition and existing literature. In addition, economic openness and freedom also are positively related to industry-level innovation growth. Lagged industry-level innovation does not appear to explain current industry-level innovation once other variables are controlled. Our sample size

[8] As reported in Table 1, the standard deviations of *MKT* and *CREDIT* are 1.204 and 0.694, respectively. Thus, the one standard deviation increase in *MKT* and *CREDIT* leads to 1.204×2.5% = 3.01% and 0.694×–5.0% = –3.47% in innovation, respectively.

varies across different model specifications due to the availability of explanatory variables included in the regressions.

3.3. Identification

While our baseline results support the hypothesis that equity market development encourages innovation and credit market development impedes innovation, an important concern is endogeneity in financial development. The endogeneity concern arises mainly due to both reverse causality and omitted variables problem. In this section, we take two different approaches to address the identification issue.

3.3.1. Granger causality

We start with addressing the reverse causality problem. As we discussed in the introduction, there is an old debate on the direction of causality between finance and growth (e.g., Schumpeter, 1911 and Robinson, 1952). Although the Arellano-Bond GMM procedure takes endogeneity in financial development into account by using lagged regressors as instruments, we still cannot completely rule out the possibility that innovation drives up contemporaneous financial development as well as future innovation, which results in a lead-lag relation between financial development and innovation. Such argument, however, is not supported by our data because both Δ*IndustryTech* and Δ*CountryTech* are negatively auto-correlated as reported in Table 1.

Another possible reverse-causality situation is that economies with good innovation prospects develop financial markets to provide the funds necessary to support those good innovation prospects. Then, innovation leads, and finance follows. To address the reverse causality, we first use Granger causality (Granger, 1969) by estimating the following models for the country-year panel:

$$MKT_{i,t} = c_0 + c_1\, \Delta CountryTech_{i,t-1} + c_2\, MKT_{i,t-1} + c_3\, CREDIT_{i,t-1} + c_4\, \Delta R\&D_{i,t-1} + c_5\, Turnover_{i,t-1} + c_6\, \Delta GDP_{i,t-1} + c_7\, Openness_{i,t-1} + c_8\, M3_{i,t-1} + c_9\, Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}, \quad (6)$$

$$CREDIT_{i,t} = d_0 + d_1\, \Delta CountryTech_{i,t-1} + d_2\, MKT_{i,t-1} + d_3\, CREDIT_{i,t-1} + d_4\, \Delta R\&D_{i,t-1} + d_5\, Turnover_{i,t-1} + d_6\, \Delta GDP_{i,t-1} + d_7\, Openness_{i,t-1} + d_8\, M3_{i,t-1} + d_9\, Freedom_{i,t-1} + Country_i + Year_t + \varepsilon_{i,t}, \quad (7)$$

where $e_{i,t}$ and $\varepsilon_{i,t}$ denote the error terms.[9]

We report the regression results in Table 3. In Panel A where $MKT_{i,t}$ is the dependent variable, the coefficient estimates of $\Delta CountryTech_{i,t-1}$ range from –0.037 to –0.016 and none of them is statistically significant. The coefficient estimates of $MKT_{i,t-1}$, however, are positive and significant at the 1% level, being consistent with our earlier findings of high autocorrelation of *MKT* as reported in Table 1. Among all other economic variables, GDP growth negatively predicts $MKT_{i,t}$, while economic freedom is able to positively predict $MKT_{i,t}$. In Panel B where $CREDIT_{i,t}$ is the dependent variable, the coefficient estimates of $\Delta CountryTech_{i,t-1}$ in all three columns are negative but not statistically significant. However, the coefficient estimates of $CREDIT_{i,t-1}$ are positive and significant at the 1% level, being consistent with our earlier findings on the persistent credit market development as reported in Table 1. Moreover, stock market development and economic freedom positively forecast $CREDIT_{i,t}$, while liquid liability negatively forecasts $CREDIT_{i,t}$. Overall, the evidence suggests that innovation does not appear to forecast financial development.

[9] We conduct the Granger causality test in the country-level sample because the dependent variables, $MKT_{i,t}$ and $CREDIT_{i,t}$ are aggregate measures at the country level. Therefore, it is more appropriate to examine if the lagged country-level innovation variables are able to predict the country-level financial development variables. The results are quantitatively unchanged if we use the lagged country-industry-level innovation variable, $\Delta IndustryTech_{j,i,t-1}$, in the Granger causality test.

Taken together, the Granger causality tests suggest that a previous increase in financial development is associated with a subsequent increase in innovation, but a previous change in innovation is not associated with subsequent change in financial development. Our evidence hence suggests that financial development Granger-causes innovation.

3.3.2. Instrumental variable approach

Endogeneity in financial development may be also due to the omitted variables problem. Unobservable characteristics that affect both financial development and innovation may bias our coefficient estimates and make the interpretation of our results difficult. Although we include country fixed effects in our baseline regressions that largely mitigate the omitted variables problem if country unobservables are time-invariant, endogeneity is still an issue if unobservables are time-varying. Thus, following Rajan and Zingales (1998) and Beck and Levine (2002), we conduct cross-country two-stage least squares (TSLS) analysis using two sets of instruments: legal origins and religious compositions.

The first set of instruments is a country's legal origin. La Porta, Lopez-de-Silanes, Shleifer, and Vishny (1997, 1998) show that a country's legal system (English, French, German, or Scandinavian system) influences its domestic capital market development. Therefore, it satisfies the relevance condition of IVs. Moreover, as suggested by Rajan and Zingales (1998) and Beck and Levine (2002), since most countries have acquired their legal systems through occupation and colonialism, a country's legal origin can be regarded as exogenous and therefore is likely to satisfy the exclusion restriction of IVs. The second set of instruments is a country's religious composition. A country's religious composition represents the fractions of Catholics, Muslims, and Protestants in its population (La Porta, Lopez-de-Silanes, Shleifer, and Vishny, 1999), and it has been used as the IVs for financial sector development in Beck and Levine

(2002). Similar to legal origins, since a country's religious composition is determined due to historical reasons, it reasonably satisfies the exclusion restriction of IVs. To examine the validity of the constructed IVs in the TSLS regressions, we conduct the Sargan-Hansen *J* test.

Following previous literature (e.g., Beck, Levine, and Loayza, 2000; Levine, Loayza, and Beck, 2000; and Beck and Levine, 2002), we first compute the time series averages of all economic variables to construct a cross-section of country-industry sample. In the first stage, we regress MKT_i or $CREDIT_i$ (i.e., the time series averages of $MKT_{i,t}$ and $CREDIT_{i,t}$) on the IVs (as well as other control variables). In the second stage, we regress $\Delta IndustryTech_{j,i}$ (i.e., the time series averages of $\Delta IndustryTech_{j,i,t}$) on the predicted MKT_i and $CREDIT_i$ from the first-stage regressions (as well as other control variables). We report the regression results in Table 4.

The top panel reports the *F*-statistics for the joint significance of IVs from the first-stage regressions. The values of *F*-statistics are much larger than the Stock-Yogo weak instrument test critical values. Therefore, we reject the null hypothesis that the instruments are weak. The weak instrument test ensures that the coefficient estimates and their corresponding estimated standard errors reported in the TSLS regressions are likely to be unbiased and the inferences based on them would be reasonably valid.

The bottom panel of table 4 reports the second-stage regression results. We continue to observe positive and significant coefficient estimates of MKT_i in all three columns, being consistent with our baseline findings that equity market development encourages innovation. The coefficient estimates of $CREDIT_i$ are negative in all three columns and statistically significant in the complete model (column (3)), being reasonably consistent with our baseline findings that credit market development impedes innovation. The insignificant Sargan-Hansen *J*-statistics for the validity of the IVs in columns (2) and (3) suggest that our instruments are reasonably valid.

Overall, the TSLS regression results reported in Table 4 suggest that the effect of financial market development on innovation is unlikely driven by unobservable country or industry heterogeneity.

In summary, the identification tests reported in this subsection reasonably suggest that our baseline results are robust to endogeneity in financial development, and there exists a causal relationship between equity and credit market development and innovation growth.

3.4. Country-level panel analysis

For robustness, we construct an alternative sample in which the innovation variable, $\Delta CountryTech_{i,t}$ is based on country-level observations. We estimate the following model to examine if our baseline findings regarding the effect of financial development on innovation growth still hold:

$$\Delta CountryTech_{i,t} = \alpha + \beta_0 \Delta CountryTech_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}, \quad (8)$$

where $\Delta CountryTech_{i,t-1}$ is the lagged value of $\Delta CountryTech_{i,t}$, and all other economic variables are the same as those in Equation (5).

Table 5 reports the GMM system estimation results of estimating Equation (8). The *t*-statistics reported in parentheses are based on heteroskedasticity-robust standard errors clustered by country. The sample size drops dramatically relative to that in Table 2, which reduces the power of our tests.

Being consistent with our baseline evidence reported in Table 2, the coefficient estimates of $MKT_{i,t-1}$ continue to be positive and significant and those of $CREDIT_{i,t-1}$ are negative and significant. For example, as reported in column (3), the coefficient estimate of $MKT_{i,t-1}$ is 0.028

(t-statistic = 2.06) and that of $CREDIT_{i,t-1}$ is –0.047 (t-statistic = –2.40). Although the estimations are based on a much smaller sample, which may substantially reduce the power of our tests, the magnitudes and significance levels of coefficient estimates of $MKT_{i,t}$ and $CREDIT_{i,t}$ closely mirror those of our baseline regressions reported in Table 2.

Consistent with our earlier findings, R&D growth, GDP growth, and liquid liability are positively related to the country's innovation growth. Moreover, stock market turnover is positively related to future innovation, while economic openness and freedom do not appear to explain innovation growth. The negative coefficient estimates of lagged innovation growth confirm the mean-reverting process in technology progress as we show in Table 1. Due to the availability of explanatory variables, the sample size varies across different specifications.

3.5. Alternative proxies of innovation

For robustness, in addition to alternative sample, we construct two alternative proxies for innovation growth: the growth in high-tech exports and the growth of scientific and technical journal articles. We then examine the effects of financial development on innovation growth measured by these two proxies. The growth in high-tech exports of country i in year t is constructed as follows:

$$\Delta HiTechExport_{i,t} = ln(1 + HiTechExport_{i,t}) - ln(1 + HiTechExport_{i,t-1}), \quad (9)$$

where $HiTechExport_{i,t}$ is the current US dollars of high-tech exports, including exporting high R&D intensity products such as aerospace-related, computers, pharmaceuticals, scientific instruments, and electrical machinery, of country i in year t. The growth in scientific and technical journal articles of country i in year t is defined as follows:

$$\Delta Article_{i,t} = ln(1 + Article_{i,t}) - ln(1 + Article_{i,t-1}), \quad (10)$$

where $Article_{i,t}$ refers to the number of scientific and technical journal articles in physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences from the authors of country i in year t. We obtain the data about high-tech exports and scientific and technical journal articles from the WDI/GDF database that covers a sample period from 1986 to 2006.

In Table 6, we report the estimation results of the following models:

$$\Delta HiTechExport_{i,t} = \alpha + \beta_0 \Delta HiTechExport_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}, \quad (11)$$

$$\Delta Article_{i,t} = \alpha + \beta_0 \Delta Article_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}. \quad (12)$$

In Panel A where the dependent variable is $\Delta HiTechExport_{i,t}$, the coefficient estimates of $MKT_{i,t-1}$ are all positive and significant while the coefficient estimates of $CREDIT_{i,t-1}$ range from –0.094 to –0.071 and are significant in the first two columns. The evidence is consistent with our earlier findings that equity market development results in a higher level of high-tech export, while the credit capital market development leads to a lower level of high-tech export. In Panel B where the dependent variable is $\Delta Article_{i,t}$, the coefficient estimates of $MKT_{i,t-1}$ are all positive and significant at the 1% level in column (1), and the coefficient estimates of $CREDIT_{i,t-1}$ are all negative. Overall, our evidence shows that the effect of financial development on innovation is reasonably robust to alternative proxies of innovation.

4. Cross-Sectional Analysis

In this section, we further examine the effect of financial development on innovation by making use of cross-sectional heterogeneity in countries' investor protections and economic development degrees. We discuss how we partition the sample for cross-sectional analysis in more details in Appendix C. We report the cross-sectional analysis results based on our baseline country-industry-level sample in Table 7 and the cross-sectional analysis results based on the country-level sample in Table 8.

First, we hypothesize that the principal-agent problem may affect the impact of equity market development on innovation. This is because public firms' R&D investment could be inefficient or even irrational due to inappropriate internal control or irrational managerial optimism (Jensen, 1993; Hall, 1993). Therefore, we expect that the marginal impact of equity market development on innovation is stronger in countries where shareholder protection is stronger. To test the hypothesis, we partition our sample countries into high shareholder protection (High SP) group and low shareholder protection (Low SP) group based on each country's anti-director rights following Djankov et al. (2008) and Spamann (2010). We run the baseline regression separately in these two groups of countries and report the results in the Panel A of Table 7. For brevity, we report only the baseline specification with lagged innovation, stock market development, credit market development, industry dummies, country dummies, and year dummies. However, including other economic variables used in Tables 2 and 5 does not substantially change our results.

The coefficient estimate of $MKT_{i,t-1}$ is 0.067 and significant at the 1% level in the high SP countries and that of $MKT_{i,t-1}$ is 0.011 but statistically insignificant in the low SP countries. Our evidence suggests that the positive effect of stock market development on innovation is stronger in the countries with better shareholder protection. The evidence is consistent with the intuition that shareholders are more confident at innovation investment when they are better protected, and therefore the impact of equity market development on innovation is stronger in countries with stronger shareholder protection.

Based on the similar rationale, we hypothesize that stronger credit rights may make creditors less concerned about their investment and wealth and hence mitigate the negative impact of credit market development on innovation. To test this hypothesis, we divide our sample countries into high creditor protection (High CP) group and low creditor protection (Low CP) group based on each country's creditor rights, following Djankov, McLiesh, and Shleifer (2007). We run the baseline regression separately in these two groups of samples and report the results in Panel B of Table 7.

The coefficient estimate of $CREDIT_{i,t-1}$ is negative but not statistically significant in countries with high creditor rights, but that of $CREDIT_{i,t-1}$ is negative and significant at the 1% level for the subsample of countries with low creditor rights. Specifically, the magnitude of the coefficient estimate of $CREDIT_{i,t-1}$ for countries with low creditor rights is much larger than that of $CREDIT_{i,t-1}$ for countries with high creditor rights, i.e., –0.204 versus –0.026. Overall, the cross-sectional analysis evidence reported above is consistent with the hypothesis that stronger shareholder protection magnifies the positive impact of equity market development on innovation, while stronger creditor rights mitigates the negative impact of credit market development on innovation.

The third cross-sectional analysis is based on a country's economic development. Our conjecture is that, relative to developed countries, emerging nations may have insufficient capital and inefficient investment in its private sector's technology development. Therefore, the impact of equity market development on innovation is stronger in emerging countries. Meanwhile, unlike developed economies, the development of credit markets in emerging economies may to some extent reflect the risk aversion of these countries' investors. Therefore, a more developed credit market may discourage risky investment innovation to a greater degree. Hence, the negative impact of credit market development on innovation could be stronger in emerging countries. Following Karolyi, Lee, and Van Dijk (2009), we classify our sample countries into developed and emerging nations. We run the baseline regressions separately in these two subsamples and report the regression results in Panel C of Table 7.

The coefficient estimates of $MKT_{i,t-1}$ are both positive and significant at the 1% level across the two subsamples. However, the magnitude of the coefficient estimate of $MKT_{i,t-1}$ is much larger for emerging countries relative to that for developed countries (i.e., 0.071 versus 0.034). The evidence seems to suggest that equity market development contributes to innovation to a greater extent in emerging countries than in developed ones, being consistent with our hypothesis that, in emerging countries, the private sector's technology investment is insufficient for various reasons, and therefore funds from equity markets become an important source for technology investments. The coefficient estimates of $CREDIT_{i,t-1}$ are –0.025 (t-statistic = –1.14) and –0.159 (t-statistic = –2.61) in developed and emerging countries, respectively, suggesting that the negative effect of credit market development on innovation is more pronounced in emerging countries. This finding is consistent with our hypothesis that credit market development to some extent reflects general risk aversion of investors in emerging countries. When investors are more risk averse, a more developed credit market tends to discourage risky and idiosyncratic investment (e.g., innovation) to a greater degree.

For robustness, we redo the cross-sectional analyses based on our country-level sample and report the regression results in Table 8. The structure of Table 8 closely mirrors that of Table 7. Panel A shows the results if the sample is split based on shareholder protection. The coefficient estimates of $MKT_{i,t-1}$ are 0.057 (t-statistic = 3.80) and 0.005 (t-statistic = 0.32) in High SP and Low SP countries, respectively, being consistent with our findings in Panel A of Table 7 that the positive effect of equity market development on innovation is stronger in countries with stronger shareholder protection. In Panel B, we split the sample based on creditor protection. The coefficient estimates of $CREDIT_{i,t-1}$ are –0.049 (t-statistic = –0.98) and –0.025 (t-statistic = –1.91) in High CP and Low CP countries, respectively, being consistent with our findings in Panel B of Table 7 that the negative effect of credit market development on innovation is largely mitigated in countries with stronger creditor protection.

When comparing the effect of financial development on innovation in developed to emerging countries, we find that, in Panel C, the coefficient estimates of $MKT_{i,t-1}$ are 0.022 (t-statistic = 0.94) and 0.033 (t-statistic = 2.77) in developed and emerging countries, respectively, and the coefficient estimates of $CREDIT_{i,t-1}$ are 0.081 (t-statistic = 1.28) and –0.022 (t-statistic = –0.75) in developed and emerging countries, respectively. The evidence regarding the effect of equity market development on innovation across the two groups of countries is consistent with our earlier findings, while the results regarding the effect of credit market development on innovation are not statistically significant (although the signs of the coefficient estimates are consistent with our hypothesis).

Overall, our evidence collectively suggests the following points. First, the positive effect of equity market development on innovation is stronger in countries with better shareholder protection, as better protected shareholders are more willing to invest in high-risk-high-return innovation. Second, the negative effect of credit market development on innovation is stronger in countries with weaker creditor protection, as creditors are more concerned with the risk accompanying innovation in these countries. Third, the positive (negative) effect of equity (credit) market development on innovation is more pronounced in emerging countries, suggesting that prevailing under-investment and poor corporate governance in emerging countries are obstacles to technological development in these countries.

5. Conclusion

In this paper we have provided, for the first time in the literature, cross-country evidence that examines how financial market development affects innovation. Making use of a large data set that includes 34 developed as well as emerging countries between 1976 and 2006, we report the different impacts of equity market and credit market development on a country's innovation growth measured by patenting. Our baseline results suggest that, while the development of equity markets encourages innovation, credit market development impedes innovation. We conduct a rich set of identification tests and show that our baseline results are robust to endogeneity and reverse causality concerns. We further examine the effect of financial development on innovation relying on cross-sectional heterogeneity in countries' investor protections and economic development degrees. Our cross-sectional analyses suggest that the effect of financial development on innovation is more pronounced in emerging countries and in countries with stronger shareholder protection and weaker creditor protection. Our findings are robust to alternative measures for innovation, such as high-tech exports and scientific and technical journal articles, and alternative measures for financial development.

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Appendix

A. Variable definitions

1. $\Delta R\&D_{i,t}$: the natural logarithmic number of country *i*'s aggregate R&D expenditure in year *t* minus its aggregate R&D expenditure in year *t-1*, i.e. $ln(R\&D_{i,t}) - ln(R\&D_{i,t-1})$. Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development. The data are from the WDI/GDF database.

2. $Turnover_{i,t}$: the natural logarithmic ratio of country *i*'s stock market traded value over its stock market capitalization in year *t*. Stocks traded refers to the total value of shares traded during the period. This indicator complements the market capitalization ratio by showing whether market size is matched by trading. The data are from the WDI/GDF database.

3. $\Delta GDP_{i,t}$: country *i*'s natural logarithmic GDP in year *t* minus it's natural logarithmic GDP in year *t-1*. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars. Dollar figures for GDP are converted from domestic currencies using single year official exchange rates. For a few countries where the official exchange rate does not reflect the rate effectively applied to actual foreign exchange transactions, an alternative conversion factor is used. The data are from the WDI/GDF database.

4. $Openness_{i,t}$: a measure for the economic openness based on export and import, defined as the natural logarithmic ratio of country *i*'s imports plus exports over its GDP in year *t*, i.e. $ln[(Import_{i,t} + Export_{i,t}) / GDP_{i,t}]$. Imports of goods and services represent the value of all goods and other market services received from the rest of the world. Exports of goods and services represent the value of all goods and other market services provided to the rest of the world. Both imports and exports include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services, such as communication, construction, financial, information, business, personal, and government services. They exclude labor and property income (formerly called factor services) as well as transfer payments. The data are from the WDI/GDF database.

5. $M3_{i,t}$: a measure of liquid liability, defined as country *i*'s M3 over its GDP in year *t*, i.e., $ln(M3_{i,t} / GDP_{i,t})$. They are the sum of currency and deposits in the central bank (M0), plus transferable deposits and electronic currency (M1), plus time and savings deposits, foreign currency transferable deposits, certificates of deposit, and securities repurchase agreements (M2), plus travelers checks, foreign currency time deposits, commercial paper, and shares of mutual funds or market funds held by residents. The data are from the WDI/GDF database.

6. $Freedom_{i,t}$: A score for country *i*'s overall economic freedom score in year *t*, defined as a simple average of its scores on ten individual freedom indexes in year *t*: business freedom,

trade freedom, fiscal freedom, government spending, monetary freedom, investment freedom, financial freedom, property rights, freedom from corruption, and labor freedom. These indexes are constructed by the Wall Street Journal and Heritage Foundation.

B. Details of dynamic panel data model estimation

Our dynamic panel regression model can be written as

$$y_{i,t} = \beta_0 y_{i,t-1} + \beta^\top X_{i,t-1} + \lambda_t + \eta_i + v_{i,t},$$

where $y_{i,t}$ is dependent variable, $X_{i,t-1}$is a vector of explanatory variables (our basic specification includes $MKT_{i,t-1}$, $CREDIT_{i,t-1}$, $\Delta R\&D_{i,t-1}$, $Turnover_{i,t-1}$, $\Delta GDP_{i,t-1}$, $Openness_{i,t-1}$, $M3_{i,t-1}$, and $Freedom_{i,t-1}$), β is the vector of coefficients associated with explanatory variables, λ_t and η_i are time and individual specific effects, respectively, and v_{it} denotes the model errors.

It is well known that the traditional LSDV (least squares dummy variable) method is biased in the above panel autoregressive model with individual effects. To see this, denote the time mean of v_{it} as $\overline{v}_i = \sum_{t=1}^{T} v_{i,t}$. Simple within-group transformation would show that the strict exogeneity condition is violated when regressors include lagged dependent variables:

$$\sum_{t=1}^{T} E[y_{i,t-1}(v_{i,t} - \overline{v}_i)] \neq 0.$$

When the time dimension of the panel data *T* is small the biases will be very large regardless of the number of cross-sections.

To address this issue, we use the one-step GMM system estimator (Arellano and Bover, 1995; Blundell and Bond, 1998) which employs two moment conditions to jointly estimates the regressions in transforms of the variables and regressions in levels. We use the past three available lagged endogenous variables as instruments in "transformed regressions" and the most recent lagged transforms of endogenous variables in "level regressions".

Specifically, denoting $z = [y\ X]$, our moment conditions for the "transformed regressions" are

$$E\left[z_{i,t-\tau} \otimes \nu^*_{i,t}\right] = 0 \text{ for } \tau = 2, ..., 4; t = 3, ...T,$$

where $\otimes$ denotes the Kronecker product and $\nu^*_{i,t}$ is the residuals from the regressions on variables after taking orthogonal deviations,

$$z^*_{i,t} \equiv \left(z_{i,t} - \frac{z_{i,t+1} + ... + z_{i,T}}{T-t}\right)\left(\frac{T-t}{T-t+1}\right)^{1/2} \text{ for } t = 1, ..., T-1.$$

Our moment conditions for the "level regressions" are

$$E\left[(\eta_i + v_{i,t}) \otimes z^*_{i,t-1}\right] = 0 \text{ for } t = 3, ...T.$$

Blundell and Bond (1998) show that GMM system estimator outperforms GMM estimator especially when the endogenous variables are persistent (which is especially true for *MKT* and *CREDIT*).

C. Detailed definitions for subsamples

1. High shareholder protection (high SP) vs. low shareholder protection (low SP): Using the revised Anti-Director index proposed by Spamann (2009) that revises the index of Djankov et al. (2008), we classify countries as high (low) SP countries as above (below) the average level of the index. The index assigns a value for each country between 1 (poor shareholder rights) and 5 (strong shareholder rights). The high SP group includes Australia, Brazil, Canada, Denmark, Hong Kong, India, Ireland, Israel, Japan, Korea, Malaysia, New Zealand, Russia, Singapore, South Africa, Spain, and U.K. The low SP group includes Austria, Belgium,

China, Finland, France, Germany, Hungary, Luxembourg, Mexico, Netherlands, Norway, Poland, Sweden, Switzerland, and U.S.

2. High creditor protection (high CP) vs. low creditor protection (low CP): We use the Creditor Rights index (Djankov, McLiesh, and Shleifer, 2007) to classify countries as high (low) CP countries as above (below) the average level of the index. The index is constructed at January for every year between 1978 and 2003, and covering 133 countries. The creditor rights index varies between 0 (poor creditor rights) and 4 (strong creditor rights). The high CP group includes Australia, Austria, Belgium, China, Denmark, Finland, Germany, Hong Kong, India, Israel, Japan, Korea, Malaysia, Netherlands, New Zealand, Norway, Spain, Singapore, South Africa, and U.K. The low CP group includes Brazil, Canada, France, Hungary, Ireland, Mexico, Poland, Russia, Sweden, Switzerland, and U.S.

3. Developed vs. emerging: We follow Karolyi, Lee, and Van Dijk (2009) to classify the countries as developed countries and emerging countries according to per capita GDP. Developed countries include Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong, Ireland, Japan, Luxembourg, Netherlands, New Zealand, Norway, Singapore, Spain, Sweden, Switzerland, U.K., and U.S. Emerging countries include Brazil, China, Hungary, India, Israel, Korea, Malaysia, Mexico, Poland, Russia, and South Africa.

Table 1
Summary statistics

The upper panel reports the summary statistics of all variables, while the lower panel reports their correlation coefficients. $\Delta IndustryTech_{j,i,t}$ is the measure of innovation growth of industry j in country i in year t and is defined as $ln(1 + Patent_{j,i,t}) - ln(1 + Patent_{j,i,t-1})$, where $Patent_{j,i,t}$ denotes the number of patents in the j-th class of 3-digit patent classes filed by the residents of country i to the USPTO in year t. $\Delta CountryTech_{i,t}$ is the measure of innovation growth of country i in year t and is defined as $ln(1 + Patent_{i,t}) - ln(1 + Patent_{i,t-1})$, where $Patent_{i,t}$ denotes the number of country i residents' worldwide patent applications filed through the Patent Cooperation Treaty procedure or with country i's national patent office in year t. $MKT_{i,t}$ is the logarithmic ratio of stock market capitalization over GDP. $CREDIT_{i,t}$ is the logarithmic ratio of domestic credit to private sectors over GDP. $\Delta R\&D_{i,t}$ is the logarithmic number of country i's aggregate R&D expenditure in year t divided by its aggregate R&D expenditure in year t-1. $Turnover_{i,t}$ is the logarithmic ratio of country i's stock market traded value over its stock market capitalization in year t. $\Delta GDP_{i,t}$ is country i's logarithmic GDP in year t divided by its logarithmic GDP in year t-1. $Openness_{i,t}$ is a measure for the economic openness based on export and import, defined as the logarithmic ratio of country i's import plus export over its GDP in year t. $M3_{i,t}$ is a measure of liquid liability, defined as the logarithmic value of country i's M3 over its GDP in year t. $Freedom_{i,t}$ is the score for country i's overall economic freedom score in year t. The p-value of Pearson correlation tests are reported in parentheses of the lower panel. The sample period: 1976-2006 for $\Delta IndustryTech_{j,i,t}$, 1985-2005 for $\Delta CountryTech_{i,t}$, and 1976-2006 for other economic variables.

Variable	Mean	St. dev.	1st auto.	Min.	25%	Med.	75%	Max.
$\Delta IndustryTech_{j,i,t}$	0.007	0.543	-0.058	-4.407	-0.288	0.000	0.318	3.784
$\Delta CountryTech_{i,t}$	0.028	0.227	-0.186	-1.099	-0.036	0.015	0.075	3.774
$MKT_{i,t}$	-0.720	1.204	0.709	-10.102	-1.206	-0.601	0.065	2.201
$CREDIT_{i,t}$	-0.551	0.694	0.948	-2.485	-1.023	-0.413	-0.034	0.838
$\Delta R\&D_{i,t}$	0.047	0.07	0.403	-0.816	0.015	0.046	0.080	0.414
$Turnover_{i,t}$	-0.833	1.007	0.670	-5.843	-1.198	-0.725	-0.243	1.828
$\Delta GDP_{i,t}$	0.038	0.035	0.330	-0.157	0.019	0.036	0.056	0.177
$Openness_{i,t}$	-2.648	1.484	0.912	-7.256	-3.426	-2.537	-1.859	1.719
$M3_{i,t}$	-0.547	0.541	0.871	-2.322	-0.850	-0.579	-0.278	1.030
$Freedom_{i,t}$	67.924	10.091	1.024	45.1	61.5	68.2	75.0	90.5

Variable	Pairwise correlation								
$\Delta CountryTech_{i,t}$	1								
$MKT_{i,t}$	0.141	1							
	(0.012)								
$CREDIT_{i,t}$	0.091	0.625	1						
	(0.106)	(0.000)							
$\Delta R\&D_{i,t}$	0.204	0.270	0.049	1					
	(0.000)	(0.000)	(0.385)						
$Turnover_{i,t}$	0.153	0.018	0.261	0.188	1				
	(0.006)	(0.744)	(0.000)	(0.001)					
$\Delta GDP_{i,t}$	0.192	0.213	0.034	0.553	0.247	1			
	(0.001)	(0.000)	(0.545)	(0.000)	(0.000)				
$Openness_{i,t}$	0.012	0.306	0.119	0.163	-0.038	0.139	1		
	(0.827)	(0.000)	(0.035)	(0.004)	(0.496)	(0.013)			
$M3_{i,t}$	0.129	0.539	0.819	0.147	0.251	0.145	0.217	1	
	(0.022)	(0.000)	(0.000)	(0.009)	(0.000)	(0.010)	(0.000)		
$Freedom_{i,t}$	0.041	0.658	0.643	0.069	0.092	-0.067	0.439	0.554	1
	(0.469)	(0.000)	(0.000)	(0.220)	(0.103)	(0.234)	(0.000)	(0.000)	

Table 2
Financial development and innovation

This table reports the GMM system estimation results for the following model: $\Delta IndustryTech_{j,i,t} = \alpha + \beta_0 \Delta IndustryTech_{j,i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Industry_j + Country_i + Year_t + e_{j,i,t}$. $\Delta IndustryTech_{j,i,t}$ is the measure of innovation growth of industry j in country i in year t. $MKT_{i,t-1}$ denotes the logarithmic ratio of stock market capitalization over GDP, $CREDIT_{i,t-1}$ denotes the logarithmic ratio of domestic credit to private sectors over GDP, $\Delta R\&D_{i,t-1}$ denotes the difference in logarithmic aggregate R&D expenditure, $Turnover_{i,t-1}$ denotes the logarithmic ratio of stock market traded value over stock market capitalization, $\Delta GDP_{i,t-1}$ denotes the difference in logarithmic GDP, $Openness_{i,t-1}$ measures the economic openness and is defined as the logarithmic ratio of the sum of import and export over GDP, $M3_{i,t-1}$ is logarithmic ratio of M3 over GDP, $Freedom_{i,t-1}$ describes the economic freedom of the country, $Industry_j$ denotes industry dummies, $Country_i$ denotes country dummies, $Year_t$ denotes year dummies, and $e_{j,i,t}$ denotes the error term. We use one-step estimators and heteroskedasticity-robust standard errors clustered by country-industry to draw statistical inferences. The sample period is 1976-2006.

	Dependent variable: $\Delta IndustryTech_{j,i,t}$		
Independent variable:	(1)	(2)	(3)
$MKT_{i,t-1}$	0.025	0.048	0.045
	(1.980)	(4.370)	(3.137)
$CREDIT_{i,t-1}$	-0.050	-0.081	-0.059
	(-2.129)	(-4.518)	(-1.748)
$\Delta R\&D_{i,t-1}$		0.162	0.226
		(0.927)	(1.525)
$Turnover_{i,t-1}$		0.005	-0.007
		(0.502)	(-0.619)
$\Delta GDP_{i,t-1}$		0.684	0.311
		(1.927)	(1.006)
$Openness_{i,t-1}$			0.045
			(5.674)
$M3_{i,t-1}$			0.102
			(5.822)
$Freedom_{i,t-1}$			0.004
			(2.702)
$\Delta IndustryTech_{j,i,t-1}$	0.099	0.021	0.000
	(2.854)	(0.687)	(0.012)
α	0.067	0.059	-0.063
	(4.402)	(2.298)	(-0.484)
Industry dummy	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes
R^2	0.104	0.174	0.216
Observation	61,907	50,906	32,375

Table 3
Reverse causality

This table reports the GMM system estimation results. Panel A estimates the following model: $MKT_{i,t} = \alpha + \beta_0 \Delta CountryTech_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}$. Panel B estimates the following model: $CREDIT_{i,t} = \alpha + \beta_0 \Delta CountryTech_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}$. $\Delta CountryTech_{i,t}$ is the measure of innovation growth of country i in year t. $MKT_{i,t-1}$ denotes the logarithmic ratio of stock market capitalization over GDP, $CREDIT_{i,t-1}$ denotes the logarithmic ratio of domestic credit to private sectors over GDP, $\Delta R\&D_{i,t-1}$ denotes the difference in logarithmic aggregate R&D expenditure, $Turnover_{i,t-1}$ denotes the logarithmic ratio of stock market traded value over stock market capitalization, $\Delta GDP_{i,t-1}$ denotes the difference in logarithmic GDP, $Openness_{i,t-1}$ measures the economic openness and is defined as the logarithmic ratio of the sum of import and export over GDP, $M3_{i,t-1}$ is logarithmic ratio of M3 over GDP, $Freedom_{i,t-1}$ describes the economic freedom of the country, $Country_i$ denotes country dummies, $Year_t$ denotes year dummies, and $e_{j,i,t}$ denotes the error term. We use one-step estimators and heteroskedasticity-robust standard errors clustered by country to draw statistical inferences. The sample period is 1985-2005.

Panel A		***MKT*** $_{i,t}$		**Panel B**		***CREDIT*** $_{i,t}$	
	(1)	(2)	(3)		(1)	(2)	(3)
$\Delta CountryTech_{i,t-1}$	-0.016	-0.030	-0.037	$\Delta CountryTech_{i,t-1}$	-0.048	-0.027	-0.033
	(-0.264)	(-0.636)	(-0.612)		(-1.331)	(-0.953)	(-0.855)
$MKT_{i,t-1}$	0.663	0.699	0.704	$MKT_{i,t-1}$	0.030	0.043	0.047
	(10.209)	(7.641)	(9.482)		(4.778)	(2.666)	(3.797)
$CREDIT_{i,t-1}$	0.108	0.065	-0.083	$CREDIT_{i,t-1}$	0.919	0.914	0.920
	(2.048)	(1.016)	(-1.135)		(39.933)	(31.688)	(42.785)
$\Delta R\&D_{i,t-1}$		0.592	0.641	$\Delta R\&D_{i,t-1}$		0.050	-0.020
		(1.662)	(1.480)			(0.373)	(-0.132)
$Turnover_{i,t-1}$		0.040	0.103	$Turnover_{i,t-1}$		0.015	0.022
		(0.932)	(1.471)			(1.246)	(1.728)
$\Delta GDP_{i,t-1}$		-2.453	-3.409	$\Delta GDP_{i,t-1}$		0.362	0.542
		(-1.796)	(-2.040)			(0.818)	(1.083)
$Openness_{i,t-1}$			0.041	$Openness_{i,t-1}$			-0.008
			(1.318)				(-0.563)
$M3_{i,t-1}$			0.124	$M3_{i,t-1}$			-0.077
			(1.539)				(-2.029)
$Freedom_{i,t-1}$			0.010	$Freedom_{i,t-1}$			0.004
			(2.247)				(2.722)
α	-0.167	-0.063	-0.485	α	0.074	0.084	-0.230
	(-1.959)	(-0.584)	(-1.172)		(3.832)	(1.822)	(-1.884)
Country dummy	Yes	Yes	Yes	Country dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Year dummy	Yes	Yes	Yes
R^2	0.876	0.869	0.879	R^2	0.956	0.956	0.958
Observation	501	497	317	Observation	494	490	315

Table 4
Two-stage least squares regression results

This table reports the results of two-stage least squares regressions with legal origins and religious compositions as instrumental variables. Legal origins include English, French, German, and Scandinavian systems. Religious compositions are fractions of Catholics, Muslims, and Protestants. In the first-stage regressions, we regress MKT_i or $CREDIT_i$ on IVs as well as other control variables, where MKT_i and $CREDIT_i$ denote the time series averages of the logarithmic ratios of stock market capitalization and domestic credit to private sectors over GDP, respectively. F stat. presents the significance of IVs in the first-stage regressions, and the null hypothesis is that the existence of IVs is insignificant in the first-stage regressions (p-values are reported in brackets). In the second-stage regressions, we regress $\Delta IndustryTech_{j,i}$ on the predicted MKT_i and $CREDIT_i$ and other control variables, where $\Delta IndustryTech_{j,i}$ denotes the time series average of $\Delta IndustryTech_{j,i,t}$. All control variables are the time series averages of the control variables used in Table 2. The null hypothesis for the Sargan-Hansen *J*-statistics is that the considered IVs are valid (p-values are reported in brackets). We use the heteroskedasticity-robust standard errors clustered by country-industry to draw statistical inferences. The sample period is 1976-2006.

Country-industry cross-section			
	(1)	(2)	(3)
1st-stage regressions			
F stat. (MKT_i)	547.3	416	431.3
	[0.000]	[0.000]	[0.000]
F stat. ($CREDIT_i$)	764.7	502.3	274.3
	[0.000]	[0.000]	[0.000]
2nd-stage regressions			
MKT_i	0.009	0.008	0.007
	(2.961)	(3.255)	(2.103)
$CREDIT_i$	-0.000	-0.000	-0.015
	(-0.037)	(-0.122)	(-1.644)
$\Delta R\&D_i$		0.022	0.019
		(2.046)	(1.688)
$Turnover_i$		0.005	0.007
		(2.663)	(3.115)
ΔGDP_i		0.099	0.078
		(1.890)	(1.377)
$Openness_i$			-0.001
			(-0.942)
$M3_i$			0.008
			(1.331)
$Freedom_i$			0.000
			(1.010)
α	0.013	0.011	-0.005
	(7.147)	(4.239)	(-0.294)
J stat. (validity)	10.69	7.22	7.73
	[0.058]	[0.205]	[0.172]
R^2	0.005	0.018	0.017
Observation	7,133	5,847	5,781

Table 5
Financial development and innovation: Country-level panel

This table reports the GMM system estimation results for the following model: $\Delta CountryTech_{i,t} = \alpha + \beta_0 \Delta CountryTech_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}$. $\Delta CountryTech_{i,t}$ is the measure of innovation growth of country *i* in year *t*. $MKT_{i,t-1}$ denotes the logarithmic ratio of stock market capitalization over GDP, $CREDIT_{i,t-1}$ denotes the logarithmic ratio of domestic credit to private sectors over GDP, $\Delta R\&D_{i,t-1}$ denotes the difference in logarithmic aggregate R&D expenditure, $Turnover_{i,t-1}$ denotes the logarithmic ratio of stock market traded value over stock market capitalization, $\Delta GDP_{i,t-1}$ denotes the difference in logarithmic GDP, $Openness_{i,t-1}$ measures the economic openness and is defined as the logarithmic ratio of the sum of import and export over GDP, $M3_{i,t-1}$ is logarithmic ratio of M3 over GDP, $Freedom_{i,t-1}$ describes the economic freedom of the country, $Country_i$ denotes country dummies, $Year_t$ denotes year dummies, and $e_{j,i,t}$ denotes the error term. We use one-step estimators and heteroskedasticity-robust standard errors clustered by country to draw statistical inferences. The sample period is 1985-2005.

	Dependent variable: $\Delta CountryTech_{i,t}$		
Independent variable:	(1)	(2)	(3)
$MKT_{i,t-1}$	0.046	0.033	0.028
	(3.584)	(2.051)	(2.057)
$CREDIT_{i,t-1}$	-0.035	-0.049	-0.047
	(-1.632)	(-1.688)	(-2.402)
$\Delta R\&D_{i,t-1}$		0.182	0.126
		(0.838)	(0.516)
$Turnover_{i,t-1}$		0.042	0.023
		(1.887)	(1.593)
$\Delta GDP_{i,t-1}$		0.559	0.848
		(1.673)	(2.083)
$Openness_{i,t-1}$			-0.006
			(-0.522)
$M3_{i,t-1}$			0.053
			(1.613)
$Freedom_{i,t-1}$			-0.001
			(-0.304)
$\Delta CountryTech_{i,t-1}$	-0.266	-0.271	-0.277
	(-1.658)	(-2.037)	(-1.969)
α	0.075	0.081	0.087
	(3.064)	(1.870)	(0.593)
Country dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes
R^2	0.01	0.081	0.144
Observation	461	457	293

Table 6
Financial development and innovation: Alternative innovation proxies
This table reports the GMM system estimation results. Panel A estimates the following model: $\Delta HiTechExport_{i,t} = \alpha + \beta_0 \Delta HiTechExport_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}$. Panel B estimates the following model: $\Delta Article_{i,t} = \alpha + \beta_0 \Delta Article_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + \beta_3 \Delta R\&D_{i,t-1} + \beta_4 Turnover_{i,t-1} + \beta_5 \Delta GDP_{i,t-1} + \beta_6 Openness_{i,t-1} + \beta_7 M3_{i,t-1} + \beta_8 Freedom_{i,t-1} + Country_i + Year_t + e_{i,t}$. $\Delta HiTechExport_{i,t}$ denotes the logarithmic growth of country *i*'s high-tech export value in year *t*, while $\Delta Article_{i,t}$ denotes the logarithmic growth in the number of country *i*'s scientific and technical journal articles in year *t*. $MKT_{i,t-1}$ denotes the logarithmic ratio of stock market capitalization over GDP, $CREDIT_{i,t-1}$ denotes the logarithmic ratio of domestic credit to private sectors over GDP, $\Delta R\&D_{i,t-1}$ denotes the difference in logarithmic aggregate R&D expenditure, $Turnover_{i,t-1}$ denotes the logarithmic ratio of stock market traded value over stock market capitalization, $\Delta GDP_{i,t-1}$ denotes the difference in logarithmic GDP, $Openness_{i,t-1}$ measures the economic openness and is defined as the logarithmic ratio of the sum of import and export over GDP, $M3_{i,t-1}$ is logarithmic ratio of M3 over GDP, $Freedom_{i,t-1}$ describes the economic freedom of the country, $Country_i$ denotes country dummies, $Year_t$ denotes year dummies, and $e_{j,i,t}$ denotes the error term. We use one-step estimators and heteroskedasticity-robust standard errors clustered by country to draw statistical inferences. The sample period is 1986-2006.

Panel A	**$\Delta HiTechExport_{i,t}$**			**Panel B**	**$\Delta Article_{i,t}$**		
	(1)	(2)	(3)		(1)	(2)	(3)
$MKT_{i,t-1}$	0.049	0.039	0.058	$MKT_{i,t-1}$	0.015	0.004	0.009
	(1.845)	(1.615)	(2.193)		(2.953)	(0.636)	(1.420)
$CREDIT_{i,t-1}$	-0.094	-0.078	-0.071	$CREDIT_{i,t-1}$	-0.012	0.018	-0.014
	(-3.326)	(-2.526)	(-1.379)		(-0.749)	(1.124)	(-1.638)
$\Delta R\&D_{i,t-1}$		-0.029	-0.033	$\Delta R\&D_{i,t-1}$		0.178	0.105
		(-0.193)	(-0.182)			(3.626)	(2.931)
$Turnover_{i,t-1}$		0.006	0.015	$Turnover_{i,t-1}$		-0.009	0.011
		(0.356)	(0.756)			(-1.050)	(2.535)
$\Delta GDP_{i,t-1}$		-0.293	-0.275	$\Delta GDP_{i,t-1}$		0.056	-0.121
		(-0.942)	(-0.757)			(0.316)	(-0.925)
$Openness_{i,t-1}$			0.014	$Openness_{i,t-1}$			0.000
			(1.018)				(0.009)
$M3_{i,t-1}$			0.007	$M3_{i,t-1}$			0.019
			(0.118)				(1.221)
$Freedom_{i,t-1}$			-0.004	$Freedom_{i,t-1}$			-0.000
			(-1.826)				(-0.516)
$\Delta HiTechExport_{i,t-1}$	-0.036	-0.033	-0.038	$\Delta Article_{i,t-1}$	0.013	-0.197	0.197
	(-0.824)	(-0.770)	(-0.758)		(0.259)	(-1.369)	(1.787)
α	0.000	0.217	0.537	α	0.000	0.094	0.143
	(3.881)	(4.954)	(2.586)		(4.799)	(4.375)	(1.861)
Country dummy	Yes	Yes	Yes	Country dummy	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Year dummy	Yes	Yes	Yes
R^2	0.151	0.159	0.179	R^2	0.074	0.049	0.291
Observation	508	506	331	Observation	535	531	336

Table 7
Cross-sectional analysis: Country-industry-level panel

In Panel A, we divide all country-industry-year samples into two groups: High shareholder protection (High SP) and low shareholder protection (Low SP). In Panel B, we divide all samples into two groups: High creditor protection (High CP) and low creditor protection (Low CP). In Panel C, we divide all samples into two groups: Developed and emerging. Within each group, we estimate the following model: $\Delta IndustryTech_{j,i,t} = \alpha + \beta_0 \Delta IndustryTech_{j,i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + Industry_j + Country_i + Year_t + e_{j,i,t}$. $\Delta IndustryTech_{j,i,t}$ is the measure of innovation growth of industry j in country i in year t. $MKT_{i,t-1}$ denotes the logarithmic ratio of stock market capitalization over GDP, $CREDIT_{i,t-1}$ denotes the logarithmic ratio of domestic credit to private sectors over GDP, $Industry_j$ denotes industry dummies, $Country_i$ denotes country dummies, $Year_t$ denotes year dummies, and $e_{j,i,t}$ denotes the error term. We use one-step estimators and heteroskedasticity-robust standard errors clustered by country-industry to draw statistical inferences. The sample period is 1976-2006.

	A. Shareholder protection (SP)		**B. Creditor protection (CP)**	
	High SP	Low SP	High CP	Low CP
$MKT_{i,t-1}$	0.067	0.011	0.049	0.016
	(4.442)	(0.635)	(3.605)	(0.904)
$CREDIT_{i,t-1}$	-0.037	-0.196	-0.026	-0.204
	(-1.766)	(-5.931)	(-1.277)	(-6.471)
$\Delta IndustryTech_{j,i,t-1}$	0.163	0.015	0.094	0.071
	(3.056)	(0.373)	(2.133)	(1.425)
α	0.105	0.025	0.111	0.024
	(5.240)	(1.115)	(5.889)	(1.109)
Industry dummy	Yes	Yes	Yes	Yes
Country dummy	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes
R^2	0.027	0.161	0.105	0.107
Observation	25,755	36,152	30,078	31,829

	C. Developed vs. emerging	
	Developed	Emerging
$MKT_{i,t-1}$	0.034	0.071
	(2.800)	(2.517)
$CREDIT_{i,t-1}$	-0.025	-0.159
	(-1.139)	(-2.614)
$\Delta IndustryTech_{j,i,t-1}$	0.057	0.163
	(1.657)	(2.003)
α	0.075	0.208
	(5.088)	(2.539)
Industry dummy	Yes	Yes
Country dummy	Yes	Yes
Year dummy	Yes	Yes
R^2	0.137	0.007
Observation	55,774	6,133

Table 8

Cross-sectional analysis: Country-level panel

In Panel A, we divide all country-year samples into two groups: High shareholder protection (High SP) and low shareholder protection (Low SP). In Panel B, we divide all samples into two groups: High creditor protection (High CP) and low creditor protection (Low CP). In Panel C, we divide all samples into two groups: Developed and emerging. Within each group, we estimate the following model: $\Delta CountryTech_{i,t} = \alpha + \beta_0 \Delta CountryTech_{i,t-1} + \beta_1 MKT_{i,t-1} + \beta_2 CREDIT_{i,t-1} + Country_i + Year_t + e_{i,t}$. $\Delta CountryTech_{i,i,t}$ is the measure of innovation growth of country i in year t. $MKT_{i,t-1}$ denotes the logarithmic ratio of stock market capitalization over GDP, $CREDIT_{i,t-1}$ denotes the logarithmic ratio of domestic credit to private sectors over GDP, $Country_i$ denotes country dummies, $Year_t$ denotes year dummies, and $e_{j,i,t}$ denotes the error term. We use one-step estimators and heteroskedasticity-robust standard errors clustered by country to draw statistical inferences. The sample period is 1985-2005.

	A. Shareholder protection (SP)		**B. Creditor protection (CP)**	
	High SP	Low SP	High CP	Low CP
$MKT_{i,t-1}$	0.057	0.005	0.058	0.031
	(3.799)	(0.323)	(2.839)	(3.729)
$CREDIT_{i,t-1}$	-0.042	-0.009	-0.049	-0.025
	(-1.434)	(-0.391)	(-0.980)	(-1.912)
$\Delta CountryTech_{i,t-1}$	-0.330	0.027	-0.309	0.071
	(-2.473)	(0.249)	(-2.257)	(0.885)
α	0.094	0.022	0.102	0.073
	(3.119)	(0.802)	(2.750)	(3.828)
Country dummy	Yes	Yes	Yes	Yes
Year dummy	Yes	Yes	Yes	Yes
R^2	0.105	0.069	0.014	0.213
Observation	239	222	294	159

	C. Developed vs. emerging	
	Developed	Emerging
$MKT_{i,t-1}$	0.022	0.033
	(0.941)	(2.773)
$CREDIT_{i,t-1}$	0.081	-0.022
	(1.277)	(-0.746)
$\Delta CountryTech_{i,t-1}$	-0.420	0.136
	(-5.065)	(1.374)
α	0.066	0.108
	(1.556)	(3.381)
Country dummy	Yes	Yes
Year dummy	Yes	Yes
R^2	0.099	0.183
Observation	315	146