Financial Architecture and Innovation

Access to finance is indispensable for innovative activity, which is inherently costly, risky, and subject to a great deal of uncertainty.[10] There is almost no way of knowing beforehand whether a particular innovation will turn out to be commercially successful. It is even more difficult to predict whether an innovator can turn his vision into a viable reality. In addition, not even the greatest inventions could take off in the absence of financing. For example, while we associate Apple with Steve Jobs, the iconic tech giant would never have made it without the bold, high-risk investment of Mike Markkula, an angel investor who provided critical seed money and managerial support during Apple's embryonic phase. A sound and efficient financial system that can channel resources to would-be innovators is a crucial component of a viable innovation environment.

In this special chapter, we take a closer look at the link between finance and innovation using cross-economy empirical analysis. We delve into the issue of whether financial intermediaries (e.g., banks) or capital markets (e.g., equity markets) are more conducive to innovation. The details of our empirical analysis are outlined in **Box 6**. There are strong conceptual grounds for why financial architecture matters for innovation. Intuitively, capital markets are better at dealing with risk and uncertainty than banks, which tend to be more conservative. But innovative activity is inherently full of risk and uncertainty. This is why capital markets are likely to matter more for innovation than banks.

Given the widely varying levels of economic development across developing Asia, we also examine whether an economy's income level affects our analytical comparison of intermediaries versus markets.[11] Although the region's financial system has historically been bank-centered, capital markets have expanded rapidly in recent decades and now play a large and growing role in financing. There is also a wide variation in financial development and maturity among the region's economies, ranging from global financial centers such as Hong Kong, China and Singapore to less developed economies with rudimentary capital markets.

The baseline results show that financial structure matters disproportionately to the innovation of an industry in an economy for the full sample of 47 economies from 1997 to 2016. In particular, we find that market-based financial systems, as represented by both the equity market and debt market, have a positive and significant effect on the quantity of innovation, as measured by the number of patents granted. The results of additional analysis indicate that the equity and debt markets also have a positive and significant effect on the quality of innovation, as measured by citation-based quality metrics and claim-based quality metrics. However, intermediary-based financial systems (i.e., banks) fail to encourage innovation and even lower the quality of innovation.

Additional analysis explores whether financial architecture matters differently for small versus large firms. To the extent that some small firms eventually grow into large firms, we can interpret size as a proxy for a firm's development stage. We find that even though the positive effect of a market-based financial system holds for both types of firms, only an equity-based financial system can improve the innovation of small firms. In contrast, a more developed debt market impedes the innovation of small firms but contributes to the innovation of large firms.

The final analysis examines whether financial system architecture matters differently for economies with different levels of national income. High-income and low-income economies are significantly different in their financial architecture, economic growth, and innovation. These differences raise the question of whether it is appropriate to apply a one-size-fit-all approach in analyzing the finance–innovation link. We find that compared to innovation in low-income economies, innovation in high-income economies is more likely to benefit from a market-based financial system and to be impeded by an intermediary-based financial system. In addition, we find that while the development of the equity market benefits the innovation of small firms in both types of economies, it impedes the innovation of large firms in low-income economies. In contrast, large

[10] This theme chapter is a revised version of Z. Huang and X. Tian. 2020. Does One Size Fit All? Financial Architecture and Innovation in the 21st Century. Background paper prepared for the *Asian Development Outlook 2020*. https://www.adb.org/documents/asian-development-outlook-2020-background-papers.

[11] Developing Asia comprises the 46 developing member economies of the Asian Development Bank.

Box 6: Econometric Analysis of the Relationship between Financial Architecture and Innovation

We collected innovation and financial architecture information for 47 economies with mixed financial structures and at least one patent granted by the United States Patent and Trademark Office (USPTO).[a] We also collected annual financial market development data and other economy-level information from the World Bank's World Development Indicators and Global Financial Development databases. Since our goal was to compare the degree of innovation in different types of financial system architecture, we restrict their sample to the period 1997–2016 for economies with mixed financial architecture and at least one patent granted by the USPTO as of March 2019. The result is a sample of 47 economies that includes both developed economies such as Canada, Japan, and the United Kingdom, as well as emerging economies such as Brazil and the People's Republic of China.

The quantity of innovation is measured by the number of patents in a two-digit US standard industrial classification industry *j* that are applied in year *t* and eventually granted and assigned to individuals or nongovernmental institutions from economy *i*. We follow the classification of the USPTO and construct Patent_Small as the number of patents filed by small entities and define Patent_Large to capture the rest. We also measure the quality of innovation based on the innovativeness and exclusiveness of patents, proxied by the numbers of citations and independent claims. Financial architecture is captured by the proxies for the level of development of the equity market, private debt market, and financial intermediaries such as deposit money banks and other financial institutions. All the proxies are divided by an economy's gross domestic product.

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 both innovation and the development of the financial system. The summary statistics suggest that both the equity market and the intermediary-based financial system are important for the economies in our sample since both occupy a larger portion of gross domestic product than that of the debt market on average.

The main obstacle that hinders any empirical attempt to study the causal effects of financial development on technological innovation is the potential for endogeneity resulting from reverse causality. In this context, the reverse causality concern is really about whether innovation, an important factor for economic growth, renders disproportional changes to the structure of the financial system. We attempt to deal with this endogeneity problem by using a panel-based, fixed-effects approach that has been widely adopted. 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.

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

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

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 a 1-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 an 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 to further mitigate the variation of common trends in the economy over time. Following practice in 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.

Table B6 reports the baseline results for a test of the relationship between financial architecture and the quantity of innovation, measured by the number of patents granted. The table only reports the results for the three variables of interest: equity, debt, and bank.

Table B6: Financial Architecture and Innovation

	Relative Number of Patents			
Equity	0.017*** (2.74)			0.030*** (5.20)
Debt		0.041*** (4.10)		0.047*** (3.36)
Bank			0.008 (0.40)	−0.020 (−0.81)
N	28,841	20,445	28,761	20,445
adj. R^2	0.912	0.912	0.912	0.912

Notes: *** indicate statistical significance at the 1% level. The numbers in parentheses represent t-statistics.
Sources: Authors' calculations.

[a] This box is a revised version of Z. Huang and X. Tian. 2020. Does One Size Fit All? Financial Architecture and Innovation in the 21st Century. Background paper prepared for the *Asian Development Outlook 2020*. https://www.adb.org/documents/asian-development-outlook-2020-background-papers.

firms in low-income economies are more likely to benefit from an intermediary-based financial system than a market-based one.

The primary focus of this special chapter was empirical analysis of the effect of financial architecture (i.e., banks and other financial intermediaries, debt markets, and equity markets) on innovation quantity and quality. However, as much as finance can affect innovation, innovation can also affect finance. Financial technology, or the integration of new technology and financial services, is currently reshaping the global financial landscape. Financial technology can potentially become a powerful agent for financial inclusion, which can contribute to inclusive growth. The financing modalities analyzed in this section are by no means complete or comprehensive. Precisely because innovation is an inherently risky and uncertain process, financing innovation has given rise to more specialized forms of financing modalities that are capable of mobilizing and allocating seed money. Silicon Valley is replete with sophisticated mechanisms for channeling risk capital, with venture capital being one well-known example.