BACKGROUND PAPER

Does One Size Fit All? Financial Architecture and Innovation in the 21st Century

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DOES ONE SIZE FIT ALL? FINANCIAL ARCHITECTURE AND INNOVATION IN THE 21ST CENTURY

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Abstract

Using a data of 47 economies and a fixed-effects identification strategy, we provide the recent evidence that trumpets the importance of the market-based financial system rather than the intermediary-based financial system in improving the long-term growth of the economy, as measured by both innovation quantity and the innovativeness and exclusiveness of the patents. Additionally, we find strong heterogeneity of such effects on innovation of high-income economies and low-income economies and firms at different stages. A specific look at the innovation in developing Asian economies suggests that the role of the intermediary-based financial system is still hard to be ignored due to the higher portion of low-income economies and smaller firm size in these regions. Our research produces illuminate insights into the functioning of these financial systems for different economies and for firms at different stages. A better understanding of the heterogeneity may encourage better and more efficient strategies that acknowledge changes and eventually encourage innovation in a better way.

Keywords

market-based financial system, intermediary-based financial system, patent, citation, independent claims, small entities, national income.

I. INTRODUCTION

Does financial architecture matter for growth? The longstanding question has gained renewed urgency with the recent development in technology that greatly improves information accessibility and expands the boundary of the overall financial system. Despite an enormous literature around the 2000s that trumpets the importance of the overall financial development rather than that financial architecture in fostering economic growth, more recent studies provide both theoretical and empirical evidence suggesting that different financial structures play disproportionate roles in powering the growth of the economy (Tadesse 2002). [2] In particular, studies focusing on aggregate research and development (R&D) and innovation, the most important factor for long-term economic growth, find that market-based financial systems, especially the equity market, encourage innovation. (Brown, Fazzari, and Petersen 2009 and Hsu, Tian, and Xu 2014).

However, one needs to be cautious when applying these conclusions directly to policies aiming at encouraging innovation of certain types of economies or certain types of firms. First of all, studies show that the effect of financial system architecture matters differently that may heavily depend on the overall environment of the economy, such as its contractual environment, the legal system (La Porta et al. 1998 and Rajan and Zingales 1998), the overall development of the finance sector (Tadesse 2002), and the information environment (Boot and Thakor 1997). Second, the effect may also vary for firms at different development stages. Compared with smaller firms, for example, larger firms always have more cash, more qualified collaterals, and more established track records. As a result, they may be less financially constrained and benefit less from the financial structure aiming at reducing the information asymmetry problem if the benefit ends up with ownership dilution. Third, the effect may change across different time periods. In particular, studies with a large sample from the early years are prone to find supportive results for the bank-based financial system due to its dominant position for centuries. However, studies that look specifically at the early 2000s are more likely to support the equity-based financial system. For

[2] For example, Merton (1992 ans 1995), Merton and Bodie (1995 and 2004) show that it is the overall financial development not the financial system architecture that determines economic growth. Empirically, Levin (2002) show that a cross-country comparison does not suggest that distinguishing between bank-based and market-based financial system is a first-order concern in understanding economic growth after controlling for the overall level of financial development. In addition, Beck and Levine (2002) show that financial structure does not help explain the differential growth rates of financially dependent industries across countries.

example, Brown et al. (2009) point out that the R&D investment in the United States (US) has experienced a finance-based driven cycle from 1994 to 2004 and the external equity finance, in particular, helps explain the waxes and wanes of R&D growth during that period. The recent years are characterized by an unprecedented development of technology. Such changes may influence and even reshape the financial system. On the one hand, it complements the traditional financial system by providing alternative data and solutions. On the other hand, it adds competition by providing alternative financial channels and greatly expands the boundary of finance to a wider group of people.

In this paper, we are aiming at exploring the real effects of financial architecture on the long-term growth of the economy during the recent decade and put emphasis on investigating how the effects vary for firms at different stages and economies with different income levels so as to make applicable and informative implications to policymakers. In particular, we zero in on the R&D output, i.e., the patents of different industries of an economy and examine the different effects of the market-based financial systems, such as the equity market and the private debt market to the effects of the intermediary-based financial systems, such as banks and other financial institutions on innovation.

The main obstacle that hinders any empirical attempts to study the causal effects of the financial development on technological innovation is the potential endogeneity concerns, resulting from possible reverse causality or omitted variable concerns. On the one hand, controversies remain for decades as researchers debate upon whether economic growth benefits from the development of the finance sector (Schumpeter 1911) or whether the development of the finance sector is fully triggered by the unsatisfied demand due to the economic growth (Robinson 1952). In our context, the reverse causality concern is really about whether innovation, an important factor for economic growth, renders disproportional changes to the different structures of the financial system. On the other hand, several persistent characteristics of industries and economies may lead to either upward- or downward- bias on all coefficients if these unobservable are correlated with both the development of the financial system and innovation. (Lerner and Seru 2017)

We attempt to deal with this endogeneity problem by using a panel-based fixed effects approach which has been widely adopted by the literature (Rajan and Zingales 1998; Hsu, Tian,

and Xu 2014; Gormley and Matsa 2014; Bhattacharya et al. 2017; Luong et al. 2017; and Moshirian et al. 2019). In particular, we add the fixed effects to each economy–industry pair as well as to each year to capture the unobserved heterogeneity within the groups. As a result, the testing power of our model mainly comes from the variance within the same economy's industry and our results are also immune to the unobserved heterogeneity across time. In arising to ameliorate the concern of reverse causality, we explore the effect of the existing financial architecture on patents that will be officially filed in the next year and be granted many years later. By construction, these patents are far from being commercialized and have not been widely adopted into the economy. As a result, they are not able to change the existing financial architecture but can only be influenced by it.

We start by exploring the fundamental question of whether financial architecture matters disproportionately to technological innovation. As underdeveloped financial systems raise concerns of financial constraints in the long-run which hinder firms' willingness to undertake R&D (Aghion et al. 2009), both intermediary-based and market-based financial systems help improve innovation by ameliorating such concerns through aggregating information at a lower cost and diversifying risks. However, the effect may vary with different financial architecture. The traditional wisdom that banks have the advantage of acquiring information and monitoring effectively may not be applicable in the case of technology innovation. As has been long argued, Innovation investment, unlike most of the traditional investment, is not only time-consuming and cash-burning but also haunted by uncertainty and risks. (Holmstrom 1989). As a result, innovative firms often have an unstable and limited amount of internally generated cash flows (Brown, Martinsson, and Petersen 2012), but are equipped with numerous intangible assets (Hall and Lerner 2010) that cannot be used as collateral. Banks and other financial intermediaries, nevertheless, have an inherent bias towards prudence (Stiglitz 1985 and Weinstein and Yafeh 1998) due to their fragile capital structure[3] (Diamond and Rajan 2001) and their limited ability to provide liquidity and diversify risks compared with the financial market. In addition, banks are never effective processors and collectors of information in new and uncertain situations involving the process of R&D and innovation (Allen and Gale 1999). These characteristics seem to suggest that an

[3] Banks and other financial intermediaries owe liquid deposits but illiquid assets. The liquidity mismatching serves as an important commitment device that keeps banks from conducting risky and long-term projects. While securitization helps with the problem, banks still have limited ability to diversify their risks due to the strict regulation.

intermediary-based financial system, or banks, in particular, may not be an effective source to finance innovation.

By contrast, a market-based finance system reduces the intermediation cost (Diamond 1984) and mitigates the additional layer of potential agency problems caused by interest conflicts between the intermediaries and investors (Black and Moersch 1997 and Laeven 2001). It has a higher tolerance for risky and innovative projects due to the investors' ability to diversify risks (King and Levin 1994) and helps produce and aggregate information via trade. In a highly liquid and active market, information is exchanged among a wide range of participants and eventually be aggregated into the trade price. New updated information can guide adjustments and improve the innovators' performance so as to achieve long-term success in an innovation agenda (Manso 2011). Under such situations, managers learn from the equilibrium price and incorporate it into their innovation decisions (Chen et al. 2007).

While both the debt market and the equity market motivate innovation in this way, their effects are not seemingly equal. Additional equity ameliorates the financial constraints of the firms, but would not increase the probability of financial distress (Brown et al. 2009). Moreover, the equity market is more liquid than the debt market. As a result, information can be incorporated into the stock prices in a more timely manner and provides additional guidance to managers' decision makings. However, the other edge of the story is that a liquid stock market increases the threat of hostile takeovers and encourages a myopic climate for both investors and the insiders. As a result, a highly liquid equity market may ultimately impede innovation in the long-run (Shleifer and Summers 1988; Bhide 1993; and Fang, Tian, and Tice 2014). Further, equity-based finance is likely to cause severe agency issues (Jensen and Mackling 1976 and Berle and Means 1932) because of the diversified ownership structure that renders the free-rider problem. Given the needs of innovative firms to get money but at the same time protect proprietary information even from potential investors, debt instruments, either provided by banks or the debt market, do have the advantage to better meet such needs. Unlike banks, bondholders may be more willing to provide flexible finance to innovative firms due to the benefit of the market and do not have the incentive to inefficiently liquidate firms to pursue prudent projects due to their inferior position over banks. Compared with the equity market, the debt market helps ameliorate the financial constraint of innovative firms, but does not challenge the ownership of the managers at an expense. Additionally,

debt instruments reduce the amount of free cash flow and help mitigate the agency problem between shareholders and debtholders (Jensen and Meckling 1976).

We collect innovation and financial architecture information for 47 economies which have at least one patent grant at the US Patent and Trademark Office (USPTO) and mixed financial structures. Our baseline results show that financial structures matter disproportionately to the innovation of the industry in a certain economy during our sample period of 1997–2016. In particular, we find that the market-based financial system, as represented by both the equity market and the debt market, has positive and significant effect on not only the R&D efficiency, as measured by the number of patents granted, but also innovation quality and exclusiveness, as measured by both the citation-based quality metrics and the claim-based quality metrics. However, the intermediary-based financial system fails to encourage innovation and even renders lower quality patents during the same period.

Next, we proceed to explore whether financial architecture matters differently for small entities and large entities. While large entities are more likely to benefit from the market-based financial system for the aforementioned reasons, we propose that the effect might change for small entities. In particular, even though small entities are more likely to have financial constraint problems, the role of the debt market is less likely to work for them. On one hand, they may want to reduce information dilution costs by obtaining bank loans or issue bonds instead of using equity (Bolton and Freixas 2000), but their ability to do so is quite limited because of their limited collateral and severe information asymmetry problem. On the other hand, the role of the debt market to reduce free cash flow is deteriorated for them because of their lack of cash at the beginning, but the role of the debt market to add financial distress may lead to ex post changes in their behavior and motivate them to give up long-term and really innovative projects. By contrast, a developed equity market may encourage their innovation regardless of their accessibilities to the equity market. In particular, even for those firms that cannot issue equity, the development of the equity market improves the possibility that those firms can be merged by larger public firms simply for their innovation (Shleifer and Vishny 2003, Phillips and Zhdanov 2013, and Bernstein 2015).

[4] The improved likelihood of cashing out motivates small entities to conduct high quality and innovative projects.

When we separate patents by small-entity and large-entity assignees, we find that even though the positive effect of the market-based financial system holds for both types of firms, only an equity-based financial system can really improve the innovation of small entities. On the contrary, a more developed debt market impedes the innovation of small entities while still contribute to the innovation conducted by large entities.

Next, we explore whether financial system architecture matters differently for economies with different levels of national income. As shown in Table A1, high-income and low-income economies are significantly different in their financial architecture, their economic growth, and their innovation. These differences raise a concern on whether it is appropriate to apply the one-size-fits-all answers to the question being studied in this paper. On one hand, the income level of each economy may be correlated with the overall development of its finance sector, but not necessarily the architecture of its financial system and its overall innovation. For example, Germany and Singapore are both high-income economies, while the former has a bank-based financial system while the latter is more likely a market-based financial system. On the other hand, the income level of each county may also reflect the average firm size in that economy. For example, if firms in low-income economies are relatively smaller than those in high-income economies, it is possible that our results for small entities may fit the picture better for low-income economies while our results for the large entities may help explain high-income economies better. All these differences suggest that whether our analyses hold in one versus the other is really an empirical question.

We generate the high-income indicator that is set to one if the economy is categorized as high-income by the World Bank and is set to zero otherwise. To alleviate the concern that the economy's income is reversely influenced by the innovation level, we add a 3-year lag to the indicator taking into account the average length of the patenting process that is approximately 2.5

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[4] Bernstein (2015) shows that public firms are more willing to acquire a substantial number of patents through mergers and acquisitions rather than conduct innovation internally. Phillips and Zhdanov (2013) provide both theoretical evidence and empirical support to show that small firms decide to innovate more when they can sell out to larger firms while larger firms find it optimal to obtain innovation through acquisition rather than engage in an "R&D race". In addition, research (Shleifer and Vishny, 2003) shows that stock market misvaluation results in merger waves.

years. Our identification works suppose the income level of the economy that we captures is not influenced by the innovation decisions of the economy to be made 3 years or 5 years from now. The supposition is likely to hold given that both the R&D process and innovation transfer is time-consuming, and it takes a long time for any innovation to be widely deployed in the economy and ultimately improve productivity and change the national income of the economy. We find that, compared with that of the low-income economies, the innovation of high-income economies is more likely to benefit from the market-based financial system and is more likely to be impeded by the intermediary-based financial system. In addition, we find that while the development of the equity market benefits the innovation of small entities in both types of economies, the development of the debt market is more likely to impede the innovation of small entities in high-income economies. On the contrary, large entities in such economies are more likely to benefit from both the equity and the debt market.

Finally, we apply our findings to developing Asian economies which are supposed to have a larger portion of low-income economies and a larger number of smaller firms compared with the overall sample. Taking as a whole, our results for such a special sample seem to be consistent with our previous analyses. We document that the innovation activities in developing Asia mimic the behavior of a combination of both small entities and low-income economies. In particular, we find that the innovation of developing Asia is more likely to benefit from the development of the equity market and the intermediary-based financial system compared with the rest of the economies in our sample. Further, we document that the economies that are categorized as ex-newly industrialized economies (NIEs) (i.e., developing Asian economies that exclude the NIEs) gain more benefits from the intermediary-based financial system compared with the rest of other economies in the sample.

Our results hold under a variety of robustness tests. First, we use alternative econometric specifications following Hsu, Tian, and Xu (2014) by adding the economy-year fixed effect and the industry fixed effect to further alleviate the concern that our results are driven by omitted time-varying characteristics of an economy or a certain industry. Second, to mitigate the possibility that our patent-based measures undermine the innovation of economies that do not have access to the US economy, we reexamine the tests using the global patent filings from the Bureau van Dijk's Orbis patent database. Third, we use alternative proxies for the intermediary-based financial

systems to explore whether the insignificant effect is driven by the possibility that our proxy only captures a specific type of financial intermediaries. We find the results hold for either a wider or a narrower definition of the intermediary-based market and remain negative or insignificant for either the bank-based or nonbank intermediary-based financial system.

Our study adds current evidence to the century-old debates upon the comparative importance of intermediary-based and market-based financial systems to economic growth (Goldsmith 1959; Allen and Gale 2000; Levine 2002; Brown et al. 2009; and Hsu, Tian, and Xu, 2014). [5] By focusing on the innovation efficiency that fosters long-term growth of the economy, we document that financial architecture matters for the innovation efficiency of the industry in a certain economy. In particular, our research produces illuminating insights into the heterogeneity of such effects to economies with different income levels and firms at different stages. By doing so, we offer a clear map for policymakers to understand the different innovation mechanisms of their economies so as to come up with more efficient and insightful strategies to motivate innovation at an aggregate level. Instead of providing a single answer of "yes" or "no" to this question, we trumpet the disproportionate importance of different structures of the financial architecture in fostering innovation during the process of financial expansion and put emphasis on the dynamic changes of the importance when firms grow larger and economies become richer.

Our study is complementary to the literature exploring how financial system architecture matters differently for different economies. For example, studies show that the comparative advantage of markets or banks in delivering particular financial services depends on the economic and contractual environments of the economy, such as the legal system (La Porta et al. 1998 and Rajan and Zingales 1998), regulatory systems, and tax systems. Tadesse (2002) finds that countries with underdeveloped finance sectors are more likely to benefit from bank-based systems while countries that are dominated by larger firms benefit more from the market-based systems. In addition, Boot and Thakor (1997) find that the market-based financial system has advantages in situations in which information feedback is especially valued.

Our paper is distinct from but closely related to Hsu, Tian, and Xu (2014) who trumpet the importance of the equity-based financial system rather than the bank-based financial system in

[5] Levin (2005) is a comprehensive survey for both the theoretical and empirical studies in this field.

fostering innovation. While their sample covers the period 1976–2006, we provide updated evidence for the period in recent decades. As an extension of their framework, we add not only the equity-based financial market but also the debt-based financial market in the architecture and explore whether the effect varies for firms at different stages and economies with different income level. While we provide consistent evidence that the development of the equity-based financial market has positive ramifications on innovation, we further document that the effect is more likely to hold for the innovation of high-income economies and the smaller entities. Further, we show that it is hard to ignore the role of the debt-market in fostering innovation especially for large entities and the role of the intermediary-based financial system especially for low-income economies. In addition, we apply our findings to the economies of developing Asia rather than the developed and well-documented economies like the US and draw insightful policy implications for these economies.

The rest of the paper is organized as follows. In section II, we describe the data collection and measure construction. In section III, we discuss the potential endogeneity concerns and our identification methods. In section IV, we report our results and provide robustness checks. In section V, we apply our results to look specifically at developing Asian economies. Finally, we conclude this paper in section VI.

II. DATA

A. Data Sources

We start our test by focusing on countries and economies with a large number of patents granted by the US Patent and Trademark Office (USPTO). At the risk of downplaying the innovation of the economies by just focusing on one single patent office, the approach has been used by numerous studies exploring cross-economy innovation performance in the literature (Acharya and Subramanian 2009; and Hsu, Tian, and Xu 2014). Our patent data is representative of the overall innovation of the economy with the assumption that the US economy is important enough to form connections with most of the important economies in the world. In addition, focusing on one single patent office instead of all 94 patent offices in the world enhances the

comparability of the granted patents. As studies (Farre-Mensa et al. 2019) indicate that the background of different examiners may influence the granting rates of patent applications, our approach guarantees that the granted patents we capture are more likely to be subjected to the same examination standards thus more comparable. Global patent information from all the 94 patent offices, as is captured by Bureau van Dijk's Orbis patent database, is used as robustness checks in later sections. [6]

We collect annual financial market development data and other related economy-level information from the WDI and WDI/GFD database. Since our goal is to compare the efficiency of different financial system architecture to innovation, we restrict our sample to economies with at least one patent granted at the USPTO up until March 2019 and with a mixed financial architecture during the period of 1997 to 2016. We end up with a sample of 47 economies that includes both developed economies such as Canada, the United Kingdom, Japan and emerging economies such as Brazil and the People's Republic of China (PRC). The whole list of economies and the development of their financial market is recorded in Appendix A2.

B. Innovation Measures

On the basis of the latest information from the website of the USPTO, we construct our innovation measures of interest. Our first innovation measure is the number of patents in a certain two-digit US standard industrial classification (SIC) industry j that are applied in year t and eventually granted and assigned to individuals or non-government institutions from economy i. As the literature (Hsu et al. 2014) suggested, the measure captures the overall quantity of innovation output for R&D investment. In particular, we include all the utility patents that are officially filed from 1997 to 2016 and eventually get granted by March 2019. Following the literature, the official application year of each patent is used to construct the innovation variables since it is closer to the time of the actual innovation. As Lerner and Seru (2017) emphasize the importance of considering how the patenting practice varies across technology classes and industries, we separate the patent counts based on their different technology classes and transfer that to the US SIC industries.

[6] We thank Luong Hoang Luong, Fariborz Moshirian, Lily Nguyen, Xuan Tian, and Bohui Zhang for sharing their data to us.

Specifically, we use the concordance scheme generated by Lybbert and Zolas (2014) to transfer the patent technological class to the International Standard Industrial Classification (ISIC) and transfer the ISIC code to US SIC code following the concordance scheme provided by the United Nations Statistics Division (UNSD).[7]

To test how the effects vary for firms at different stages, we separate the patent counts by whether their assignees are classified as small entities or not. Patent assignees are labeled as small entities by the USPTO for the prospective of patent fees. We follow the classification of the USPTO and construct *Patent_Small* as the number of patents filed by small entities while define *Patent_Large* to capture the rest.

To address the potential limitation that patent counts cannot fully distinguish record-breaking innovation from incremental utilities, we construct several measures to capture the innovativeness and exclusiveness of the patents. Following the literature, we define *Citation* as the number of forward citation received by the patent applied in year t in technical class j that is assigned to economy i. To make the measure more comparable for patents across industries, we standardize the citation of each patent by the median number of citations received by patents applied in the same year and technology class before aggregating it to the economy-industry-year level measure.

Following Hall, Jaffe, and Trajtenberg (2001), we generate the other two citation-based measures, patent originality and generality, to capture the distribution of the citation made or received. In particular, a patent's originality (generality) is defined as one minus the Herfindahl index of all the patents it cites (cite it) that are distributed in different patent classes. Patents that cite more diversified patents, i.e., have higher originality, and patents that are cited by more diversified patents, i.e., have higher generality, are considered to be more innovative. We take the mean of each individual patents' originality and generality and generate the economy-industry-year level measures, respectively.

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[7] In particular, as the USPTO stopped using the US patent classification (USPC) technology class after 2015, the technology class is measured as the USPC for patents applied before 2012 while the first 4-digit of the main international patent classification (IPC) is used for patents applied afterwards.

While the citation-based metrics are widely accepted by researchers in this area, its limitations can hardly be ignored. As Lerner and Seru (2017) point out, citation or patent counts suffer inevitable truncation problem and may lead to biases that can hardly be addressed easily. Additionally, citation-based innovativeness, or the citation received in particular, is more important to researchers than to business decision-makers or the customers who are using the patent-based products or services. For example, a highly innovative patent in certain areas can sometimes be exclusive enough that prevent many incremental experiments in the future. Under the circumstances, the citation received by the patent can be quite limited and cannot fully reflect its innovativeness. These limitations motivate us to apply different metrics for patent quality that can alleviate the concern of the truncation issue and meanwhile capture the importance of the patents to business decision-makers. In particular, we use the number of independent claims of the patent combined with several claim-related measures for innovation quality, following Marco et al. (2016). Typically, broader claims extend a patent's scope that enables the owner to exclude more people or firms from using the technology, making it more difficult for competitors to invent around. As a consequence, the patent prosecution process is really about the contest between the applicants who have the incentive to file a patent with the broadest claims and the patent examiners who are obligated to narrow the scope to circumvent the prior art. A common practice for the applicants, as mentioned by Marco et al. (2016), is to include many independent claims, which are used to extend the patent scope, while along with narrower dependent claims, which are formed by adding limitations to the original independent claim. By construction, patents with more independent claims have broader patent scope thus are of higher quality. Further, since the number of independent claims is set at the grant date, it is not subjected to any truncation problem as mention before. We calculate the number of independent claims of each patent and aggregate it up to the industry-economy-year level. Specifically, to alleviate the concern that the number of claims may not be comparable for patents in different technology classes, we standardize the number of independent claims of each patent by the median number of claims owned by patents filed in the sample year and same technology class before the aggregation.

Our last two innovation measures capture the number of patents in the top quartile of either the number of citations (*Top75_ Citation*) or the number of independent claims (*Top75_Claim*) for comparable patents that are filed in the same technology class at the same year. These patents are considered to have higher quality, respectively.

Another concern is that our innovation measures may be quite dominated by applicants from the US because of our data source. To alleviate the concern and avoid the potential local bias problem, we remove the US from our testing sample and adjust our innovation measures accordingly following the literature (Rajan and Zingales 1998; and Hsu, Tian, and Xu 2014). In particular, we standardize our innovation measures for each economy-industry-year by its corresponding values in the US data and obtain the relative innovation measures in all our tests. Compared with the raw measures, the relative innovation measures are more comparable and are more likely to be insensitive to the time-varying patenting propensity for different industries.

Table 1 reports the summary statistics of our relative innovation measures for the pooled sample.[8] In general, our patent-based innovation measures are more skewed but are otherwise comparable to that of Hsu, Tian, and Xu (2014). In addition, we find it obligated to conduct the adjustment as the data suggests a strong local bias problem. For example, the average number of patents for the industry of a non-US economy is only 2.8% of that produced by the same industry in the US in the same year.

C. Financial Development Measures and Other Controls

We collect the annual data for financial development and macroeconomics from the World Development Indicators and Global Development Finance (WDI/GDF) database. To generate the measures for market-based financial systems and intermediary-based financial systems, we consider the following three proxies for each economy i in year t:

First, the development of the equity market (*Equity*) is generated as the ratio of stock market capitalization over gross domestic profuct (GDP) while the stock market capitalization is defined as the market capitalization of listed domestic companies.[9]

Second, our proxy for the development of the private debt market (*Debt*) is defined as the total amount of domestic private debt securities issued in the domestic markets as a share of GDP. According to the World Bank, it covers not only long-term bonds and notes but also commercial paper and other short-term notes.

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[8] We report the summary statistics for our raw innovation measures in Appendix A2.

[9] Using the market value of all listed companies instead of domestic companies provides similar conclusions.

Third, our proxy for the development of the intermediary-based financial system is the ratio of private credit by deposit money banks and other financial institutions to GDP (*Bank*). For robustness checks, we also use the ratio of private credit by deposit money banks to GDP to explore the effect of banks (*Bank_pure*) in later sections.

The summary statistics in Table 1 suggest that both the equity market and the intermediary-based financial system are important for the economies in our sample since both occupy a large portion of the GDP compared with the size of the debt market on average.

We further control for several other variables for each economy-year. These characteristics may capture some time-varying features of the economy and are likely to affect innovation as well as the development of the financial system. In particular, we control for the ratio of research and development expenditure over GDP (*R&D*) to alleviate the concern that the difference in patent output is mainly driven by the different R&D investment strategies deployed by different economies despite how developed their financial systems are. In addition, we control for potential investment opportunities and the growth of the economy by adding GDP growth rate (*GDP_g*) and population growth rate (*Population_g*). Further, we control for the labor force of the economy to alleviate the concern that the difference in human capital is the main driver for the different levels of innovation. In particular, *Labor* is defined as the ratio of the number of labor force over the population within 15 and 64 ages. Finally, we construct two export-related measures to address the concern that the results are largely driven by the difference of the economy's exports especially the economy's accessibility to the US economy. Specifically, *Export* is constructed as the ratio of exports of goods and services over the GDP of economy i at year t. Using data from the Comtrade Database of the United Nations, *Export_US* is defined as the portion of export made by economy i to the US over the total amount of export received by the US.

Throughout this study, our financial market measures and economy-year controls are winsorized at the first and 99th percentiles to mitigate the influence of extreme observations and eliminate data coding errors if any.

III. IDENTIFICATION STRATEGY

We examine the effects of financial architecture on innovation using a fixed effect approach. In the economy-industry-year level data, the basic regression we estimate is the following:

$$y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}. \quad (1)$$

where $y_{i,j,t+1}$ is one of the relative innovation measures for each industry j of economy i at time t. We add one year lag in all our explanatory variables to alleviate the concern of reverse causality. By adding the economy-industry fixed effect $\delta_{i,j}$, our coefficient estimates are identified by the variation within each industry of the economy. Thus the fixed effect absorbs any time-invariant difference across different economies and across different industries in an economy. In addition, we add year fixed effect μ_{t+1} to further mitigate the variation of common trends in the economy over time. Follow the literature, standard errors are clustered by economy and industry and adjusted for heteroscedasticity. Our tests center on both the sign and the significance of the estimated β_1, β_2, and β_3.

In robustness checks, we further adjust the model following the specification of Hsu, Tian, and Xu (2014) by adding the economy-year fixed effect to mitigate the concern that our results are driven by unobserved time-varying economy-level characteristics. In particular, we examine how the effects vary for highly innovative industries as discussed in later sections.

IV. EMPIRICAL ANALYSIS AND RESULTS

In this section, we start by investigating how innovation is influenced by the development of market-based financial systems and the development of intermediary-based financial systems. Then we explore how the effects vary for innovation conducted by small entities and large entities and for innovation conducted by economies at different income levels.

A. Basic Tests

1. The Relative Number of Patents

Following the specification of equation (1), we start by introducing each key financial variable individually. In the first three columns of Table 2, we find that the estimated coefficients for the market-based financial system, as measured by the size of the equity market and the size of the private debt market, are positive and significant at the 1% level. However, the estimated coefficient for the intermediary-based financial system, as measured by the ratio of private credit by deposit money banks and other financial institutions to GDP, is not statistically insignificant. The results provide the preliminary support for our hypothesis that innovation is more likely to be efficiently financed by the financial market while the role of banks and other financial institutions is deteriorated especially in the recent decade.

In the last column, we introduce all three variables and restrict our sample to economies with a mixed financial structure during our sample period. We find that the estimated coefficients β_1 and β_2 remain positive and significant at 1% level while the estimated coefficient β_3 turns to negative but remains insignificant. In particular, we document that relative patent counts increase by 3% of the standard deviation with one standard deviation increase in the size of the equity market. That is approximately 11.68% (=0.03×0.109/0.028×100%) of the mean (0.028) for relative patent counts. Comparatively, one standard deviation increase in the size of the private debt market leads to a 4.7% standard deviation increase in the relative number of patents, which is approximately 18.3% (=0.047×0.109/0.028×100%) increase regarding the mean of relative patent counts. With the effect of the debt market gets slightly larger, both proxies for the market-based financial system turn out to have a positive and significant effect on the innovation output of the economy while intermediary-based financial system fails to show any effect in all settings.

2. Quality

In Table 3, we investigate the effect of different financing market structure on the innovation quality by changing the dependent variable to the aforementioned patent quality measures. We find that the development of the financial market, or the private debt market, in

particular, is more efficient and plays a significant role in financing high-quality innovation projects, referring to those that receive more citations and are more exclusive. In terms of the magnitude, for example, the results in column (1) suggest that one standard deviation increase in private debt issuance leads to a 3.9% standard deviation increase in the relative number of patents that belong to the 75% percentile in terms of the number of citation received. That is approximately 18% (=0.039×0.092/0.02×100%) increase in the value relative to the mean. With regard to the patents that belong to the 75% percentile due to their high exclusiveness, the results in column (2) illustrate that one standard deviation increase in private debt issuance leads to an 8.8% standard deviation increase in the number of such patents which represents 36.6% (=0.088×0.079/0.019×100%) of the mean value. Considering the number of citations received, we find that one standard deviation increase in private debt issuance leads to a 6.3% standard deviation increase in the relative number of citations received by the innovation projects which stands for 28% (=0.063×0.08/0.018×100%) of the mean value. As shown in column (4), the positive and significant coefficient estimate β_2 indicates that one standard deviation increase in private debt issuance results in a 5.9% standard deviation increase in the number of claims received by the patents which is approximately 24.4% (=0.059×0.095/0.023×100%) that of the mean value.

With regard to the development of the equity market, the estimated results suggest that the development of the equity market is in general positively related to the quality of innovation. However, compared with the effect of the private debt market, it shows a weaker significance and becomes mostly insignificant for the majority of patent quality measures that we document here.

When it turns to the intermediary-based financial system, we find the coefficient estimates of β_3 remain negative. In particular, as suggested by the results in column (1) and (2), the development of the intermediary-based financial system significantly reduces the number of high-quality patents that belong to the top percentile regarding both the number of citations received and the number of claims owned. In addition, we find that intermediary-based financial structure is also negatively and significantly related to the fundamental innovativeness of the patents as measured by the aggregated originality. In particular, the results in column (5) indicate that one standard deviation increase in the development of the intermediary-based financial system leads to a 4.3% standard deviation decrease in the originality of the projects which represents 7% (=0.043×0.755/0.461×100%) of the mean value.

B. Firms at Different Development Stages

Our baseline results act as strong support demonstrating that financial architecture matters for long-term economic growth, as represented by the innovation level of the economy. In particular, we illustrate that innovation benefits more from the market-based financial system than the intermediary-based financial system. In this subsection, we take a closer look at the effect and investigate how it varies with firms at different development stages. Specifically, we separate the total number of patents to those filed by small entities and those filed by large entities. We re-examine the problem following the specification of equation (1) for patents filed by these two groups and summarize the estimated results in Table 4. For simplicity, we restrict our attention to the key variable of interest and report the estimated β_1, β_2, and β_3 only.

While the effect of the equity market remains positive and significant for both small entities and large entities, we document that the effect of the private debt market flips to negative for small entities despite its remaining positive effect on the innovation of large entities. In particular, when included alone, as shown in columns (1) and (2), the coefficient estimates of β_1 remain positive for both small entities and large entities and a comparison of the magnitude suggests that the effect is slightly large for smaller innovators. To be concrete, one standard deviation increase in equity market valuation leads to a 12.4% standard deviation increase in the number of patents for small entities while that only leads to a 0.7% standard deviation change in the number of patents for large entities. Nevertheless, the coefficient estimate for the private debt market, β_2, is positive and significant for large entities but turns to be negative for small entities with a significance of the 10% level. We get a similar pattern when introducing all the variables together. In particular, as shown in column (4), one standard deviation increase in the development of the equity market results in a 14.6% standard deviation increase in the number of patents filed by small entities while that only leads to a 2.1% standard deviation increase in the number of patents filed by large entities. As for the effect of the private debt market, one standard deviation increase in private debt issuance leads to a 2.4% standard deviation decrease in innovation from small entities. However, that leads to a 6% standard deviation increase to the number of patents filed by large entities. A comparison of the magnitude suggests that the positive effect of the equity market is larger than the negative effect of the debt market on the innovation of small entities. By contrast, the positive effect of the debt market is slightly larger than the effect of the equity market on the innovation of large entities.

Under all specifications, we find that the effect of the intermediary-based financial structure remains insignificant despite that it remains positive for small entities while flips to negative for large entities.

C. Economies with Different Income Levels

In this subsection, we set out to investigate whether financial architecture matters differently for economies with different income levels. We start by adding the high-income indicator in the basic model and re-examine the effect as the following:

$$y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \beta_4 Equity_{it} \times High_Income_{i,t-3} + \beta_5 Debt_{it} \times High\_Income_{i,t-3} + \beta_6 Bank_{it} \times High\_Income_{i,t-3} + \beta_7 High\_Income_{i,t-3} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1} \quad (2)$$

where $High\_Income$ is the indicator that is set to one if the economy is categorized as high-income by the World Bank and is set to zero otherwise. To alleviate the concern that the economy's income could be influenced by its innovation level, we add a three-year lag to the indicator taking into account that the average length of the patenting process that is approximately two and a half years. To further mitigate the concern that the economy's income level turns to be persistent over time, we also try 5-year and 4-year lags. We get similar conclusions under such settings. Our identification works under the assumption that the income level of the economy that we capture is not influenced by the innovation decisions of the economy 3 years or 5 years from now. Our assumption is likely to be true given the fact that not only the innovation process is time-consuming, but it also takes time for the innovation to be widely commercialized and transferred in a way that ultimately improves the productivity of the economy and changes its income level.

We center on both the sign and significance of coefficients β_4, β_5, and β_6 which capture how the effects of the financial architecture differ for economies with different income levels. In addition, β_7 captures the difference in innovation between high-income economies and low-income economies when the development of the financial market is at the average level.

1. The Relative Number of Patents

We proceed to investigate the heterogeneity using the relative number of patents as the proxy for innovation. As shown in Table 5, we find that, in general, the innovation of high-income economies is more likely to benefit from the market-based financial system rather than the intermediary-based financial system compared with that of low-income economies.

In particular, when we introduce the variables individually, the negative and significant β_1 in column (1) Table 5 suggests that the effect of the equity market turns to be negative for low-income economies even though the overall effect of the equity market remains positive. The difference of the effect, as suggested by the coefficient of the interaction term, β_4, is positive and significant at the 1% level, indicating that the equity market is a more important source for innovation in high-income economies compared with that of low-income economies. When it turns to the effect of the debt market, the estimated coefficient β_2 in column (2) suggests that the effect of the debt market remains positive for low-income economies but the effect is insignificantly different from zero and cannot lead to more innovation. The estimated coefficient for the interaction term, β_5, suggests that the difference is significant at the 1% level and the effect of the debt market is stronger for innovation conducted by high-income economies than by low-income economies. In column (4), we restrict our sample to economies with a mixed financial architecture and introduce all the variables in the model following equation (2). We find consistent results as suggested by the positive and significant coefficient estimates of β_4 and β_5 for the interaction term of both the equity market and the debt market. In terms of magnitude, ceteris paribus, one standard deviation increase in the size of stock market leads to 4.49% standard deviation more patents for high-income economies than for low-income economies, which represent approximately 17.5% (=0.109×0.0449/0.028×100%) of the mean value; one standard deviation increase in the size of the private debt market leads to 8.98% standard deviation more patents for high-income economies than for low-income economies, accounting for approximately 35% (=0.109×0.0898/0.028×100%) of the mean.

Further, we find that the role played by the intermediary-based financial system is significantly deteriorated for innovation conducted by high-income economies as suggested by the negative and significant β_6 in column (4). In particular, one standard deviation increase in the size

of the system leads to a 7.74% standard deviation increase in patent counts for low-income economies, but that leads to a 6.16% standard deviation decease for innovation of high-income economies. The difference accounts for approximately 54% (=0.139×0.109/0.028×100%) of the average level of patent counts and it remains positive and significantly different from zero.

These results hold after we control for the difference in the innovation levels of these two types of economies. The positive and significant coefficient estimate of β_7 suggests that high-income economies are more innovative than low-income economies when their financial system are all at a similar level.

2. Quality

In Table 6, we use patent quality metrics as the dependent variable to explore the heterogeneity of the effect with regard to the innovation quality for these two types of economies. We find consistent results indicating that a more advanced market-based financial system leads to higher innovation quality for high-income economies while a more developed intermediary-based financial system leads to relatively lower quality innovation for high-income economies compared with low-income economies.

In particular, for low-income economies, innovation quality is higher for a more advanced intermediary-based system, as suggested by the coefficient estimates of β_3 in row (3), but remains lower if the economy has a larger equity market, as suggested by the coefficient estimates of β_1 in row (1). While the development of the debt market seems to be insignificant for most of the quality measures, it leads to slightly better innovation in terms of patent originality and generality. As for high-income economies, innovation quality gets improved from both the development of the equity market and the debt market. For example, the results in column (3) suggest that one standard deviation increase in the size of the equity market leads to a 3% (=(-0.049+0.079) × 100%) standard deviation increase in the number of citations received by patents from high-income economies. The difference represents approximately 35.1% (=0.079×0.08/0.018× 100%) of the mean value of the relative citation measure. Likewise, one standard deviation increase in the size of the private debt market leads to a 10.8% (= (0.107+0.00087) ×100%) standard deviation increase in the number of citations received for patents assigned to high-income economies. The difference accounts for approximately 47.6% (=0.107 × 0.08/0.018 × 100%) of the mean.

Considering the effect of the intermediary-based financial system, one standard deviation increase in such a system leads to a 0.6% (=(0.124-0.118) ×100%) increase in patent quality for high-income economies with regard to citation. The difference, which is negative and significant, accounts for approximately 52.4% (=0.118×0.08/0.018×100%) of the mean. As for the originality and generality of innovation, the results in column (5) and column (6) suggest that while the development of the debt market improves the quality of innovation for low-income economies, the effects get deteriorated for high-income economies, as suggested by the negative and significant estimated β_5 in row (5).

3. Small Entities versus Large entities

We then proceed to examine how financial architecture in these two types of economies perform differently for small entities and for large entities. As we find the negative effect of debt markets for small entities and the positive effect of the market-based financial system for large entities in our baseline results, we document that the pattern gets clearer for the innovation of high-income economies.

In Table 7 Panel A, we find that the development of the equity market is important for the innovation of small entities, as suggested by the positive and significant estimated β_1. Additionally, the insignificant estimates for the interaction term β_4 indicates that the effect remains similar for small entities from both high-income economies and low-income economies. On the contrary, while the development of the debt market fails to improve small entities' innovation in low-income economies, it indeed impedes innovation in high-income economies. In particular, as shown in column (4), one standard deviation increase in the size of debt markets leads to a 3.96% standard deviation decrease in the relative number of patents filed by small entities in high-income economies. A comparison of high-income and low-income economies suggests that one standard deviation increase in the development of the debt market leads to 5.8% fewer patents for small entities in high-income economies. That represents approximately 26.1% (=0.058× 0.063/0.014 × 100%) of the mean.

For the innovation of large entities in low-income economies, the role of the intermediary-based financial system can hardly be ignored. As shown in Table 7 Panel B, the coefficient estimates of β_3 remain positive and significant either when it is introduced individually or is put

together with all other variables. However, its effect gets weaker for high-income economies, as suggested by the negative and significant estimated β_6. In contrast to the weaker effect of the debt market for small entities, the positive and significant coefficient estimates of β_5 imply that the development of the debt market remains positive for large entities especially for those from high-income economies. With regard to the role of the equity market for innovation of large entities, the negative and significant estimated $\beta_1$suggests that a more developed equity market leads to fewer patents for large entities from low-income economies. However, the effect turns positive for those of high-income economies.

D. Robustness

In this subsection, we report a bunch of robustness checks for our main results. We start by testing whether our results hold for alternative specifications of our main model. In particular, we control for economy-year fixed effects and the industry fixed effect for high-tech industries following Hsu, Tian, and Xu (2014). Their settings would allow us to further alleviate the concern that our results may be driven by omitted time-varying characteristics of an economy that are related to both innovation and the financial architecture measures. Next, we use the global patent data from the Bureau van Dijk's Orbis patent database to test whether our results are driven by the probability of patenting at the USPTO for different economies. In addition, we study whether our results are robust to alternative proxies for financial market development. For brevity, we report the results estimating equation (1) that includes all the financial architecture proxies in the regression.

1. Economy-Year Fixed Effects

To alleviate the concern that our results are driven by omitted time-varying characteristics of an economy, we control for the economy-year fixed effect and the industry-fixed effects and add economy-industry-year characteristics to the model. In particular, we follow the specification of Hsu, Tian, and Xu (2014) and examine the effect as follows:

$$y_{i,j,t+1} = \beta_0 + \beta_1(Equity_{it} \times High\_Tech_j) + \beta_2(Debt_{it} \times High\_Tech_j) + \beta_3(Bank_{it} \times High\_Tech_j) + \beta_4 Export_{ijt} + \delta_{i,t+1} + \mu_j + \delta_{i,j,t+1}. \quad (3)$$

where $\delta_{i,t+1}$ represents the economy-year fixed effect and μ_j represents the industry fixed effect. To make our coefficient identifiable, we add an industry-characteristic interaction term to our financial system measures following the same logic of Hsu, Tian, and Xu (2014). In particular, $High\_Tech_j$ captures the characteristics of the industry j in terms of their innovativeness. Following Hsu, Tian, and Xu (2014), it is measured as the average level of R&D growth for US public firms in each 2-digit SIC industry. Specifically, we first calculate each firms' high-tech intensiveness as the time series mean of its annual gross growth in R&D expenses (XRD) from 1997 to 2016. Second, we get the industry-level innovativeness measures by taking the cross-sectional mean of all firms' high-tech insensitiveness in the industry.[10] We add $Export_{ijt}$ as an additional control which denotes the ratio of the trade value of goods and services that are exported to the US by industry j of economy i over the aggregate amount that is exported to the US by economy i.[11] Other variables are nevertheless mostly the same as in our baseline tests. To be specific, $y_{i,j,t+1}$ represents the relative innovation measures for each industry j of economy i at time t+1. *Equity* is the stock market capitalization of listed domestic companies over GDP. *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks to GDP following the definition of Hsu, Tian, and Xu (2014). All the standard errors are robust and clustered at the economy-industry level.

If our basic results hold, we expect to see that the coefficient estimates for market-based financial systems, β_1 and β_2, to be positive and significant while the coefficient estimates for intermediary-based financial systems, β_3, to be negative and significant.

Table 8 summarizes the main results for both patent counts and patent quality. In sum, our basic results seem to hold under this setting. In particular, we find that even though the coefficient estimates for the development of the equity market remains insignificant in most of the cases, the coefficient estimates for the development of the debt market remain positive and significant,

[10] We also tried to generate the dependence on external finance measure as an alternative following Hsu, Tian, and Xu (2014) but failed to get enough observations as the Compustat database seems to suggest that very few firms report cash flows from operations during our sample periods (i.e., 1997–2016).

[11] We do not control for the value-added variable since it is mostly insignificant in the settings of Hsu, Tian, and Xu (2014).

indicating that the market-based system, especially the debt market, is promoting the innovation for highly innovative industries regarding both the number of patents and the innovation quality.

Considering how the effect varies for firms at different stages. A comparison of the results in columns (2) and (3) seems to suggest that for innovation intensive industries, the equity market seems to be more efficient in encouraging innovation for small entities, as indicated by the positive and significant estimated β_1, than for large entities, as indicated by the insignificant coefficient estimates of β_2. A comparison of the magnitude of the estimated β_2, which is 0.015 for small entities and 0.034 for large entities, seems to suggest that the effect of the debt market is slightly larger for large entities than for smaller ones. The overall results seem to be consistent with our main findings.

To explore how the effects differ for economies at different income levels, we separate the sample into high-income economies and low-income economies based on their categories assigned by the World Bank at t-3. The results are summarized in Table 9. Overall, our main results are largely born out in this setting. In particular, as reported in column (1) and (2), the coefficient estimates for the development of the equity market remain positive for high-income economies but turn to negative and significant for low-income economies. In addition, while the coefficient estimates for the development of the debt market remain positive and significant for both high-income and low-income economies, a comparison of both the magnitude and significance seems to suggest that the effect is slightly lower for low-income economies. Both findings imply that the effect of the market-based financial system is stronger for the innovation of high-income economies, especially for highly innovative industries. Further, while the coefficient estimates for the development of the intermediary-based system remain negative for high-income economies, we find a significant positive effect of such financial structure on innovation in low-income economies. Both are consistent with our main results.

Regarding firms at different stages, a comparison of the results in the last four columns of Table 9 seems to draw a similar picture as we show above. In particular, a pure comparison of the subsamples seems to suggest that the effects are applicable for both small entities and large entities.

2. The Global Patent Database

In Table 10, we change our sample to all economies with at least one patent granted in any patent offices in the world. Following the literature (Moshirian et al. 2019), we start by centering on patents that are assigned to public firms in these economies. Four patent-based proxies are generated to capture the innovativeness of the industry j in economy i at year t. In particular, *Patent* is the logarithm transfer of one plus the total number of patents assigned to the public firms in each 2-digit SIC industry j of economy i at time t. *Citation* is the logarithm transfer of one plus the adjusted number of citations received while the adjustment is achieved by time-technology class fixed effect (Atanassov 2013, Hirshleifer et al. 2012, and Moshirian et al. 2019). Originality and Generality are Herfindahl Index measures following Hall, Jaffe, and Trajtenberg (2001). We take the mean of the originality and generality of all public firms to get the aggregated measure for each economy-industry-year. Following the literature, we use the earliest priority year as time t and replace it with the patent application year if not applicable. By doing so, we get rid of possible replicated patent filings that are registered at more than one patent office. The sample ranges from 1997 to 2013.

Overall, the results seem to support most of our main findings. In particular, we follow the specification of equation (1) and find that the coefficient estimates of β_1 and β_2 remain positive and significant at the 1% level. By contrast, the coefficient estimates of the intermediary-based financial system remain negative and significant. These results hold not only for patent quantity but also for innovation quality, as measured by the adjusted number of citations received and the fundamental innovativeness, as measured by the average originality.

We then proceed to examine how the effect varies with the national income of the economy. In Table 11, we separate the sample by their income categories assigned by the World Bank at t-3 and re-examine the effect for each subsample. As shown in Table 11, the positive effect of the market-based financial system and the negative effect of the intermediary-based financial system are more likely to explain the innovation of high-income economies. We find that for low-income economies, the coefficient estimates of the equity market (β_1) and the debt market (β_2) turn to negative while the coefficient estimates of the intermediary-based financial system (β_3) turn to positive even though it is not significantly different from zero. As for patent quality, we find that

the effect of the intermediary-based financial systems is more negative for high-income economies than the low-income ones with the exception that innovation generality from low-income economies seems to benefit from all three sources.

3. Alternative Proxies For the Intermediary-Based Financial System

In this subsection, we use four different alternative proxies to capture the credit provided by the intermediary-based financial system so as to mitigate the concern that our results are driven by a noisy proxy. We start by constructing the *Credit_Finance* ratio which is defined as all domestic credit provided by the finance sector over GDP where the finance sector includes monetary authorities and deposit money banks, as well as other financial corporations where data are available.[12] Then we construct the *Credit_all* ratio which captures all domestic credit to the private sector over GDP. To explore whether the effect differs for deposit banks and non-bank financial institutions, we generate the *Bank_pure* ratio, defined as the private credit provided by deposit money banks over GDP, to capture the effect of banks only. In addition, our *Non-Bank* ratio captures the difference between the *Credit_Finance* ratio and the *Bank_pure* ratio.

Table 12 summarizes the results for these alternative proxies. Overall, our main results seem to hold under these settings. In particular, A comparison of columns (1) and (2) in Panel A suggests that the coefficient estimates for the intermediary-based financial system, as either measured by overall credit from the finance sector or all domestic credit, are negative and slightly significant. The coefficient estimates for β_3 in columns (3) and (4), representing the effect of banks and non-bank intermediaries, are also negative and slightly significant. These results imply that the deteriorating effect of the intermediary-based financial system on innovation is representative to not only banks but also non-bank financial institutions.

Panel B and Panel C summarize the results for the innovation of small entities and large entities. While the coefficient estimates of the equity market and debt market, β_1 and β_2, remain positive and significant for large entities, β_2 turns to negative for small entities. Regarding the effect of the intermediary-based financial system, the coefficient estimates of β_3 remain either

[12] ccording to the World Bank, it also includes corporations that do not accept transferable deposits but do incur such liabilities as time and savings deposits. Examples of other financial corporations are finance and leasing companies, money lenders, insurance corporations, pension funds, and foreign exchange companies.

negative or insignificant for large entities yet turns to positive for small entities especially when the intermediary-based system is measured by *Credit_Finance* and *Non-Bank.* On one hand, these results are in line with our main results which emphasize the role of the equity market for small entities rather than the debt market. On the other hand, the results imply that the credit from the overall finance sector, especially the credit from non-bank financial institutions is likely to lead to more innovation for small entities.

In Table 13, we proceed to examine whether we still find the heterogeneity with regard to the income level of each economy. As demonstrated in Table 13 Panel A, the coefficient estimates of the interaction terms of the equity market and the debt market, β_4 and β_5, remain positive and significant at the 1% level. By contrast, the coefficient estimates for the interaction of the intermediary-based financial system, β_6 remain negative for most of our alternative proxies even though it turns to slightly positive for non-bank financial institutions. While the results are more likely to describe the innovation behavior of large entities, as indicated by Panel C. We again find that the effect of the debt market is weaker for small entities in high-income economies, as indicated by the negative and significant estimated β_5 in Panel B.

Overall, we find consistent results using alternative proxies for the intermediary-based financial system.

E. Policy Implications for Developing Asia

In this section, we explore how applicable our findings are by centering on the innovation activities of developing Asian economies. In particular, we start by exploring the effect of financial architecture on innovation for economies that are categorized as developing Asia by the Asia Development Banks (ADB). Then we proceed to explore its heterogeneity by comparing the innovation of developing Asian economies and the rest of the sample.

1. Developing Asia

Among the 47 economies that we retain in our baseline tests, 33 economies have been categorized as high-income for at least once during the sample period of 1997 to 2016. While 9

economies are categorized as developing Asia by ADB,[13] only 3 out of 9 are categorized as high income for at least once between 1997 and 2016. Since a larger portion of these economies falls into the category of low-income, we expect that our implications for low-income economies can better explain their innovation actives. In addition, we expect that these patents are more likely to be filed by smaller entities, indicating that our observations for small entities may fit the picture better.

Table 14 summarizes the results. In Panel A, we re-estimate our model on a subsample of these 9 economies. We find that the innovation of these economies benefits more from the development of the equity market but not the debt market. As previously shown in our baseline tests, smaller entities are more likely to benefit from the equity market rather while larger entities are more likely to benefit from both the equity and debt market. The results are seemingly consistent with the overall findings.

In addition, the role of the intermediary-based financial system can hardly be ignored in supporting the innovation activities of these economies. As shown in row (3), we document that the positive coefficient estimates for β_3 are not only significant but also large in terms of the magnitude. The results are consistent with what we observe for lower-income economies as shown in the previous section.

In Panel B, we further compare the innovation activities of developing Asian economies with the rest of the sample. In particular, we generate an indicator $DAsia_i$ that is set to one if the economy is categorized as developing Asia by ADB and zero otherwise. the positive and significant coefficient estimates of Bank×DAsia, β_6, seem to suggest that the development of the intermediary-based financial system leads to higher-level innovation in developing Asia compared with that in the rest of the economies. Further, while more original and general innovation seems to benefit more from the development of the debt market for developing Asia, as suggested by the positive coefficient estimates of Debt×DAsia in the last two columns, the majority of the results seem to imply that the innovation of developing Asian economies, as measured by both patent quantity and quality, is less likely to be driven by the debt market.

[13] These economies may include the PRC; Hong Kong, China; India; Indonesia; the Republic of Korea; Malaysia; the Philippines; Singapore; and Thailand.

Regarding firms at different stages, the results in column (2) and (3) of Panel A suggest that the innovation of both small and large entities in developing Asia benefits from the development of the equity market and the intermediary-based financial system. The effect of the debt market, however, is more negative for large entities in these economies than for small entities, as suggested by the negative coefficient estimates for Debt×DAsia in Panel B.

Taking together, while the portion of low-income economies is relatively higher for the subsample of developing Asian economies compared with that in the overall sample, we document that the innovation activities in such economies might be better explained by what we observe for the low-income economies and for small entities. The evidence that the intermediary-based financial system plays an important role in developing Asia seems to be consistent with our aforementioned findings.

2. Ex-NIE Developing Asia

In this subsection, we proceed to explore whether our main findings shed light on the innovation activities of developing Asian economies that exclude the newly industrialized economies. For the nine developing Asian economies that we have in our sample, three of them are also categorized as newly industrialized economies. Namely, Hong Kong, China; the Republic of Korea; and Singapore. All three are categorized as high-income economies for at least once during our sample periods.

We start by focusing on a subsample of these ex-NIEs, namely, developing Asian economies that exclude the newly industrialized ones. As shown in Panel A Table 15, we find weak evidence that both the equity market and the intermediary-based financial system help foster the innovation of small entities in these economies. To get a clearer view of the heterogeneity of the effect, we make a comparison of these economies with the rest of the economies in our sample. In particular, in Panel B, we generate an indicator $EAsia_i$ that is set to one if the economy is categorized as developing Asian economies by ADB but does not belong to newly industrialized economies. We focus on the sign and significance of the coefficient estimates for the interaction terms $Equity \times EAsia$, $Debt \times EAsia$, and $Bank \times EAsia$.

We find that in general, the innovation of these economies benefits more from the intermediary-based market, as indicated by the positive and significant coefficient estimates of Bank× $DAsia$, but not the debt market, as indicated by the negative and significant coefficient estimates of Debt× $EAsia$. The effect remains for not only innovation quantity, as shown in column (1), but also its quality, as shown in columns (4) to (7). However, when it turns to the fundamental importance of the innovation, as measured by either patent originality or its generality, we find that the development of the debt market plays a more important role for these economies compared with the rest of others, even though it fails to improve innovation quantity for those economies.

VI. CONCLUSION

Using both the patent quantity and innovation quality metrics in the recent decade, we find evidence showing that not only the financial architecture matters for the long-term growth of the economy but also there is strong heterogeneity in such effects on the innovation of firms at different stages and economies with different income levels. As a result, such economy-level characteristics and firm-level features may have real ramifications on both the efficiency and correctness of policies aiming to improve the innovation of a specific type of economies or a specific group of firms.

In particular, we document that the market-based financial systems, such as equity markets and debt markets, are in general more efficient in encouraging innovation, especially for high-income economies. By contrast, the role played by the intermediary-based financial system, such as banks and other financial intermediaries, gets gradually deteriorated and the deterioration accelerates with the improvement of the wealth of the economy. In addition, we demonstrate that small entities benefit more from the development of the equity market rather than the debt market and the effect is stronger for high-income economies.

A specific look at the developing Asian economies suggests that while the equity market remains important for their innovation activities, the effect of the debt market is strongly deteriorated. More importantly, we find that the role of the intermediary-based financial system in encouraging innovation can hardly be ignored for both developing Asia and ex-NIE developing Asia. A comparison of developing Asia with the rest of others in our sample shows that the effect

of the intermediary-based financial system is even more important in improving innovation in these economies at this stage.

We hope that our findings can produce illuminate insights for policymakers aiming at improving the innovation in different economies or firms at different stages and draw a relatively clear map in helping them figure out a dynamic strategy when economies become richer and firms grow larger.

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Table 1: Summary Statistics

	Mean	sd	p25	p50	p75
Patent	0.028	0.109	0.000	0.001	0.012
Patent_Small	0.014	0.063	0.000	0.001	0.012
Patent_Large	0.031	0.125	0.000	0.001	0.012
Top75_Cit	0.020	0.092	0.000	0.001	0.008
Top75_Claim	0.019	0.079	0.000	0.001	0.009
Citation	0.018	0.080	0.000	0.000	0.008
Claim	0.023	0.095	0.000	0.001	0.011
Originality	0.461	0.755	0.035	0.257	0.656
Generality	0.442	0.824	0.012	0.213	0.622
Equity (% of GDP)	78.757	88.017	31.522	53.499	92.534
Debt (% of GDP)	26.230	23.602	6.179	18.736	38.546
Bank (% of GDP)	84.817	46.186	44.521	85.944	116.296
GDP_g	3.065	3.396	1.343	3.017	5.061
Population_g	0.846	0.769	0.313	0.759	1.333
Labor	0.716	0.069	0.672	0.715	0.772
Export (% of GDP)	47.592	40.654	24.097	34.563	55.747
R&D(% of GDP)	1.400	1.011	0.584	1.127	2.004
Export_US (% of US)	0.026	0.045	0.003	0.010	0.022
N	20,445				

GDP = gross domestic product, R&D = research and development, US = United States.

Source: Authors' calculations.

Table 1 reports the summary statistics of variables across all economy-industry-year observations. Patent (*Patent_Small, Patent_Large, Top75_Citation, Top75_Claim, Citation, Claim, Originality, and Generality*) are the economy-industry-year number of Patent (*Patent_Small, Patent_Large, Top75_Citation, Top75_Claim, Citation, Claim, Originality, and Generality*), respectively, scaled by the corresponding industry-year values in US data. To generate the economy-industry-year level measure, we take the sum of Patent (*Patent_Small, Patent_Large, Top75_Citation, Top75_Claim, Citation, Claim*) and the mean of *Originality (Generality)* for all the granted patents that belong to industry j and assigned by the US Patent and Trademark Office (USPTO) to companies or individuals of economy i. We use the official filing date instead of the grant date for patent measures following the literature. Regarding the definition of each of the innovation measures, *Patent* is the number of patents that are ultimately granted and assigned to companies or individuals by the USPTO before March 2019. *Patent_Small (Patent_Large)* is the number of such patents filed by small (middle or large) entities. *Top75_Citation* is the number of such patents of which the total number of citations received is in the upper 75% of all the patents filed in the same patent class-year. *Top75_Claim* is the number of such patents of which the total number of independent claims is in the upper 75% of all the patents filed in the same patent class-year. For each patent, *Citation* is the number of forward citations received adjusted by the median number

of citations received by all the patents in the same class-filing year. *Claim* is the total number of independent claims filed adjusted by the median number of independent claims of patents in the same class-filing year. *Originality (Generality)* is the Herfindahl index following Hall, Jaffe, and Trajtenberg (2005). *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. The industry is the two-digit standard industry classification (SIC) code. The sample period is 1997-2016. We include the economy-industry observations with at least one patent granted by the USPTO during our sample period and with available data on the financial architecture measures and other control variables. Detailed definitions of the other variables can be found in Appendix II.

Table 2: Financial Architecture and Innovation

	The Relative Number of Patents			
Equity	0.017***			0.030***
	(2.74)			(5.20)
Debt		0.041***		0.047***
		(4.10)		(3.36)
Bank			0.008	-0.020
			(0.40)	(-0.81)
GDP_g	-0.007***	-0.005***	-0.005*	-0.010***
	(-5.03)	(-3.12)	(-1.74)	(-2.93)
Population_g	0.001	0.006*	-0.001	0.009***
	(0.35)	(1.87)	(-0.41)	(3.49)
Labor	-0.049***	-0.064***	-0.053***	-0.056***
	(-4.19)	(-4.43)	(-4.98)	(-4.00)
Export	-0.009	-0.021	0.004	-0.050***
	(-0.57)	(-1.35)	(0.23)	(-3.01)
R&D	0.126***	0.154***	0.128***	0.155***
	(4.78)	(5.14)	(4.71)	(4.88)
Export_US	0.082	0.071	0.078	0.077
	(0.76)	(0.66)	(0.76)	(0.74)
N	28,841	20,445	28,761	20,445
adj. R^2	0.912	0.912	0.912	0.912
Economy-Industry Fixed Effect (FE)	Yes	Yes	Yes	Yes
Year Fixed Effect (FE)	Yes	Yes	Yes	Yes

GDP = gross domestic product, R&D = research and development, US = United States.
Source: Authors' calculations.

Table 2 summarizes the standardized estimated results of equation (1): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is the relative number of patents. For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over GDP. *Debt* is the outstanding domestic private debt securities to gross domestic product (GDP). *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g (Population_g)* is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of the labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 3: Quality

	Top75_Citation	**Top75_Claim**	**Citation**	**Claim**	**Originality**	**Generality**
Equity	0.017	0.015*	0.024	0.009	0.026	0.031
	(1.51)	(1.93)	(1.40)	(1.26)	(1.19)	(1.46)
Debt	0.039**	0.088***	0.063**	0.059***	0.013	-0.012
	(2.29)	(4.74)	(2.55)	(3.75)	(0.64)	(-0.51)
Bank	-0.072*	-0.061**	-0.009	-0.068**	-0.043*	-0.029
	(-1.94)	(-2.04)	(-0.37)	(-2.22)	(-1.82)	(-1.34)
GDP_g	-0.012***	-0.012***	-0.008**	-0.016***	0.002	0.000
	(-2.87)	(-3.09)	(-2.05)	(-4.01)	(0.27)	(0.00)
Population_g	0.008***	0.014***	0.013***	0.004	0.001	0.005
	(3.34)	(3.70)	(4.67)	(1.53)	(0.09)	(0.52)
Labor	-0.027*	-0.085***	-0.087**	-0.064***	0.036	0.069***
	(-1.79)	(-4.68)	(-2.44)	(-4.18)	(1.34)	(2.74)
Export	-0.065***	-0.060***	-0.032*	-0.059***	0.015	-0.038
	(-2.79)	(-3.05)	(-1.78)	(-2.96)	(0.45)	(-1.13)
R&D	0.209***	0.153***	0.096***	0.196***	-0.019	0.005
	(6.01)	(5.15)	(2.94)	(6.11)	(-0.60)	(0.17)
Export_US	-0.150	-0.148	0.150	-0.127	0.077*	0.124***
	(-0.97)	(-1.24)	(1.40)	(-1.02)	(1.81)	(4.02)
N	20,445	20,445	20,445	20,445	20,445	20,445
adj. R^2	0.863	0.876	0.766	0.886	0.502	0.488
Economy-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

FE=fixed effects, GDP = gross domestic product, R&D = research and development, US = United States.
Source: Authors' calculations.

Table 3 summarizes the standardized estimated results of equation (1): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each column. For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g (Population_g)* is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of the labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 4: Financing Innovation: Firms at Different Stages

Panel A: Patent_Small				
Equity	0.124***			0.146***
	(5.99)			(6.44)
Debt		-0.020*		-0.024***
		(-1.81)		(-2.73)
Bank			0.008	0.027
			(0.34)	(1.09)
N	28,841	20,445	28,761	20,445
adj. R^2	0.148	0.185	0.147	0.187
Panel B: Patent_Large				
Equity	0.007			0.021***
	(0.89)			(3.11)
Debt		0.056***		0.060***
		(4.76)		(3.89)

Bank			0.019	-0.016
			(1.04)	(-0.68)
N	28,841	20,445	28,761	20,445
adj. R2	0.911	0.913	0.911	0.913
Controls	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

FE=fixed effects
Source: Authors' calculations

Table 4 summarizes the standardized estimated results of equation (1): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each panel. For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestix product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g (Population_g)* is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of the labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 5: Financing Innovation: Economies at Different Income Levels

	The Relative Number of Patents			
Equity	-0.0174*			-0.0116
	(-1.78)			(-1.04)
Equity × High	0.0431***			0.0449***
	(2.79)			(3.29)
Debt		0.00541		-0.00626
		(0.40)		(-0.56)
Debt × High		0.0493***		0.0898***
		(4.15)		(5.81)
Bank			0.0118	0.0774***

			(1.62)	(5.07)
Bank × High			-0.00554 (-0.27)	-0.139*** (-3.62)
High	0.0779*** (4.86)	0.0873*** (5.01)	0.0579*** (2.92)	0.0587** (2.27)
N	28,841	20,445	28,761	20,445
adj. R^2	0.912	0.912	0.912	0.912
Controls	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

FE=fixed effects
Source: Authors' calculations

Table 5 summarizes the standardized estimated results of equation (2) $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \beta_4 Equity_{it} \times High\_Income_{i,t-3} + \beta_5 Debt_{it} \times High\_Income_{i,t-3} + \beta_6 Bank_{it} \times High\_Income_{i,t-3} + \beta_7 High\_Income_{i,t-3} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is the relative number of patents. *High* is a dummy set to one if economy i is categorized in the high-income group by the World Bank at t-3, and it is set to zero otherwise. For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g (Population_g)* is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of the labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 6: Quality

	Top75_Citation	Top75_Claim	Citation	Claim	Originality	Generality
Equity	-0.00163	-0.0211**	-0.0491**	-0.0274**	-0.0139	0.0182
	(-0.16)	(-2.16)	(-2.03)	(-2.51)	(-0.48)	(0.69)
Debt	0.00289	0.0107	0.000877	-0.00901	0.0631*	0.0415*
	(0.26)	(0.95)	(0.08)	(-0.71)	(1.87)	(1.65)
Bank	0.0260**	0.0998***	0.124***	0.0689***	-0.0277	-0.0239
	(2.02)	(5.15)	(3.92)	(4.01)	(-0.57)	(-0.50)
Equity × High	0.0120	0.0285**	0.0790***	0.0318**	0.0454	0.0130
	(0.84)	(2.20)	(4.15)	(2.39)	(1.30)	(0.39)
Debt × High	0.0631***	0.130***	0.107***	0.114***	-0.0642*	-0.0698**
	(3.74)	(6.85)	(3.37)	(6.86)	(-1.83)	(-2.38)
Bank × High	-0.136***	-0.227***	-0.188***	-0.194***	-0.00860	0.00489
	(-2.71)	(-4.97)	(-2.73)	(-4.59)	(-0.16)	(0.09)
High	-0.0210	0.00655	0.0518*	0.0173	0.0275	0.0327
	(-0.56)	(0.21)	(1.94)	(0.55)	(0.75)	(0.87)
N	20,445	20,445	20,445	20,445	20,445	20,445
adj. R^2	0.863	0.877	0.767	0.887	0.502	0.488
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

FE=fixed effects
Source: Authors' calculations

Table 6 summarizes the standardized estimated results of equation (2) $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \beta_4 Equity_{it} \times High\_Income_{i,t-3} + \beta_5 Debt_{it} \times High\_Income_{i,t-3} + \beta_6 Bank_{it} \times High\_Income_{i,t-3} + \beta_7 High\_Income_{i,t-3} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each column. *High_income* is a dummy set to one if economy i is categorized in the high-income group by the World Bank at t-3, and it is set to zero otherwise. For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g (Population_g)* is the annual growth rate of GDP

(population) for economy i at time t. *Labor* is the number of the labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 7: Income: Firms at Different Stages

Panel A: Patent_Small				
Equity	0.128***			0.148***
	(3.79)			(3.31)
Equity × High	-0.00590			-0.00211
	(-0.19)			(-0.05)
Debt		0.0286		0.0184
		(1.58)		(1.22)
Debt × High		-0.0609**		-0.0580***
		(-2.46)		(-3.13)
Bank			0.0108	0.0169
			(0.52)	(0.43)
Bank × High			-0.00332	0.0232
			(-0.13)	(0.55)
High	-0.0103	0.0112	-0.0189	0.0349
	(-0.48)	(0.42)	(-0.70)	(1.30)
N	28,841	20,445	28,761	20,445
adj. R^2	0.148	0.185	0.147	0.187
Panel B: Patent_Large				
Equity	-0.0281***			-0.0221**
	(-3.25)			(-2.04)
Equity × High	0.0429***			0.0446***
	(3.11)			(3.91)
Debt		0.00903		-0.00506
		(0.67)		(-0.46)
Debt × High		0.0635***		0.109***
		(5.72)		(6.31)
Bank			0.0206***	0.0967***
			(2.69)	(5.71)

Bank × High			-0.00220	-0.162***
			(-0.11)	(-3.93)
High	0.0859***	0.0989***	0.0684***	0.0605**
	(5.64)	(6.03)	(3.68)	(2.41)
N	28,841	20,445	28,761	20,445
adj. R2	0.912	0.913	0.912	0.913
Controls	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

FE = fixed effects
Source: Authors' calculations.

Table 7 summarizes the standardized estimated results of equation (2)$y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \beta_4 Equity_{it} \times High\_Income_{i,t-3} + \beta_5 Debt_{it} \times High\_Income_{i,t-3} + \beta_6 Bank_{it} \times High\_Income_{i,t-3} + \beta_7 High\_Income_{i,t-3} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each panel. *High_income* is a dummy set to one if economy i is categorized in the high-income group by the World Bank at t-3, and it is set to zero otherwise. For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g (Population_g)* is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of the labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 8: Robustness: Economy-Year Fixed Effect

	Patent	Patent_Small	Patent_Large	Top75_Citation	Top75_Claim	Citation	Claim	Originality	Generality
Equity_High-Tech	-0.001	0.003***	0.000	-0.002	0.002	-0.001	-0.000	-0.002	-0.003
	(-0.61)	(6.92)	(0.24)	(-0.65)	(1.17)	(-1.04)	(-0.18)	(-0.28)	(-0.45)
Debt_High-Tech	0.039***	0.015***	0.034***	0.025***	0.037***	0.041***	0.037***	-0.004	-0.010*
	(4.41)	(3.53)	(4.29)	(3.30)	(4.75)	(4.82)	(4.37)	(-0.73)	(-1.88)
Bank_High-Tech	-0.014***	-0.010**	-0.016***	-0.003	-0.014***	-0.010***	-0.013***	0.006	0.006*
	(-3.89)	(-2.38)	(-5.04)	(-0.53)	(-5.24)	(-2.75)	(-4.06)	(1.65)	(1.88)
Export	0.019	0.007	0.018	0.013	0.015	0.013	0.018*	0.020*	0.019*
	(1.67)	(1.06)	(1.67)	(1.53)	(1.63)	(1.35)	(1.72)	(1.84)	(1.88)
N	21,493	21,493	21,493	21,493	21,493	21,493	21,493	21,493	21,493
adj. R^2	0.565	0.199	0.594	0.420	0.479	0.432	0.510	0.321	0.299
Economy-Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

FE = fixed effects

Source: Authors' calculations.

Table 8 summarizes the standardized estimated results estimating the specification of equation (3): $y_{i,j,t+1} = \beta_0 + \beta_1(Equity_{it} \times High\_Tech_j) + \beta_2(Debt_{it} \times High\_Tech_j) + \beta_3(Bank_{it} \times High\_Tech_j) + \beta_4 Export_{ijt} + \delta_{i,t+1} + \mu_j + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each column. *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks to GDP. *Hi-Tech* is the average level of research and development growth for each 2-digit SIC industry of United States public firms. *Export* is the trade value of goods and services that are exported to the United States by industry j in economy i at time t. We include the economy-year fixed effect and the industry fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 9: Robustness: Economy-Year Fixed Effect

	Patent High-Income	Patent Low-Income	Patent_Small High-Income	Patent_Small Low-Income	Patent_Large High-Income	Patent_Large Low-Income
Equity_High-Tech	0.003	-0.015***	0.009***	-0.015**	0.004**	-0.013***
	(1.32)	(-6.28)	(10.18)	(-3.17)	(2.48)	(-6.63)
Debt_High-Tech	0.043***	0.034**	0.019***	0.076***	0.037***	0.016***
	(4.09)	(2.76)	(4.02)	(4.49)	(3.86)	(3.29)
Bank_High-Tech	-0.013**	0.044***	-0.024***	0.105***	-0.018***	0.020**
	(-2.22)	(3.21)	(-4.03)	(4.50)	(-3.84)	(2.56)
Export	0.028*	0.038	0.016	-0.003	0.027*	0.051
	(1.95)	(1.31)	(1.41)	(-0.11)	(1.95)	(1.32)
N	11,560	3,561	11,560	3,561	11,560	3,561
adj. R^2	0.564	0.736	0.194	0.411	0.591	0.718
Economy-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes

FE = fixed effects
Source: Authors' calculations.

Table 9 summarizes the standardized estimated results for a subsample of high-income economies and low-income economies. The estimations follow the specification of equation (2) $y_{i,j,t+1} = \beta_0 + \beta_1(Equity_{it} \times High\_Tech_j) + \beta_2(Debt_{it} \times High\_Tech_j) + \beta_3(Bank_{it} \times High\_Tech_j) + \beta_4 Export_{ijt} + \delta_{i,t+1} + \mu_j + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each column. *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks to GDP. *Hi-Tech* is the average level of R&D growth for each 2-digit SIC industry of United States public firms. *Export* is the trade value of goods and services that are exported to the United States by industry j in economy i at time t. We include the economy-year fixed effect and the industry fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 10: Robustness: The Global Patent Database

	Patent	Citation	Originality	Generality
Equity	0.038**	0.052**	-0.080**	0.072
	(1.97)	(2.05)	(-2.50)	(1.40)
Debt	0.141***	0.104**	0.142*	0.010
	(4.13)	(2.54)	(1.83)	(0.17)
Bank	-0.194***	-0.205***	-0.155***	-0.033
	(-5.01)	(-5.08)	(-2.65)	(-0.51)
GDP_g	-0.062***	-0.061***	0.040	-0.075*
	(-5.10)	(-3.77)	(0.92)	(-1.78)
Population_g	-0.042**	-0.057**	0.011	-0.071*
	(-2.10)	(-2.23)	(0.13)	(-1.95)
Labor	-0.224***	-0.089	0.226	0.216*
	(-3.72)	(-1.24)	(1.47)	(1.71)
Export	-0.388***	-0.321***	0.196	0.196
	(-5.52)	(-4.88)	(1.08)	(1.10)
R&D	0.630***	0.530***	-0.239	-0.117
	(12.39)	(8.38)	(-1.28)	(-1.12)
Export_US	-0.106	0.026	0.163	0.403***
	(-1.14)	(0.27)	(0.50)	(3.16)
N	4,168	4,168	1,988	3,078
adj. R^2	0.868	0.739	0.286	0.339
Economy-Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

FE=fixed effects, GDP = gross domestic product, R&D = research and development, US = United States.

Source: Authors' calculations.

Table 10 summarizes the standardized estimated results when innovation is measured by the global patent-filings of public firms of economy i that are captured by the Bureau van Dijk's Orbis patent database. The tests follow the specification of equation (1): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each column. In particular, *Patent* is the logarithm transfer of one plus the number of patents. *Citation* is the logarithm transfer of one plus the adjusted number of citations received. *Originality* and *Generality* are Herfindahl Index measures following Hall, Jaffe, and Trajtenberg (2005). For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$,

R&D is the research and development expenditure over GDP. *GDP_g (Population_g)* is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 11: Robustness: The Global Patent Database

	Patent	Patent	Citation	Citation	Originality_a	Originality	Generality	Generality
	High-Income	Low-Income	High-Income	Low-Income	High-Income	Low-Income	High-Income	Low-Income
Equity	0.070***	-0.152*	0.077***	-0.317**	-0.091**	-0.023	0.068	2.869***
	(3.28)	(-1.91)	(2.76)	(-2.06)	(-2.15)	(-0.05)	(1.11)	(9.04)
Debt	0.106***	-0.289***	0.058	-0.435**	0.166*	0.638	0.003	2.783***
	(3.37)	(-3.30)	(1.45)	(-2.36)	(1.70)	(0.64)	(0.04)	(5.93)
Bank	-0.070**	0.235	-0.050	0.132	-0.234***	0.375	-0.051	1.315**
	(-2.19)	(1.10)	(-1.33)	(0.42)	(-3.54)	(0.21)	(-0.67)	(2.62)
N	3300	463	3300	463	1699	202	2530	351
adj. R^2	0.877	0.922	0.736	0.807	0.420	0.152	0.321	0.377
Economy-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

FE=fixed effects
Source: Authors' calculations.

Table 11 summarizes the standardized estimated results for a subsample of high-income economies and low-income economies. Innovation is measured by the global patent-filings of public firms of economy i that are captured by the Bureau van Dijk's Orbis patent database. The tests follow the specification of equation (1): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each column. In particular, Patent is the logarithm transfer of one plus the number of patents. Citation is the logarithm transfer of one plus the adjusted number of citations received. *Originality* and *Generality* are Herfindahl Index measures following Hall, Jaffe, and Trajtenberg (2005). For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g* (*Population_g*) is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of labor force over the

population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the United States that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 12: Robustness: Alternative Proxies for Intermediary-Based financing

	Credit_Finance	Credit_All	Bank_pure	Non-Bank
	Panel A: Patent			
Equity	0.028***	0.031***	0.027***	0.042***
	(4.34)	(6.10)	(4.02)	(3.19)
Debt	0.050***	0.044***	0.051***	0.042***
	(3.57)	(3.40)	(3.82)	(3.57)
Bank	-0.034*	-0.012	-0.062*	0.036
	(-1.71)	(-0.42)	(-1.84)	(1.46)
N	20,445	20,445	20,445	18,843
adj. R^2	0.912	0.912	0.912	0.912
	Panel B: Patent_Small			
Equity	0.155***	0.145***	0.146***	0.188***
	(6.09)	(6.06)	(6.41)	(3.63)
Debt	-0.042***	-0.021**	-0.020**	-0.040**
	(-3.26)	(-2.21)	(-2.06)	(-2.03)
Bank	0.106***	0.021	0.019	0.094**
	(5.16)	(0.99)	(0.85)	(2.47)
N	20,445	20,445	20,445	18,843
adj. R2	0.188	0.187	0.187	0.184
	Panel C: Patent_Large			
Equity	0.016**	0.021***	0.017**	0.019
	(2.19)	(3.73)	(2.18)	(1.62)
Debt	0.069***	0.058***	0.066***	0.064***
	(4.32)	(4.00)	(4.36)	(4.88)
Bank	-0.055**	-0.012	-0.065*	0.016
	(-2.54)	(-0.44)	(-1.92)	(0.72)
N	20,445	20,445	20,445	18,843
adj. R2	0.913	0.913	0.913	0.912
Controls	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

FE=fixed effects

Source: Authors' calculations.

Table 12 summarizes the standardized estimated results for the robustness check using alternative proxies for the intermediary-based financial system of the economy. The tests follow the specification of equation (1): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each panel. The proxy for the intermediary-based financial system is specified as the title of each column. In particular, *Bank_pure* is the private credit provided by deposit money banks over gross domestic product (GDP); *Credit_Finance* is the ratio of domestic credit provided by the finance sector over GDP; *Credit_all* is all domestic credit to the private sector over GDP; *Non-Bank* captures the difference between *Credit_Finance* and *Bank_pure* that is supposed to measure the credit provided by the non-bank financial institutions. *Equity* is the stock market capitalization of listed domestic companies over GDP. *Debt* is the outstanding domestic private debt securities to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g* (*Population_g*) is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 13: Robustness: Alternative Proxies for Intermediary-Based Financing

	Credit_Finance	Credit_All	Bank_pure	Non-Bank
Panel A: Patent				
Equity	0.00357	-0.00890	-0.00166	0.00891
	(0.37)	(-0.80)	(-0.16)	(1.02)
Equity×High	0.0293**	0.0485***	0.0323**	0.0721***
	(2.28)	(3.62)	(2.56)	(4.94)
Debt	-0.00387	-0.0158**	-0.00319	0.0304**
	(-0.38)	(-2.10)	(-0.33)	(1.97)
Debt×High	0.0923***	0.0881***	0.0946***	0.0191
	(5.75)	(5.36)	(5.77)	(1.03)
Bank	0.0649***	0.0729***	0.0597***	0.000837
	(3.33)	(5.37)	(4.97)	(0.08)
Bank×High	-0.146***	-0.118***	-0.161***	0.0421*
	(-3.12)	(-2.76)	(-3.26)	(1.82)
High	0.0381	0.0770***	0.0442	0.129***
	(1.11)	(3.02)	(1.46)	(6.47)
N	20,445	20,445	20,445	18,843
adj. R^2	0.913	0.913	0.913	0.912
Panel B: Patent_Small				
Equity	0.157***	0.141***	0.146***	0.136***
	(3.63)	(3.15)	(3.44)	(3.40)
Equity×High	-0.00967	0.00119	-0.00456	0.0888*
	(-0.23)	(0.03)	(-0.11)	(1.85)
Debt	0.0193	0.0152	0.0203	0.0139
	(1.17)	(1.15)	(1.35)	(1.15)
Debt×High	-0.0749**	-0.0444**	-0.0477***	-0.0657*
	(-2.28)	(-2.18)	(-2.80)	(-1.94)
Bank	0.164***	0.0335	0.0550	0.163***
	(2.61)	(0.99)	(1.53)	(3.13)
Bank×High	-0.0549	-0.0121	-0.0351	-0.0776
	(-0.73)	(-0.29)	(-0.67)	(-1.39)
High	-0.00522	0.0239	0.00891	0.0265
	(-0.13)	(0.93)	(0.29)	(0.80)
N	20,445	20,445	20,445	18,843
adj. R2	0.188	0.187	0.187	0.184
Panel C: Patent_Large				
Equity	-0.00615	-0.0190*	-0.00916	-0.00146
	(-0.69)	(-1.77)	(-0.96)	(-0.19)
Equity×High	0.0255**	0.0483***	0.0288***	0.0503***
	(2.35)	(4.35)	(2.74)	(3.97)
Debt	-0.00392	-0.0164**	-0.000189	0.0356**
	(-0.40)	(-2.19)	(-0.02)	(2.23)

Debt×High	0.123***	0.109***	0.113***	0.0400**
	(6.51)	(5.71)	(6.12)	(2.39)
Bank	0.0710***	0.0877***	0.0718***	-0.00146
	(3.51)	(5.82)	(5.34)	(-0.14)
Bank×High	-0.187***	-0.140***	-0.181***	0.0204
	(-3.64)	(-3.06)	(-3.50)	(0.93)
High	0.0292	0.0812***	0.0454	0.122***
	(0.85)	(3.34)	(1.54)	(6.23)
N	20,445	20,445	20,445	18,843
adj. R2	0.914	0.913	0.914	0.913
Controls	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

FE=fixed effects
Source: Authors' calculations.

Table 13 summarizes the standardized estimated results for the robustness check using alternative proxies for the intermediary-based financial system of the economy. The tests follow the specification of equation (2): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \beta_4 Equity_{it} \times High\_Income_{i,t-3} + \beta_5 Debt_{it} \times High\_Income_{i,t-3} + \beta_6 Bank_{it} \times High\_Income_{i,t-3} + \beta_7 High\_Income_{i,t-3} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each panel. The measure for the intermediary-based financial system is specified as the title of each column. In particular, *Bank_Pure* is the private credit provided by deposit money banks over gross domestic product (GDP); *Credit_Finance* is the ratio of domestic credit provided by the finance sector over GDP; *Credit_all* is all domestic credit to the private sector over GDP; *Non-Bank* captures the difference between *Credit_Finance* and *Bank_pure* that is supposed to measure the credit provided by the non-bank financial institutions. *Equity* is the stock market capitalization of listed domestic companies over GDP. *Debt* is the outstanding domestic private debt securities to GDP. As for $Controls_{it}$, *R&*D is the research and development expenditure over GDP. *GDP_g* (*Population_g*) is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 14: Developing Asia

	Patent	Patent_Small	Patent_Large	Top75_Citation	Top75_Claim	Citation	Claim	Originality	Generality
Panel A: Developing Asia									
Equity	0.081***	0.101**	0.086***	0.081***	0.128***	0.081***	0.055*	-0.018	-0.029
	(2.92)	(2.49)	(3.38)	(4.15)	(4.79)	(2.82)	(1.82)	(-0.34)	(-0.63)
Debt	-0.136***	-0.013	-0.140***	-0.073**	-0.117***	-0.136***	-0.145***	0.109**	0.080**
	(-3.12)	(-0.26)	(-3.51)	(-2.29)	(-3.48)	(-2.91)	(-3.53)	(2.31)	(2.21)
Bank	0.341***	0.250***	0.337***	0.283***	0.362***	0.205***	0.340***	-0.130***	-0.166***
	(5.81)	(6.89)	(5.36)	(5.35)	(6.31)	(3.67)	(5.83)	(-2.73)	(-3.07)
N	4,354	4,354	4,354	4,354	4,354	4,354	4,354	4,354	4,354
adj. R^2	0.691	0.275	0.722	0.612	0.709	0.442	0.699	0.511	0.527
Panel B: Interactions									
Equity	0.0160	0.149**	-0.00816	0.0229**	0.00131	-0.0252	0.0115	0.112***	0.142***
	(1.31)	(2.33)	(-0.75)	(2.52)	(0.12)	(-0.79)	(0.79)	(4.13)	(5.05)
Equity×DAsia	0.0200	-0.0246	0.0433**	-0.0131	0.0205	0.0752**	-0.00530	-0.136***	-0.172***
	(0.97)	(-0.35)	(2.45)	(-0.82)	(1.03)	(2.57)	(-0.21)	(-3.75)	(-4.71)
Debt	0.0681***	-0.0290***	0.0869***	0.0601**	0.123***	0.0896**	0.0894***	-0.0302	-0.0508*
	(3.39)	(-2.73)	(3.89)	(2.38)	(4.73)	(2.41)	(4.00)	(-1.41)	(-1.84)
Debt×DAsia	-0.0429**	0.144***	-0.0683***	-0.0200	-0.0852***	-0.0804**	-0.0641***	0.156***	0.137***
	(-2.21)	(5.07)	(-3.15)	(-0.87)	(-3.44)	(-2.01)	(-3.01)	(3.11)	(3.42)
Bank	-0.0574*	-0.0226	-0.0578*	-0.118**	-0.116***	-0.0474	-0.119***	0.00743	0.0204
	(-1.77)	(-0.92)	(-1.80)	(-2.38)	(-2.97)	(-1.17)	(-3.04)	(0.31)	(0.93)
Bank×DAsia	0.175***	0.403***	0.176***	0.248***	0.243***	0.144**	0.237***	-0.148**	-0.156**
	(4.43)	(5.81)	(4.31)	(4.14)	(5.18)	(2.19)	(5.33)	(-2.41)	(-2.38)
N	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445
adj. R^2	0.912	0.190	0.913	0.863	0.877	0.766	0.887	0.503	0.489
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

FE=fixed effects

Source: Authors' calculations.

Table 14 summarizes the standardized estimated results for developing Asian economies. In Panel A, the tests are conducted on a subsample of developing Asian economies follow the specification of equation (1): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. And in Panel B, the tests are conducted on the full sample following the specification of equation (2): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \beta_4 Equity_{it} \times DAsia_i + \beta_5 Debt_{it} \times DAsia_i + \beta_6 Bank_{it} \times DAsia_i + +\rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. $DAsia_i$ is a dummy that is set to one if the economy is categorized as developing Asian economies by the Asian Development Bank and zero otherwise. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each column. For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g* (*Population_g*) is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

Table 15: Ex-NIE Developing Asia

	Patent	Patent_Small	Patent_Large	Top75_Citation	Top75_Claim	Citation	Claim	Originality	Generality
Panel A: Ex-NIE Economies									
Equity	-0.051	0.089*	-0.048	0.007	-0.055	-0.060	-0.056	-0.088**	-0.107**
	(-0.91)	(1.81)	(-0.92)	(0.24)	(-1.20)	(-1.28)	(-1.02)	(-1.98)	(-2.20)
Debt	-0.110	0.237	-0.079	0.122***	-0.055	-0.109**	-0.098	0.189**	0.137*
	(-0.99)	(1.53)	(-1.05)	(4.24)	(-0.54)	(-2.28)	(-0.93)	(2.42)	(1.93)
Bank	-0.266	0.509*	-0.274	0.032	-0.323	-0.355*	-0.250	-0.080	-0.238
	(-1.01)	(1.66)	(-1.37)	(0.38)	(-1.38)	(-1.93)	(-1.04)	(-0.57)	(-1.17)
N	2,462	2,462	2,462	2,462	2,462	2,462	2,462	2,462	2,462
adj. R^2	0.419	0.174	0.501	0.366	0.476	0.253	0.464	0.427	0.414
Panel B: Interactions									
Equity	0.0290***	0.135***	0.0198**	0.00970	0.0104	0.0239	0.00378	0.0335	0.0383*
	(3.84)	(6.47)	(2.35)	(0.65)	(1.03)	(1.25)	(0.42)	(1.52)	(1.73)
Equity×EAsia	-0.0318	-0.0475	-0.0237	-0.00511	-0.00626	-0.0381	-0.0128	-0.137**	-0.122**
	(-1.41)	(-0.67)	(-1.22)	(-0.22)	(-0.37)	(-1.11)	(-0.63)	(-2.40)	(-2.47)
Debt	0.0605***	-0.0478***	0.0778***	0.0515**	0.113***	0.0833***	0.0797***	-0.0198	-0.0401
	(3.40)	(-4.78)	(3.93)	(2.35)	(4.88)	(2.58)	(3.99)	(-0.98)	(-1.53)
Debt×EAsia	-0.0387**	0.169***	-0.0613***	-0.0221	-0.0899***	-0.0710**	-0.0626***	0.172***	0.148***
	(-2.39)	(4.53)	(-3.51)	(-1.11)	(-4.39)	(-2.10)	(-3.47)	(3.02)	(3.45)
Bank	-0.0406	0.0341	-0.0400	-0.0984**	-0.0989***	-0.0363	-0.101***	-0.00521	0.00410
	(-1.29)	(1.23)	(-1.31)	(-2.09)	(-2.63)	(-1.01)	(-2.64)	(-0.23)	(0.19)
Bank×EAsia	0.133**	0.162*	0.133**	0.220**	0.231***	0.147*	0.220***	-0.151*	-0.138
	(2.31)	(1.78)	(2.34)	(2.52)	(3.55)	(1.69)	(3.34)	(-1.79)	(-1.44)
N	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445
adj. R^2	0.912	0.188	0.913	0.863	0.876	0.766	0.887	0.503	0.489
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

FE=fixed effects
Source: Authors’ calculations.

Table 15 summarizes the standardized estimated results for a subsample of developing Asian economies that excludes newly industrialized economies. In Panel A, the tests follow the specification of equation (1): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. And in Panel B, the tests are conducted on the full sample following the specification of equation (2): $y_{i,j,t+1} = \beta_0 + \beta_1 Equity_{it} + \beta_2 Debt_{it} + \beta_3 Bank_{it} + \beta_4 Equity_{it} \times EAsia_i + \beta_5 Debt_{it} \times EAsia_i + \beta_6 Bank_{it} \times EAsia_i + +\rho Controls_{it} + \delta_{i,j} + \mu_{t+1} + \delta_{i,j,t+1}$. $EAsia_i$ is a dummy that is set to one if the economy is categorized as developing Asian economies by the Asian Development Bank but does not belong to newly industrialized economies. It is set to zero otherwise. For each economy-industry-year, $y_{i,j,t+1}$ is specified as the title of each column. For each economy-year, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. As for $Controls_{it}$, *R&D* is the research and development expenditure over GDP. *GDP_g* (*Population_g*) is the annual growth rate of GDP (population) for economy i at time t. *Labor* is the number of labor force over the population within 15 and 64 ages. *Export* is the export of goods and services over GDP. *Export_US* is the portion of export received by the US that is provided by economy i. We include the economy-industry fixed effect and the year fixed effect in all specifications. t-statistics are robust to heteroskedasticity and the standard errors are clustered at the economy-industry level. *, ** and *** indicate statistical significance at the 10%, 5% and 1% level, respectively.

APPENDIX 1: ADDITIONAL TABLES

Table A1: T-test for Economies with High-Income and Low-Income

	Low-Income	High-Income	Difference	T-statititics
Financial Market				
Equity (% of GDP)	59.72	96.16	-36.45***	-30.90
Debt (% of GDP)	14.96	37.10	-22.14***	-75.53
Bank (% of GDP)	58.22	108.65	-50.43***	-89.59
Innovation				
Patent*	95.25	849.86	-754.61***	-18.07
Patent_Small*	12.09	54.96	-42.87***	-24.37
Patent_Large*	59.14	742.82	-683.68***	-18.13
Top75_Citation*	18.78	195.70	-176.92***	-18.05
Top75_Claim*	28.06	263.06	-235.00***	-16.82
Citation*	109.45	1,361.66	-1,252.21***	-18.49
Claim*	98.36	951.24	-852.88***	-18.32
Originality*	0.27	0.61	-0.34***	-37.75
Generality*	0.19	0.48	-0.29***	-39.24
Macro-Characteristics				
GDP_g	3.88	2.07	1.81***	38.01
Population_g	0.95	0.75	0.19***	19.52
Labor	0.69	0.74	-0.05***	-51.56
Export	35.69	57.90	-22.21***	-43.00
R&D	0.74	1.95	-1.21***	-110.01
Export_US	0.03	0.03	0.00	-0.37

GDP = gross domestic product, US = United States.
Source: Authors' calculations.

In table A1, we summarize the difference between economies in the high-income category and the low-income category. In particular, an economy is set to the high-income group if it is categorized in the high-income group by the World Bank at t-3. All the numbers are the pooled averages of each variable. Patent* is the raw number of patents that are ultimately granted and assigned to companies or individuals by the USPTO before March 2019. Patent_Small* (Patent_Large*) is the raw number of such patents filed by small (middle or large) entities. Top75_Citation* is the raw number of such patents of which the total number of citations received is in the upper 75% of all the patents filed in the same patent class-year. Top75_Claim* is the raw number of such patents of which the total number of independent claims is in the upper 75% of all the patents filed in the

same patent class-year. For each patent, Citation* is the raw number of forward citations received adjusted by the median number of citations received by all the patents in the same class-filing year. Claim* is the sum of the raw number of independent claims filed adjusted by the median number of independent claims of patents in the same class-filing year. Originality* (Generality*) is the Herfindahl index following Hall, Jaffe, and Trajtenberg (2005). The definitions of other variables are specified in Appendix II.

Table A2: Economy-Level Averages

	Patent	Patent_Small	Patent_Large	Top75_Citation	Top75_Claim	Citation	Claim	Originality	Generality
Panel A: Developing Asia									
Equity	0.081***	0.101**	0.086***	0.081***	0.128***	0.081***	0.055*	-0.018	-0.029
	(2.92)	(2.49)	(3.38)	(4.15)	(4.79)	(2.82)	(1.82)	(-0.34)	(-0.63)
Debt	-0.136***	-0.013	-0.140***	-0.073**	-0.117***	-0.136***	-0.145***	0.109**	0.080**
	(-3.12)	(-0.26)	(-3.51)	(-2.29)	(-3.48)	(-2.91)	(-3.53)	(2.31)	(2.21)
Bank	0.341***	0.250***	0.337***	0.283***	0.362***	0.205***	0.340***	-0.130***	-0.166***
	(5.81)	(6.89)	(5.36)	(5.35)	(6.31)	(3.67)	(5.83)	(-2.73)	(-3.07)
N	4,354	4,354	4,354	4,354	4,354	4,354	4,354	4,354	4,354
adj. R^2	0.691	0.275	0.722	0.612	0.709	0.442	0.699	0.511	0.527
Panel B: Interactions									
Equity	0.0160	0.149**	-0.00816	0.0229**	0.00131	-0.0252	0.0115	0.112***	0.142***
	(1.31)	(2.33)	(-0.75)	(2.52)	(0.12)	(-0.79)	(0.79)	(4.13)	(5.05)
Equity×DAsia	0.0200	-0.0246	0.0433**	-0.0131	0.0205	0.0752**	-0.00530	-0.136***	-0.172***
	(0.97)	(-0.35)	(2.45)	(-0.82)	(1.03)	(2.57)	(-0.21)	(-3.75)	(-4.71)
Debt	0.0681***	-0.0290***	0.0869***	0.0601**	0.123***	0.0896**	0.0894***	-0.0302	-0.0508*
	(3.39)	(-2.73)	(3.89)	(2.38)	(4.73)	(2.41)	(4.00)	(-1.41)	(-1.84)
Debt×DAsia	-0.0429**	0.144***	-0.0683***	-0.0200	-0.0852***	-0.0804**	-0.0641***	0.156***	0.137***
	(-2.21)	(5.07)	(-3.15)	(-0.87)	(-3.44)	(-2.01)	(-3.01)	(3.11)	(3.42)
Bank	-0.0574*	-0.0226	-0.0578*	-0.118**	-0.116***	-0.0474	-0.119***	0.00743	0.0204
	(-1.77)	(-0.92)	(-1.80)	(-2.38)	(-2.97)	(-1.17)	(-3.04)	(0.31)	(0.93)
Bank×DAsia	0.175***	0.403***	0.176***	0.248***	0.243***	0.144**	0.237***	-0.148**	-0.156**
	(4.43)	(5.81)	(4.31)	(4.14)	(5.18)	(2.19)	(5.33)	(-2.41)	(-2.38)
N	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445	20,445
adj. R^2	0.912	0.190	0.913	0.863	0.877	0.766	0.887	0.503	0.489
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Economy-Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

FE=fixed effects
Source: Authors' calculations.

In table A2, we report the economy-level averages for both the financial market measures and the raw innovation measures. We report the time-series averages of the financial market proxies and the pooled averages of the raw innovation measures for each economy in the sample period of 1997 to 2016. In particular, *Equity* is the stock market capitalization of listed domestic companies over gross domestic product (GDP). *Debt* is the outstanding domestic private debt securities to GDP. *Bank* is the private credit by deposit money banks and other financial institutions to GDP. *Patent** is the number of patents that are ultimately granted and assigned to companies or individuals by the USPTO before March 2019. *Patent_Small** (*Patent_Large**) is the number of such patents filed by small (middle or large) entities. *Top75_Citation** is the number of such patents of which the total number of citations received is in the upper 75% of all the patents filed in the same patent class-year. *Top75_Claim** is the number of such patents of which the total number of independent claims is in the upper 75% of all the patents filed in the same patent class-year. For each patent, *Citation** is the number of forward citations received adjusted by the median number of citations received by all the patents in the same class-filing year. *Claim** is the sum of the number of independent claims filed adjusted by the median number of independent claims of patents in the same class-filing year. *Originality** (*Generality**) is the Herfindahl index following Hall, Jaffe, and Trajtenberg (2005).

APPENDIX 2: VARIABLE DEFINITIONS

	Definition	Source
Panel A: Financial Market		
Equity (% of GDP)	The stock market capitalization of listed domestic companies over GDP.	The WDI/GDF database
Debt (% of GDP)	The outstanding domestic private debt securities to GDP.	
Bank (% of GDP)	The private credit by deposit money banks and other financial institutions to GDP.	
Bank_pure (% of GDP)	The private credit provided by deposit money banks over GDP.	
Credit_Finance (% of GDP)	The ratio of domestic credit provided by the finance sector over GDP.	
Credit_all (% of GDP)	All domestic credit to the private sector over GDP.	
Non-Bank (% of GDP)	The difference between Credit_Finance and Bank.	
Panel B: Innovation		
Patent*	The number of patents that are ultimately granted and assigned to companies or individuals by the USPTO before March 2019.	The USPTO filings for Patent Grants
Patent_Small*	The number of patents filed by small entities.	
Patent_Large*	The number of patents filed by middle or large entities.	
Top75_Citation*	The number of patents of which the total number of citations received is in the upper 75% of all the patents filed in the same patent class-year.	
Top75_Claim*	The number of patents of which the total number of independent claims is in the upper 75% of all the patents filed in the same patent class-year.	
Citation*	The number of forward citations received adjusted by the median number of citations received by all the patents in the same class and the same filing year.	
Claim*	The total number of the independent claims filed adjusted by the median number of independent claims of patents in the same class-filing year.	
Originality*	The Herfindahl index following Hall, Jaffe, and Trajtenberg (2005).	

Generality*	The Herfindahl index following Hall, Jaffe, and Trajtenberg (2005).	
	Panel C: Macro-Characteristics	
GDP_g	The annual growth rate of GDP for economy i at time t.	The WDI database
Population_g	The annual growth rate of population for economy i at time t.	
Labor (% of GDP)	The number of labor force over the population within 15 and 64 ages.	
Export (% of GDP)	The export of goods and services over GDP.	
R&D	The research and development expenditure over GDP.	
Export_US	The portion of export received by the US that is provided by economy i.	The United Nations Commodity Trade Statistics database
High_Income	A dummy that is set to one if economy i is categorized in the high-income group by the World Bank and zero otherwise.	The World Bank

GDP = gross domestic product, R&D = research and development, US = United States.
Source: Authors.

APPENDIX 3: THE LIST OF DEVELOPING ASIAN ECONOMIES

Following the Asian Developmenbt Bank, Developing Asian economies consists of the following 45 economies, which are in five subregions:

1. Central Asia comprises Armenia, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan.
2. East Asia comprises Hong Kong, China; Mongolia; the People's Republic of China; the Republic of Korea; and Taipei,China.
3. South Asia comprises Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.
4. Southeast Asia comprises Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Viet Nam.
5. The Pacific comprises the Cook Islands, the Federated States of Micronesia, Fiji, Kiribati, the Marshall Islands, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.