THE RELATIONSHIP BETWEEN FINANCIAL DEVELOPMENT AND INNOVATION: EMPIRICAL EVIDENCE FROM SELECTED ASIAN COUNTRIES

Tuan Doanh Le[1], Duong Phuong Thao Pham[1], Tuan Bach Le[2]

[1]University of Economics Ho Chi Minh City, 59C Nguyen Dinh Chieu, Ward 6, District 3, Ho Chi Minh City, Vietnam
[2]Foreign Trade University, No.15, Street D5, Ward 25, District Binh Thanh, Ho Chi Minh city, Vietnam

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Abstract

This study extends research on the relationship between financial development (FD) and innovation by dividing FD into bank-based FD and stock-market-based FD and investigating their effects on innovation. The number of patent applications is used as a proxy for innovative activities, and the financial development of a country is measured by the development of the banking sector and the stock market. The study employs the two-step Generalized Method of Moments (GMM) to test the relationship using a panel data set in 25 various Asian countries in the period from 2000 to 2015. The development of the banking sector and the stock market increase the number of patent applications, but their interaction calculated by financial structure is not related to innovation. The finding indicates that the development of a financial system encourages innovation regardless of the difference in the development level between its components. The study provides more insights into the impact of financial market development on the domestically economic activities.

Keywords: financial markets, innovation, finance, generalized method of moments, Asian countries

INTRODUCTION

This study extends research on the relationship between financial development (FD) and innovation by dividing FD into bank-based FD and stock-market-based FD and investigating their effects on innovation. Innovation has long been known as an important element for sustaining the long-term economic growth and generating the competitive advantages (Solow, 1957; Romer, 1990; Grossman and Helpman, 1994; Pradhan *et al.*, 2016; Pradhan *et al.*, 2018). Nowadays, this view is even more supported due to the fierce competition of the globalized economy. It means that the innovation process must be considered as an obligate requirement in promoting a country's economy and the conceptions such as "repetition, similarity or traditional manner" should be limited to appear.

In the literature, the impact of financial markets on innovation is increasingly drawing scholars' interest. In particular, financial obstacles and market frictions are supposed to discourage innovation (Cabral and Mata, 2003;

Hyytinen and Toivanen, 2005; Mohnen *et al.*, 2008; García-Quevedo *et al.*, 2018). Therefore, it is worth lessening financial barriers and spurring the development of financial markets to stimulate innovation. Prior studies provide empirical evidence to support the association between financial markets and innovation (Holmstrom, 1989; Ginarte and Park, 1997; Fitzgerad, 2006; Kanwar and Evenson, 2009; Ang, 2010; Ang, 2011). Empirically, the well-functioning financial systems create opportunities for the innovative firms to access the external financing resources. Accordingly, the innovative products will be made with ease without the anxiety of capital mobilization under the support of the well–developed financial markets. Besides, the development of financial markets reinforces the power of intellectual property protection. In this way, scientists and researchers are motivated to generate new things.

Previous studies imply the possibility that the development of the banking sector and the stock market influence innovation (Grossman, 1976; Jensen and Murphy, 1990; Levine, 1991; King and Levine, 1993; Holmstrom and Tirole, 1993; Boot and Thakor, 1997; Allen and Gale, 1999; Levine, 2005; Bravo and Biosca, 2007; Brown *et al.*, 2009; Barbosa and Faria, 2011; Maskus *et al.*, 2012). In particular, bank-based FD leads to a higher level in corporate governance, risk management, monitoring costs and moral distortions, thereby likely affecting positively on innovation. Moreover, the development of stock markets brings several benefits to innovative activities such as having no requirements for collateral and rejecting noisy information. Hence, there seems to be a positive relationship between stock-market-based FD and innovation.

This study examines these hypotheses not only separately but also simultaneously in the Asian countries using data of financial markets and innovation from 2000 to 2015. The findings show that both bank-based FD and stock-market-based FD are positively associated with patent applications, but their interaction has no impact on innovation. The study supplements to the literature of the effects of financial markets on the development of an economy.

The remainder is structured as the following. Section 2 presents the background literature and hypothesis development. Section 3 describes data collection and methodology. Next, the findings are reported and discussed in Section 4. The study closes with conclusions in Section 5.

Literature review and hypothesis development

In a recent study, Kahn (2018) provides conceptions for understanding innovation in different ways. That is, innovation can be determined by three various things: an outcome, a process, or a mindset. Accordingly, there are different approaches to innovation. Furman *et al.* (2002) analyze the basic features of the innovation process by suggesting the definition of "national innovative capacity." Relying on this, other empirical studies observe that the difference in innovation among countries is affected by a country's total stock of knowledge or intellectual property protection rights. Moon *et al.* (2017) find that the higher education institutions (HEIs) are vital to innovation because they promote human capital development related to science and engineering fields, thereby having positive effects on the performance of innovative firms. Likewise, Spielman *et al.* (2008) argue that education and training have great influences on innovation. In another word, there is a positive correlation between education and innovation. Scientists are not only outputs of the education production function but also inputs in the knowledge production function (Griliches, 1998; Acs *et al.*, 2002). Thus, a science-oriented education system tends to increase innovative activities. Another advantage of getting a high-quality education is to generate a highly skilled and educated workforce, which, in turn, nurtures innovative ideas to develop later ones (Youtie and Shapira, 2008). Also, Varsakelis (2006) assumes that there is a significantly positive relationship between science-oriented education and innovation. Besides, he emphasizes the role of a nation's governance quality such as high accountability, political rights and low corruptions in encouraging the innovative activities. The findings indicate that the governance quality has a strongly positive impact on the innovative activities. Similarity, Fu (2008) contends that a country with the intellectual property rights protection and the well-formed legislation lure more foreign investors to innovative sectors. Therefore, countries which maintain the sustainable development of innovative activities usually concentrate on improving their governance quality via the rights of intellectual property protection (Ginarte and Park, 1997).

As mentioned by Barbosa and Faria (2011), a country's wealth is considered as a crucial element in nurturing the efficiency of activities related to innovation. When customers' income gets higher, their demand for the differentiated products,

especially innovative products, tends to get higher. There seems to be a relationship between innovation capacity and income. Teitel (1994) finds that per capita income is positively correlated with patenting activities. Romer (1994) also agrees that when customers get richer, the innovative firms have to accelerate the productivity of innovative products. Accordingly, the innovative firms have to generate a new invention to meet customers' need consecutively.

In the literature of innovation, there has been a growing interest in the impact of financial markets on innovative activities. Empirically, financial barriers and market imperfections deteriorate innovation. As investigated by García-Quevedo *et al.* (2018), the probability of abandoning an innovation project relies substantially on financial obstacles. Theoretical underpinnings for the relationship between financial barriers and the likelihood of failure of innovation projects can be traced back to the decade-old work of Mohnen *et al.* (2008). They demonstrate that facing financial constraints averts innovative firms from accomplishing innovation projects successfully. Moreover, Cabral and Mata (2003) offer a similar opinion that the failure of allocating capital to firms restrains the sustainable development of innovative activities and prevents them from reaching their optimal size. In addition, Hyytinen and Toivanen (2005) argue that the growth of firms' innovative activities in Finland is restrained by the imperfections of a financial market. The problems could be solved by the existence of well-developed banking sectors and stock markets (Merton and Bodie, 1995; Levine, 1997). In this way, mitigating financial barriers and market imperfections as well as developing financial markets might encourage innovation.

When a financial system is well – functioning, it plays a crucial role in allocating scarce resources, alleviating financing costs, managing risk and monitoring managers (Holmstrom, 1989). As a result, the innovative firms and government will have better access to financial resources, thereby leading to better patent protection (Ginarte and Park, 1997; Kanwar and Evenson, 2009). These findings assert that innovative activities are unable to develop without the protection of intellectual property rights. Fitzgerad (2006) argues that the financial mobilization supports the growth of innovative firms. Ang (2010, 2011) supports this opinion by indicating the importance of FD in mitigating the shortage of intellectual property rights protection to spur innovation. Schumpeter (1912) finds that financial development (FD) improves economic growth and technological innovation. The stock market and the banking sector are widely considered as the two primary components of financial systems. The purpose of this study is to provide more insights into the relationship between financial development and innovation. Therefore, the impact of stock-based FD and bank-based FD on innovation should be investigated separately and concurrently.

With regard to the association between bank-based FD and innovation, prior studies have found empirical evidence on the relationship. Bank-based FD allocates suitably and immediately capital to firms in general and innovative firms in particular (King and Levine, 1993; Morales, 2003; Acemoglu *et al.*, 2006). An important function of having a developed banking sector is to enhance corporate governance quality (Diamond, 1984; Ramakrishnan and Thakor, 1984). Boot and Thakor (1997) provides another finding in that a well – developed bank system lessens monitoring costs and moral hazard distortions. It also improves the quality of risk management (Allen and Gale, 1999). Barbosa and Faria (2011) pinpoint the relationship between credit-market-based FD and innovation. They find that FD promotes innovative activities due to the improvement of information sharing and the effective credit allocation to technology-based firms. Similarly, Maskus *et al.* (2012) conclude that the development of private credit by deposit money banks has considerably positive effects on research and development (R and D). These discussions lead to the possibility that the development of the banking sector might expedite innovative activities, as stated in the first hypothesis.

- H1: Bank-based FD is positively related to innovation.

  In addition to bank-based FD, stock-based FD has been documented as the crucial factor in encouraging innovation. Brown *et al.* (2009) report that the existence of a stock market creates many opportunities for investors to do innovative activities because there are no collateral requirements as a firm decides to finance them via the equity market. In other words, this helps innovative firms reduce the likelihood of the financial distress. Additionally, the stock market enables investors to extract the relevant yet noisy information from equilibrium prices (Grossman, 1976). Hence, the stock market could provide useful information when it comes to financing innovation. Other supporters of the stock-market-based FD also highlight the advantages of achieving a well–developed equity market for innovation such as minimizing

risk intertemporally (Levine, 1991), lowering information acquisition costs (Holmstrom and Tirole, 1993), and improving the quality of corporate governance (Jensen and Murphy, 1990). Besides, Maskus *et al.* (2012) find there is a significantly positive relation between stock-market-based FD and R and D intensity. Levine (2005) and Bravo *et al.* (2007) argue that the development of an equity market encourages investors to shift their portfolios toward innovative projects. Kim *et al.* (2016) point out that the equity financing plays a critical role in developing the technological innovation activities (TIA) of Korean companies. With these arguments, the second hypothesis can be expressed as:

- H2: Stock-market-based FD is positively related to innovation.

Both the banking sector and stock market development occur to foster liquidity, mitigate risk exposures, enhance corporate controls, and minimize market frictions (Merton and Bodie, 1995; Levine, 1997). Their interaction results in the complementarity or the substitutability, which, in turn, affect the development of an economy. Garcia (1973) indicate that bank-based FD and stock-market-based FD are negatively correlated while Garcia and Liu (1999) state that the interaction between the development of the banking sector and the stock market stimulates economic activities. However which one is predominant has still been controversial. These arguments seem to support the effect of the interaction between bank-based FD and stock-market-based FD on innovation, one of the most important economic activities. Further more, previous work has only focused on the separate impact of components of FD on innovation. Empirical studies of the effect of the interaction between stock-market-based

I: *Variables and Sources*

Variables	Sources	Expression	Expression after adjustment
Patent applications	World Development Indicators Database	patent	lpatent
R and D expenditure	World Development Indicators Database	rdexpend	lrdexpend
Real GDP per capita	World Development Indicators Database	gdpcap	lgdpcap
Education	Education Statistics – All Indicators Database	education	education
Governance	Worldwide Governance Indicators Database	governance	governance
Financial structure	Global Financial Development Database	fd_structure	dfd_lstructure
Private credit by deposit money banks to GDP	Global Financial Development Database	fd_bank	dfd_lbank
Deposit money bank assets to GDP	Global Financial Development Database	fd_asset	dfd_lasset
Bank credit to bank deposits	Global Financial Development Database	fd_deposit	dfd_ldeposit
Private credit by deposit money banks and other financial institutions to GDP	Global Financial Development Database	fd_credit	dfd_lcredit
Stock market capitalization	Global Financial Development Database	fd_stock	dfd_lstock
Stock market value traded	Global Financial Development Database	fd_trade	dfd_ltrade
Stock market turnover	Global Financial Development Database	fd_turnover	dfd_lturnover
Stock market depth	Global Financial Development Database	fd_depth	dfd_ldepth

Source: Own summarization

FD and bank-based FD on innovation are very limited. These arguments result in the final hypothesis as follows:

- H3: The interaction between bank-based FD and stock-market-based FD is significantly related to innovation.

MATERIALS AND METHODS

Collecting And Selecting Sample Data

This study uses a data sample of 14 variables on the scale of 25 selected Asian countries in the period from 2000 to 2015. Due to data limitation and requirements of having stock markets in selected countries, this study ends up with a panel data covering 25 economies: Armenia, China, Cyprus, Georgia, India, Indonesia, Iran, Israel, Japan, Jordan, Kazakhstan, Korea, Kyrgyzstan, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Russia, Saudi Arabia, Singapore, Sri Lanka, Thailand, Turkey and Vietnam. The data are retrieved from the World Bank Open Data (WBOD). In addition, most of the variables in the models are adjusted to be in logarithmic form except "education" and "governance" due to their minor volatility in value (Tee *et al.*, 2014). Since the effect of FD on patent applications is only observed with delays, this study applies a 1−year lag on all measurements related to FD variables. Specifically, all research variables are summarized in Tab. 1 below.

Describing And Measuring Variables

Innovation Activity Measures

According to the World Intellectual Property Organization (WIPO), a patent is an exclusive right granted for an invention which refers to a new way of implementing something or a new-fangled technological solution to a predicament. Hence, the number of patent applications is considered as a reliable proxy for the flow of new knowledge in general and innovative outputs in particular (Kortum, 1993; Griliches, 1998; Acs *et al.*, 2002; Varsakelis, 2006). Therefore, this study employs patent applications in logarithmic form (lpatent) as the dependent variable which represents innovative activities.

Fd Measures

This study separates FD variables into three main groups which proxies for bank-based FD, stock-market-based FD, and their interaction. First, bank-based FD (dfd_lbfd) is measured via four indicators expressed in logarithmic form: private credit by deposit money banks to GDP (dfd_lbank); deposit money bank assets to GDP (dfd_lasset); bank credit to bank deposits (dfd_ldeposit); private credit by deposit money banks and other financial institutions to GDP (dfd_lcredit) (Levine and Zervos, 1998; Levine, 2002; Beck and Levine, 2004; Beck *et al.*, 2010). Second, stock-market-based FD (dfd_lsmfd) is determined by four indicators expressed in natural logarithm (Levine and Zervos, 1998; Levine, 2002; Beck and Levine, 2004; Beck *et al.*, 2010). The first one is the stock market capitalization to GDP (dfd_lstock) which represents the total value of all listed shares expressed as a percentage of GDP. Stock market value traded (dfd_ltrade) is the second element which is defined as the total value of all traded shares expressed as a percentage of GDP. The third one is the stock market turnover (dfd_lturnover). It proxies for the total value of shares traded divided by the average market capitalization. While dfd_ltrade measures the value of shares transactions in relation to the size of an economy, dfd_lturnover computes the similar value but in relation to the size of stock markets. Besides, dfd_lturnover generally measures the trading volume of the stock markets (Tee *et al.*, 2014). Stock market depth (dfd_ldepth) is the final component in measuring stock market-based FD. It is mentioned as a better indicator of stock market liquidity than dfd_lturnover (Amihud, 2002). The reasons can be found at dfd_lturnover, particularly its dismissal of trading volume on stock prices. When the volume of traded shares gets higher, the price volatility reaches a stronger level as well. In this circumstance, dfd_ldepth appears to deal with the price swings that occur on high trading volume by dividing the trading volume with the standard deviation of stock market returns (Tee *et al.*, 2014). In this study, the trading volume is replaced by stock market turnover ratio according to Daouk *et al.* (2006).

Third, relying on Tee *et al.* (2014), Levine (2002) and Beck *et al.* (2010), the interaction of FD components (dfd_liofd) is determined by financial structure (dfd_lstructure), this element is established by dividing dfd_lbank by dfd_lstock. Levine (2002) and Beck *et al.* (2010) suggest that FD is more dependent on the banking sector if the value of dfd_lstructure gets higher.

Control Variables

Besides the primary variables related to FD and innovation, this study also constructs the four following control variables that affect innovative

activities. First, R and D expenditure (lrdexpend) is employed to present gross domestic expenditures on R and D, expressed as a percentage of GDP. Teitel (1994) argues that R and D expenditure spurs innovative activities because it creates more great opportunities to invent new things. Second, that is real GDP per capita converted to international dollars using purchasing power parity (PPP) rates, expressed as lgdpcap. This indicator is a proxy for the level of a country's wealth, and it is expected to cause an increase in the quality of inventive activities (Romer, 1994). The third control variable is the ratio of the total number of students enrolled at both public and private tertiary education institutions divided by the population of the relevant age group. This one represents a country's knowledge expressed as "education". Griliches (1998), Acs *et al.* (2002) and Moon *et al.* (2017) provide empirical evidence on the positive relationship between education and a country's innovative capacity. Finally, according to Kaufmann *et al.* (2011), the governance quality of a country expressed as "governance" is also taken into consideration. It is evaluated by a range of scores from –2.5 to a maximum of + 2.5. The higher values mean better governance quality. These scores are calculated from the average value of the six following dimensions of governance: corruption control, government effectiveness, political stability and the absence of violence/terrorism, regulatory quality, law, voice, and accountability. Varsakelis (2006) and Fu (2008) find that innovative activities have more incentives to foster in a country with a well–developed governance mechanism.

Research Model

As discussed in the introduction and hypothesis development section, this study proposes to divide the analyses into three empirical models below:

$$lpatent_{it} = \beta_0 + \beta_1 dfd\_lbfd_{\_it-1} + \beta_2 lrdexpend_{it} + \beta_3 lgdpcap_{it} + \\ + \beta_4 education_{it} + \beta_5 governance_{it} + \alpha_i + u_{it} \quad (1)$$

$$lpatent_{it} = \beta_0 + \beta_1 dfd\_lsmfd_{it-1} + \beta_2 lrdexpend_{it} + \beta_3 lgdpcap_{it} + \\ + \beta_4 education_{it} + \beta_5 governance_{it} + \alpha_i + u_{it} \quad (2)$$

$$lpatent_{it} = \beta_0 + \beta_1 dfd\_liofd_{it-1} + \beta_2 lrdexpend_{it} + \beta_3 lgdpcap_{it} + \\ + \beta_4 education_{it} + \beta_5 governance_{it} + \alpha_i + u_{it} \quad (3)$$

where $i = 1,...,N$ captures countries and $t = 1,...,T$ captures the years; β are the vectors of the estimated coefficients; α is the unobserved country heterogeneity and u denotes idiosyncratic disturbances.

Equation (1) investigates the link between bank-based FD and patent applications. Next, equation (2) analyzes the association between stock-market-based FD and the number of patent applications. Finally, equation (3) examines the effects of the interaction of FD components on patent applications. All of these equations above are structured to expect that there are positive impacts of the bank- and stock–market-based FD along with its mutual interaction on patent applications.

Research Method

This study employs panel data analysis to investigate how FD affects innovation-related activities. As to a panel data, the Fixed Effects Model (FEM) and Random Effects Model (REM) dominate the pooled Ordinary Least Squares (OLS) since they can control the influence of country-specific characteristics on explanatory variables. However, they fail to deal with the problem of endogeneity. In this regard, Arellano and Bover (1995) suggest that Generalized Method of Moments (GMM) method not only solves the heterogeneity issues but also copes with the autocorrelation in the time series and the problem of endogenous variables in the model. The two-step GMM regression is employed to deal with the dynamic panel data formed from imposing a 1-year lag on all FD-related-variables. The Arellano-Bond serial correlation tests (AR(1) and AR(2)) and Hansen test are used to test for the validity of the instruments (Arellano and Bond, 1991; Baum, 2003). Accordingly, endogenous variables are instrumented with GMM-style instruments. Specifically, the lags of the endogenous vaiables are used as instruments. The number of groups are the one of countries. Notably, they probably differ among different models due to the difference in the information availability of the variables and the process of the instrument selection. Technically, Mileva (2007) suggests that the rule of thumb for GMM regression is to keep the number of instruments less than or equal to the number of groups. Otherwise, it could cause the Hasen test to be weak. Also, the AR(2) test is more important than the AR(1) test in the verification of the serial correlation test.

Empirical Analyses

Descriptive Statistics

As is shown in Tab. II, descriptive statistics for key variables provide some highlights. First, while patent applications (patent) on average are 32,000

II: *Descriptive statistics from 2000–2015*

Variables	Obs	Mean	Std. Dev.	Min	Max
patent	400	31728.53	104421	2	968252
rdexpend	400	0.861372	1.107386	0.04233	4.40546
gdpcap	400	15568.9	15164.53	1220.425	86139.09
education	384	38.35887	21.29873	2.730151	99.66034
governance	400	–0.1362316	0.681337	–1.23232	1.592235
fd_size	400	108.5174	81.88417	4	370.61
fd_activity	400	2649.851	4085.698	0.1314	32519.45
fd_structure	400	5.014417	15.73793	0.210325	123.7561
fd_bank	400	59.38167	46.18814	3.74	260.7
fd_asset	400	71.8467	51.11368	4.21	260.7
fd_deposit	400	123.2341	111.4067	37.12	879.66
fd_credit	400	64.04677	51.1708	3.74	260.7
fd_stock	400	49.24105	50.8775	0.1	259.61
fd_trade	400	33.74127	45.74265	0.01	331.27
fd_turnover	400	66.3264	86.28074	0.15	632.44
fd_depth	320	2.770232	3.025816	0.018799	16.74429

Source: Own processing

(rounded to the nearest 1,000), the highest number of patent applications reaches up to 968,252, significantly higher than the mean value. These numbers prove that there are a few countries in the selected data sample have the advantage of the patent. Second, the only negative value in Mean column goes to governance with the value of -0.14. Such number indicates the majority of selected countries get negative points in evaluating their governance quality. Hence, the governance systems in these countries are not well–functioning, consistent with Kaufmann et al. (2011). The last striking thing is from the financial structure indicator (fd_structure) with the average value of 5.01 that is higher than 1. A conclusion can be claimed is that FD of most of the selected Asian countries is more reliant on the banking sector rather than the stock market.

RESULTS

Tab. III shows the results of the link between bank–based FD and patent applications. The findings occur as expected in H1: all models (from model 1 through model 4) show that measures of the development of a bank system have a positive influence on patent applications. Specifically, the coefficients of dfd_lbank, dfd_lasset, dfd_ldeposit, and dfd_lcredit are 0.31; 0.41; 0.88; 0.37 respectively, which are significant at the conventional levels. The results indicate that the more developed a country's banking system is, the higher a quantity of innovative outputs gets. In addition, control variables representing the expenditures for R & D, a country's wealth (lgdpcap), education and governance are also related positively to the number of patent applications.

As reported in Tab. IV, all four indicators measuring stock-market-based FD (Model 5 through 8) encourage the number of patent applications, which support H2. The coefficients of dfd_lstock, dfd_ltrade, dfd_lturnover, and dfd_ldepth are 0.45; 0.21; 0.57; 0.63 respectively, which are all significantly positive. Again, the expenditures on R and D, the quality of governance and the tertiary education are positively related to patent applications. However, the study does not find the statistically significant relationship between a country's wealth and patent applications.

Tab. V presents the findings of the effect of the interaction of the FD components on the number of patent applications. The result of model 9 does not support H3. The interaction between bank-based FD and stock-market-based FD expressed as financial structure (dfd_lstructure), is not related to patent application numbers. Along with the findings mentioned above, the result implies that the development of

III: *The link between Bank–Based FD and Patent Applications*

	Model 1	Model 2	Model 3	Model 4
Constant	–3.153769 (–2.34)	0.4380629 (0.41)	–6.367405 (–3.53)	4.534926 (3.70)
lrdexpend	–0.1274734 (–1.61)	–0.1042874 (–1.25)	0.2801064*** (4.08)	0.2411587*** (3.92)
lgdpcap	0.8139686*** (3.65)	0.3863564*** (2.65)	0.9337755*** (4.07)	–0.0552442 (–0.37)
education	0.0268151* (1.86)	0.0358486*** (4.90)	0.0251953** (2.44)	0.0478243*** (7.22)
governance	–0.3290736 (–0.72)	0.7008041** (2.22)	0.2047804 (0.49)	0.7988436*** (4.09)
dfd_lbank	0.3146047** (2.31)			
dfd_lasset		0.4056697** (2.2)		
dfd_ldeposit			0.8799281*** (3.52)	
dfd_lcredit				0.368317** (2.48)
Number of instruments	23	23	21	24
Number of groups	24	24	24	24
Arellano–Bond test for AR (2)	0.543 (0.61)	0.612 (0.51)	0.63 (0.48)	0.524 (0.64)
Hansen test	0.47 (16.76)	0.491 (16.47)	0.485 (14.55)	0.497 ([17.39)

Source: Own processing
z–statistics shown in the parentheses, Chi–square statistics depicted in square brackets, *, **, and *** indicate significance at the 10 %, 5 %, and 1 % levels respectively.

IV: *The link between Stock–Market–Based FD and Patent Applications*

	Model 5	Model 6	Model 7	Model 8
Constant	4.463806 (2.09)	4.882954 (1.79)	4.620695 (3.46)	6.721994 (1.69)
lrdexpend	0.0080221 (0.12)	0.0417449 (0.42)	0.2598456*** (3.61)	0.3551981*** (3.91)
lgdpcap	–0.1380574 (–0.49)	–0.0022061 (–0.01)	–0.1619923 (–1.05)	–0.1827371 (–0.38)
education	0.0568817*** (6.31)	0.042653* (1.95)	0.0464303*** (10.81)	0.0462086*** (3.74)
governance	0.4862829** (2.24)	0.9284253** (2.27)	0.5441595** (2.38)	–0.0682881 (–0.20)
dfd_lstock	0.4456125*** (3.56)			
dfd_ltrade		0.210022*** (2.94)		
dfd_lturnover			0.5685627*** (8.66)	
dfd_ldepth				0.6327138*** (12.33)
Number of instruments	24	22	24	19
Number of groups	24	24	24	19
Arellano–Bond test for AR (2)	0.652 (–0.45)	0.847 (0.19)	0.716 (0.36)	0.446 (–0.76)
Hansen test	0.386 (19.10)	0.486 (15.54)	0.232 (22.01)	0.300 (15.12)

Source: Own processing
z–statistics shown in the parentheses, Chi–square statistics depicted in square brackets, *, **, and *** indicate significance at the 10 %, 5 %, and 1 % levels respectively.

V: The link between the Interaction of FD Components and Patent Applications

	Model 9
Constant	3.673951 (1.54)
lrdexpend	0.0221758 (0.3)
lgdpcap	0.1609822 (0.6)
education	0.0473772*** (5.25)
governance	0.6196042** (2.2)
dfd_lstructure	–0.2175859 (–1.39)
Number of instruments	23
Number of groups	24
Arellano–Bond test for AR (2)	0.878 (–0.15)
Hansen test	0.378 [18.17]

Source: Own processing
z–statistics shown in the parentheses, Chi–square statistics depicted in square brackets, *, **, and *** indicate significance at the 10 %, 5 %, and 1 % levels respectively.

financial systems creates many advantageous conditions to spur innovative activities without being concerned about the development level of its components. Additionally, while tertiary education and the quality of governance are found to have a significant impact on innovation, the expenditures on R and D and a country's wealth are irrelevant to innovation.

CONCLUSION

This study provides cross-country empirical evidence about the impact of FD on innovative activities in the period of 16 years from 2000 to 2015. The findings show that both bank-based FD and stock-market-based FD have positive effects on patent applications, which is broadly consistent with the arguments of previous studies (King and Levine, 1993; Morales, 2003; Levine, 2005; Acemoglu *et al.*, 2006; Bravo and Biosca, 2007; Brown *et al.*, 2009; Barbosa and Faria, 2011; Maskus *et al.*, 2012; Kim *et al.*, 2016; other studies). However, their interaction has no impact on innovation. Taken together, the development of the financial system encourages innovation regardless of whether bank-based FD or stock-based FD is predominant. The study adds to the body of research on the relationship between financial markets and the development of an economy, providing a profound understanding of the influence of the development of financial markets on the economic activities. Thus, the findings could be of interest to regulators in considering financial systems reforms. Furthermore, the study is conducted on the scale of 25 different Asian countries excluding the ones without the stock market. Therefore, the country-specific characteristics in financial systems are not taken into consideration in depth. Therefore, the association between the specific features of a financial system and innovation would be an interesting topic for future research.

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Contact information

Tuan Doanh Le: doanhle81.k40@st.ueh.edu.vn
Duong Phuong Thao Pham: pdpthao@ueh.edu.vn
Tuan Bach Le: letuanbach.cs2@ftu.edu.vn