The Impact of Financial Development on Innovation

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ABSTRACT

Being a driver of technological innovation and an indicator of economic growth, the theme of financial development is studied widely, arguing that a well-developed financial system mobilizes capital for growth. However, the literature on the subject issue is limited to panel data studies. Also, results vary across countries having different economic and financial structures. Therefore, this thesis is aimed to empirically examine the relationship between financial sector development and innovation patent application in Bangladesh over the period 1980-2018. The thesis used auto- regressive distributive (ARDL) lag to quantify the subject relationship, with the number of innovation patent applications as the dependent variable that measures the country's innovation performance. Results of ARDL indicate that financial sector development indicators both banking and non-banking have a positive relationship with the number of innovation patent applications in Bangladesh in the long run. However, this thesis found that secondary level education is not contributing to innovation. Therefore, the country should focus on their higher education and technical education and build an effective regulatory capital framework that can help resolve market failure and strengthen the whole financial infrastructure and innovation practices in the country as a result.

Keywords: financial development, inovasyon patent başvurusu, ARDL.

ÖZ

Teknolojik yeniliğin itici gücü ve ekonomik büyümenin bir göstergesi olan finansal gelişim, iyi gelişmiş bir finansal sistemin büyüme için sermayeyi harekete geçirdiği tartışılarak geniş çapta incelenmiştir. Ancak konuyla ilgili literatür panel veri çalışmaları ile sınırlıdır. Ayrıca sonuçlar, farklı ekonomik ve finansal yapılara sahip ülkeler arasında farklılık gösterir. Bu nedenle, bu tezde 1980-2018 döneminde Bangladeş'te finans sektörünün gelişimi ile inovasyon arasındaki ilişkinin ampirik olarak incelenmesi amaçlanmıştır. Tez, ülkenin inovasyon performansını ölçen patent başvurularının sayısı ve finansal gelişim ilişkisini ölçmek için dağıtılmış gecikmeli otoregresif model (ARDL) yöntemini kullanmıştır. ARDL sonuçları hem bankacılık hem de bankacılık dışı finansal gelişim göstergelerinin uzun vadede Bangladeş'teki inovasyon patent başvurularının sayısı ile pozitif bir ilişkiye sahip olduğunu göstermektedir. Ancak bu tez, orta öğretim düzeyinin yeniliğe katkıda bulunmadığını ortaya çıkarmıştır. Bu nedenle ülke, yüksek öğrenim ve teknik eğitiminin gelişimine odaklanmalıdır. Bunun yanında piyasa başarısızlığını çözmeye yardımcı olabilecek finansal altyapıyı ve yenilik uygulamalarını güçlendirmeye yardımcı olabilecek etkili bir düzenleyici sermaye çerçevesi oluşturmalıdır.

Anahtar Kelimeler: finansal gelişme, inovasyon patent başvurusu, ARDL.

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INTRODUCTION

1.1 Study Background

Bangladesh's firms and institutions are lagging behind their counterparts in India, Vietnam and Sri Lanka when it comes to invention and protection of intellectual property owing to inadequate research, investment and awareness. The Department of Patents, Designs & Trademarks (DPDT) granted patents for 106 inventions in 2016 out of 344 applications submitted by local and foreign firms. Of the approved, only seven were local patents. In 2015, the state-run intellectual property rights authority approved 101 patent applications, of which 11 were local. In the same year, 1,388 products or inventions were patented in Vietnam and 6,022 in India, according to the World Intellectual Property Organization. The low number of patents is a symptom of weakness of our economy as higher number of patents reflects that an economy is on track of innovations.

Though initially nurturing and encouraging innovation seems complicated, but once it happens, it proves very dynamic to long-term economic growth and the creation of competitive advantage (Solow, 1957). Moreover, the whole process of innovation not only to be distinctive, long, and volatile, but the chances of failure are also very high (Holmstrom, 1989). Joseph Schumpeter is the first scholar who discusses the matter of innovations in economic growth extensively. What he argues can be narrated as "capitalism can only be understood as an evolutionary process of continuous

innovation and creative destruction." In line with the Schumpeterian theory of growth, Porter (1992) maintains that a sustainable innovation in a country's business environment is a must for competitive advantage and effective competition in international markets. Therefore, what contributes to the up-gradation and innovation is the constant investment in physical and human capital.

In the wake of the aforementioned reservation, a well-functioning financial market is required to promote innovation successfully. This well-functioning financial market, according to Schumpeter (1911) is critical for a nation's innovation in the sense that it plays multiple roles ranging from reduction in financing costs to evaluation of innovative projects, allocation of scarce funds, and risk management. Increasing empirical evidence maintained that technological advancement drives economic growth. Also, Aayale (2016) emphasized that it is the innovative capacity that drives economic growth and not the capital accumulation asserted by the neoclassical economists.

There are two mechanisms through which financial market development and financial institutions help improve innovation. One most crucial function of the financial market is that it helps overcome the problem of adverse selection and moral hazard. The lesser the problem of adverse selection and moral hazard, the lesser will be firms' external capital cost. Moreover, countries with more developed financial markets and industries that rely more on external finance can become more innovative. Also, high-tech industries in countries with developed financial markets innovate more than countries where financial market development is underway. As the developed financial market has the ability to diversify the risk and provide credit, high-tech industries usually undertake more innovative and risky projects that involve long and intensive research

processes before final production. The second mechanism/channel that examines the finance and innovation literature examines several strategies for promoting innovation. In this regard, Manso (2011) identifies the managerial contracts though not suitable for motivating innovation in the short run but best suited in the long run. According to Ferreira et al. (2014), it is private ownership that spurs innovation and not necessarily public ownership. Moreover, innovation could be promoted through the "hot" financial market instead of "cold ".

Literature suggests that a well-established financial system is vital for economic growth and attracts foreign investment, poverty eradication, and overall development of the economy. Regarding indicators including financial intermediation and expansion of financial services, numerous studies identified that developed financial system positively affects economic growth and, in fact, stimulates the increase of output (Beck & Levine, 2004). Although financial stability is directly related to the progress of macroeconomic stability, the positive spillover effect of a well-established financial system on economic growth is transmitted indirectly. According to Levine (2005), financial development first rightfully involves the resource allocation that allows allocating the funds to risky, innovative projects and increasing productivity and economic growth.

According to Schumpeter (1911), financial market development plays a crucial role in the country's technological innovation. However, empirical studies in single country frameworks investigating the relationship between financial market development and technological innovation are scant.

Our contribution to the innovation and financial development nexus is three-fold. First, no study investigates the role of financial development on innovations patent application in a single country framework to the author's limited knowledge. This thesis will utilize the latest available data and examine the impact of financial development on innovation patent applications. Second, this thesis will also synthesize the role of other control variables (such as gross student enrolment rate, secondary education in percentage) in explaining innovation patent application. Third, this thesis will examine the subject relationship through the autoregressive distributive lag (ARDL) model, a dynamic co-integration relationship that can quantify the subject relationship both in the short run and in the long run.

1.2 Objectives of the Thesis

The specific objectives of the thesis are as follows:

- To investigate the role of financial sector development in explaining innovations patent applications in Bangladesh while utilizing a dynamic co-integration technique.
- To explore the role of capital market development along with banking sector development on innovation in Bangladesh while utilizing a dynamic co-integration technique.
- To analyze the role of gross student enrolment rate, secondary education in percentage in explaining innovation patent application in Bangladesh while utilizing a dynamic co-integration technique.
- To draw policy implications for all the stakeholders involved, donor agencies/consultants, academics, among others, to design measures for improvement in financial sector development in a developing country like Bangladesh to promote innovation in the country.

The rest of the thesis is structured as follows. Section 2 discusses the relevant literature addressing the finance-related determinants of innovations patent applications. Section 3 discusses the variables, their definition, data sources, and proposed econometric methodology. Section 4 provides a detailed explanation of results interpretation and discussion, while section 5 concludes the thesis and provides some policy implications.

Chapter 2

LITERATURE REVIEW

The relationship between innovation and financial sector development is very old, dating back to the 19th century. It was argued that a well-developed finance sector could help support the mobilization of capital and transfer of resources, which positively affects the growth outcomes (Bagehot, 1873). Also, well-adjusted banks and financial intermediaries play a significant role in innovation, as it guarantees the identification of profitable business plans and facilitates the development of new markets (Schumpeter, 1982). To acquire a competitive advantage to compete effectively in new market development, a permanent innovation of processes and practices needs time. Investment in physical and human capital is required to achieve this type of innovation (Porter, 1992). In this context, Schumpeter (1911) believed that a well-developed financial system is inevitable to spur growth through innovation patent applications.

Innovations are facilitated through financial services provided by a well-developed financial system, such as information facilitation and risk management. These services help reducing transaction costs and help the investor to invest in innovation-oriented risky projects having the long-run potential of profit (Levine, 1997; Gries et al., 2011). High and persistent economic growth in developed countries is made possible by developing technologies through capital accumulation from financial channels along with institutional cooperation with research centers and universities (Moguillansky,

2006). Therefore, a positive relationship between innovation and financial development is projected in advanced economies. However, developing countries are characterized by lower competitiveness for private innovation, lower government investment in innovation, and fewer research academic institutions. Therefore, these factors must be kept in mind while comparing the results of the impact of financial sector development on innovation in developed and developing countries (Aristizabal-Ramirez et al., 2017).

A plethora of literature exists to find evidence supporting the positive relationship between financial sector development and innovation activities. In this regard, De la Fuente & Marin (1996) conclude that investment that finances innovative activities positively influences economic growth while lowering informational difficulties. Similarly, according to Rajan & Zingales (1998), the more developed the financial system in a country is, the higher is the chances of the start-up of more young companies, therefore increasing the effect of finance on innovation and, in turn, enhanced economic growth (Allen et al., 2018; Igan et al., 2020). Innovations also help in lowering the production cost and increasing overall productivity (Tadesse, 2005). The findings of Tadesse (2005) suggest that the country's well-developed financial system positively affects technological progress and competitiveness. The study further reveals that the stronger the country's banking sector, the better its effect on productivity gain. Chava et al. (2017) find consistent results maintaining that the larger is the stock market, the better is the innovations and, as a result, the higher and sustainable economic growth. Other studies that found a positive relationship between financial development and innovations include (Maskus et al., 2012; Tee et al., 2014). While examining whether national and international financial market development contributes to the intensity of research and development in 18 OECD countries,

Maskus et al. (2012) maintained that the main factors that contribute to the research and development intensity include foreign direct investment, capitalization of the financial market, capitalization of the private bond market and bank credit to the private sector. Stronger innovative activity is positively influenced by a higher level of financial development in 51 countries (Meierrieks, 2014). Tee et al. (2014) identified three factors that contribute positively to the patent applications: the size of the financial sector, the stock market, and banks' overall activity using panel data for seven East Asian countries.

Investment in research and development by firms is inevitable as it can help develop new or improve the existing products and absorb knowledge from somewhere else. A growing body of literature exists that links the stock market (stock prices and volatility) to innovations. To name a few that examine the relationship between patents and market values includes (Pakes, 1985; Griliches et al., 1991). The firm investment in inventive activity may be driven by R&D expenditure and a number of firms' patent applications. This has been investigated by Pakes (1985) and found that the stock market value of the firm plays a significant role in this regard. Excess volatility in stock prices can be due to industrial revolutions (Shiller, 2000).

Contrasting evidence exists on whether development in the banking sector promotes innovation or not. Schumpeter's early work (1911) postulates that a well-functioning financial system drives technological innovation. More specifically, services of financial intermediaries perform many functions such as channelization of resources to productive uses, assessment of entrepreneurs, and diversification of risks in innovative projects, thus confirming the positive effect of the development of the banking sector on innovation (Laeven et al., 2015). Banking development may also

have a negative effect on innovations in the sense that bank debt financing discourages firms from investing in innovative projects.

The empirical evidence on the relationship between banking development and its impact on innovations is different; the potential explanation lies in what channels they use to influence innovation through banking development and the nature of the banking development they focus on. Some of the empirical papers that investigate the effect of banking development on innovation are summarized here. A study on what promotes corporate innovations in public manufacturing firms of the US (Amore et al., 2013) finds that banking development through interstate banking deregulation is a major source of corporate innovation in the US's public manufacturing firms. The study further finds that banks' ability to diversify risk at a geographical level enables them to provide credit to firms to engage in risky, innovative projects. Chava et al. (2013) explore which banking deregulation positively affects innovation, intrastate, or interstate. He examined data of young private firms in the US from 1975 to 2005 and concluded that intrastate banking deregulation negatively affects innovation while interstate banking deregulation positively affects innovation. This is so because intrastate deregulation increases banks' market power while interstate deregulation decreases the market power of banks, which in turn increases (decreases) credit to innovative firms. To investigate what kind of banking development improves innovation in public and private firms of the US, Cornaggia et al. (2015) find that banking development through interstate branching has a positive effect on private firms while negatively affecting innovations in public firms of US. Interstate branching of banking deregulation increases the credit for private firms but reduces credit to public firms. Hombert & Matray (2016) analyze the effect of banking development through intrastate branching on innovation in public and private firms of the US. The

study maintained that this kind of banking deregulation positively affects private firms' innovation while negatively affecting innovation in public firms. Study findings suggest that bank lending ability to firms is weakened by intrastate branching, and so less amount is available for the innovation with the firms. Whether banking suffering during the great depression negatively influences corporate innovation, Nanda & Nicholas (2014) investigated this research question for public and private firms of the US and find that it has a negative effect on corporate innovation, because bank distress reduces credit supply for innovative activities.

Bank information may also play a significant role in innovation. In this regard, Herrera & Minetti (2007) investigated whether bank information drives innovation in Italian manufacturing firms. The study finds positive evidence in this regard and suggests that innovation is positively influenced through relationship lending because of the shift in local supply of banking services innovation. Another study on Italian manufacturing firms to explore whether development in local banking increases innovation, Benfratello et al. (2008) suggest that development in local banking increases the supply of credit to firms involved in innovative activities and decreases capital cost. The financing of firms' operating in emerging economies through banks is a major source of innovation (Ayyagari et al., 2011). In the absence of a market-based financing facility, financing through banks is an alternative source that plays a vital role in providing credit for innovative activities in emerging economies. One exceptional paper finds that credit market development has a negative effect on innovations in industries. This study was carried out by Hsu et al. (2014) for 32 economies; the argument provided to support the findings is that bank financing lacks an effective price signal. Due to a lack of effective price signals, the banks are unable to channel credit to innovative projects.

Human capital, more specifically educated employees, plays a significant role in innovation activities where higher productivity results from innovation. Firms that use educated laborers intensively are more prone to have innovation practices than firms that employ less-educated laborers. Several studies found positive association at firm and industry level among total factor productivity growth, years of schooling, and investment in research and development (Jorgenson, 2005; Havik et al., 2008).

Studies also find that adopting new technologies and innovative systems is strongly linked with a higher number of workers who received the proper education (Kiiski & Pohjola, 2002; Chinn & Fairlie, 2007; Brynjolfsson & Saunders, 2010). Human capital is used as a determinant of innovation in the macroeconomic models, where it was found that a higher number of employees working in R&D increases the probability of innovation (Uzawa, 1965; Romer, 1990; Barro, 1997). More specifically, some studies incorporate the number of engineers in research and development as an input in knowledge production and found it significant (Jones, 1995; Romer, 2001).

Scientific innovation plays a significant role in social and industrial development. A plethora of research exists, investigated the impact of education on the tendency for innovation. Entrepreneurship courses are taught as foundation courses in most American schools (Gendron, 2004). Manager's ability may also play a role in the probability of being innovative. In this respect, De Mel et al. (2009) examines entrepreneur qualities as a determinant of innovation. For this purpose, a Longitudinal Survey of enterprises from Sri Lanka was used and fined that owner characteristics play an inevitable role in explaining innovation. This confirms that the greater is the year of schooling, the higher is the probability of firms being innovative. Type of education and employee incentive may also influence innovation in companies

(Sauermann & Cohen, 2010). Dutta et al. (2011) analyze that diversified and specialized education could foster innovativeness and increase the innovation output of a firm.

The research in the area of innovations and financial development is growing over time, covering the various dimensions of financial development and innovations. However, the research on financial development and its influence on different dimensions of the innovations discussed above is limited to economies other than Bangladesh. Though several studies can be found, which investigated the role of financial development and financial innovation on economic growth, to name a few include (Qamruzzaman, & Jianguo, 2017; Chung, 2019 among others). However, very few academic papers examined the relationship between financial deepening and financial development on innovation activities and innovation efficiency in Bangladesh but in a panel data framework (Loukil, 2020; Ho et al., 2017). Loukil (2020) finds that there is a non-linear relationship between financial development and innovation for a sample of 54 countries from 1980 to 2009 using panel threshold model. Similarly, Ho et al. (2017), while using panel data from 69 countries covering the period from 1970 to 2010, concluded that increased innovation efficiency depends on banking market deepening subject to the condition that political institutions must be necessarily democratic. On the other hand, a lower level of political democracy is required for enhancing the effect of stock market deepening on innovation efficiency. Moreover, the results are stronger for less developed countries than for developed countries.

Chapter 3

ECONOMETRIC METHODOLOGY AND DATA

3.1 Data Sources and Construction

The detail of the data is given in table 1 below

Table 1: Data description and sources

Variable(s) description	Notation	Data source
Dependent variable		
The number of innovation patent applications (in logarithmic form)	LINPA	World Bank
Independent variables		
The total value of shares traded to GDP (stock market) (in logarithmic form)	LTVST	Federal Reserve Bank of St. Louis
Private credit by deposit money in depository institution to GDP (in logarithmic form)	LPCBDMB	Federal Reserve Bank of St. Louis
Deposit money bank assets to GDP (in logarithmic form)	LDMBA	Federal Reserve Bank of St. Louis
Bank credit to bank deposits (in logarithmic form)	LBCTBD	Federal Reserve Bank of St. Louis
Gross student enrolment rate, secondary education (in percentage)	GSESE	World Bank

The table contain variable description, variables notation and data sources. All the variables are in log form except gross student enrolment rate, secondary education. Gross student enrolment, secondary education is the widely used indicator of education in social science research. Though the enrolment and/or attainment of higher education seems to be the more appropriate indicator determining the level of innovation but data for this indicator is often not available especially in third world countries like Bangladesh. This is so, this thesis makes use of gross student enrolment, secondary

education to represent how it influence the level of innovation patent application in the country.

3.2 Auto-Regressive Distributed Lag (ARDL) Model

The evolution of innovation patent application is a complex and dynamic process. Its current value has been determined by the current and lag values of its determinant. Therefore, to estimate the parameters of the model, the present thesis employs the ARDL bound estimation approach. The simple model of innovation patent application and its determinants is specified below.

$$LINPA_t = \alpha_0 + \beta_1 LTVST_t + \beta_2 LPCBDMB_t + \beta_3 GSESEt + \beta_5 LDMBA_t + \beta_6 LBCTBD_t + \varepsilon_t \quad (1)$$

where, ***LINPA*** is the natural log of innovation patent application, ***LTVST*** is the natural log of the total value of shares traded to GDP, ***LPCBDMB*** is the log of private credit by deposit money in depository institution to GDP, ***GSESE*** is Gross student enrolment rate, secondary education (in percentage), ***LDMBA*** is the natural log of deposit money bank assets as share of GDP, ***LBCTBD*** is the natural log of bank credit to bank deposits (%) while ε_t *is an* error or disturbance term.

The bounds test to Co-integration (ARDL) developed by (Pesaran et al. 2001) is preferred over the Engel-Granger two-step technique (Engel & Granger, 1987) and system based reduced rank regression approach (Johansen, 1991) to test the long run relationship among variables. The Bound test approach has the capability to estimate both short run and long run parameters of the model. Moreover, it does not depend upon whether the order of integration of variables is I (0) or I (1) or any mixture. Also, the parameters estimates are efficient in the case of a small sample.

The generalized ARDL (P, Q) model is specified as follows:

$$Y_t = \gamma_{0j} + \sum_{i=1}^{p} \delta_j Y_{t-i} + \sum_{i=0}^{q} \beta'_j X_{t-i} + \varepsilon_{jt} \quad (2)$$

where Y_t and Y_{t-1} is the dependent variable and its lag respectively, while the variables in X_t are allowed to be purely I (0) or I (1) or co-integrated; δ_j and β'_j are coefficients and γ_{0j} is a constant; $j = 1, \ldots\ldots, k; p, q$ are optimal lag orders; ε_{jt} is a vector of error terms.

The unrestricted error correction version of the ARDL model is given as follows:

$$\Delta(Y_t) = \alpha_0 + \sum_{i=1}^{k} \sum_{j=0}^{p} \beta_{ij} \Delta X_{it-j} + \sum_{i=1}^{k} \varphi_i X_{it-1} + \varepsilon_t \qquad j > 0 \; if \; i = 1 \quad (3)$$

Whereas, α_0 and β_{ij} respectively is a constant term, and short-run coefficients in which i represents the- variable and j is for the lags included. The long run coefficients are given by φ_i, where the Wald test F version is used to test the joint significance of the variables in the long run. The Schwarz Bayesian Criteria (SBC) is used to select the optimal lag length).

The null and alternative hypothesis of the long run relationship among variables is given below.

$$\mathbf{H_0}: \varphi_1 = \varphi_2 = \varphi_3 = \varphi_4 = \varphi_5 = 0 \quad (4)$$

Against the alternative

$$\mathbf{H_1}: \varphi_1 \neq \varphi_2 \neq \varphi_3 \neq \varphi_4 \neq \varphi_5 \neq 0 \quad (5)$$

The restriction in equation (4) is tested by comparing the Wald test with the critical values taken from (Pesaran, 2001) table. In the next stage, the long-run coefficients of equation (3) are estimated. The long-run equation in which the optimal lag length is again selected through SBC is given below.

$$Y_t = \theta_0 + \sum_{i=1}^{k} \sum_{j=0}^{p} \alpha_{ij} Y_{it-j} + \varepsilon_t \qquad j > 0 \; if \; i = 1 \quad (6)$$

The constant term and long term estimated coefficients are respectively given by θ_0 and α_{ij}. The variable vector is given by $\boldsymbol{X}$ while ε_t is the random error term. The Error Correction (EC) form of the ARDL model is algebraically expressed as follows:

$$\Delta Y_t = \omega_0 + \sum_{i=1}^{k} \sum_{j=0}^{p} \lambda_{ij} \Delta X_{it-j} + \gamma ECT_{t-1} + \upsilon_t \qquad j > 0 \; if \; i = 1 \tag{7}$$

Here, ω_0 is constant, λ_{ij} are short term coefficients, how much time is required to adjust to the long run equilibrium (in case of short run deviation) is represented by γ. Similarly, the lag of error term in the long-term equation is given by ECT_{t-1} while **(**6) υ_t is the usual error term assumed as white noise. All the variables are converted to natural logs except gross student enrolment rate, secondary education (in percentage) to generate smoothness in the data.

Chapter 4

RESULTS AND DISCUSSIONS

4.1 Introduction

This section provides the empirical findings and results of the thesis. The main feature of the data what is known as descriptive statistics are provided in Table 2 while correlation analysis is provided in Table 3. The Augmented Dickey-Fuller (ADF) and Phillips-Perron unit root tests are performed to analyze the stationarity (non-stationarity) of the selected set of variables (see Table: 5).

A summary statistic for the variables under consideration is provided in table 2 below. The annual mean of all the variables in Bangladesh is positive and is around 3 on average except the total value of shares traded which is negative. The volatility in the total value of shares traded is about two times higher than the volatility in other variables. Most of the variables are negatively skewed (i.e., more of the observations lying to the left of the mean value of the series) and platykurtic (Kurtosis shows the peakedness of the data). Moreover, since all the variables, the Jarque-Bera test is insignificant which means series are normally distributed.

Table 2: Descriptive Statistics

	GSESE	LINPA	LPCBDMB	LTVST	LDMBA	LBCTBD
Mean	3.52887	3.76439	2.83943	-0.73975	3.26128	4.31938
Median	3.78282	3.76120	2.90197	-0.96758	3.17136	4.31722
Maximum	4.19795	4.34380	3.74714	1.77492	4.07973	4.56985
Minimum	2.60417	2.77258	1.41585	-3.21887	2.23216	3.89995
Std. Dev.	0.46892	0.38631	0.66066	1.34073	0.58000	0.15260
Skewness	-0.30823	-0.53216	-0.37150	0.17542	-0.07287	-0.53794
Kurtosis	1.65006	2.66284	2.07391	1.89585	1.58540	2.90719
Jarque-Bera	3.57883	2.02550	2.29074	2.18111	3.28626	1.89498
Probability	0.16705	0.36321	0.31810	0.33603	0.19337	0.38771
Observations	39	39	39	39	39	39

To check for the multicollinearity problem, the correlation matrix is computed for all the variables under consideration and is given in table 3. There is no evidence of high multicollinearity problems except few exceptional cases such as between LTVST and GSESE, LTVST and LDMBA, GSESE and LPCBDMB. The correlation between these variables is greater than 0.8 but the data analyst says that if $r \geq 0.95$ then collinearity is problematic. Since the r value for none of the above-mentioned pair of variables is greater than 0.95, so our interpretation of the relationship is correct.

Table 3: Covariance Analysis: Ordinary

Correlation	LINPA	LBCTBD	LTVST	GSESE	LPCBDMB	LDMBA
LINPA	1.00000					
LBCTBD	0.20540	1.00000				
LTVST	0.44331	0.73090	1.00000			
GSESE	0.46231	0.58534	0.81727	1.00000		
LPCBDMB	0.39929	0.67037	0.79394	0.85552	1.00000	
LDMBA	0.46252	0.66613	0.82878	0.78875	0.72388	1.00000

In order to further check whether multicollinearity is really a problem in the regression or not, this study compute variance inflation factor (VIF) which is one of the detection test of multicollinearity problem in the regression. It is maintained that if VIF is less

than 10 then there is no problem of multicollinearity. The results suggest that we don't have any multicollinearity problem in our case.

Table 4: Test of Multicollinearity

Variable	Coefficient Variance	Centered VIF
LTVST	0.006405	3.3909
LPCBDMB	1.353965	1.0500
LDMBA	3.427947	3.6205
LBCTBD	1.390677	2.5385
GSESE	5.277470	5.4973
C	31.75090	NA

In order to examine the time-series properties of the variables under consideration, the given thesis runs the Dickey–Fuller and Phillips & Perron (1988) unit root test. Phillips & Perron (1988) is a non-parametric modified version of the Dickey-Fuller test corrected for any serial correlation and heteroscedasticity in the errors. The results of the unit root test are provided in table 5 below. Results suggest that all the variables are integrated of order one except LINPA which is integrated of order zero. Since the integration of the series is in mixed order, i.e., some are integrated of order one and some are integrated of order zero, therefore the appropriate method of analysis is the Auto-regressive distributive lag (ARDL) model.

Table 5: Results of unit root test

	ADF					
	Only Intercept		Intercept and trend		None	
	Level	Difference	Level	Difference	Level	Difference
Variables						
LINPA	-4.39***	-9.20***	-5.23***	-9.08***	0.08	-9.32***
LTVST	-1.53	-6.56***	-2.94	-6.48***	-1.82*	-6.50***
LBCTBD	-2.59	-3.29**	-3.38**	-3.20*	0.55	-3.27***
LDMBA	-1.31	-5.33***	-1.69	-5.36***	4.69	-3.69***
LPCBDMB	-2.76*	-4.72***	-2.90	-4.96***	4.29	-2.20**
GSESE	-2.15	-3.52*	-2.15	-3.52*	2.75	-2.61**

Note: *** denotes significance at 1%, ** denotes significance at 5% and * denotes significance at 10%.

Table 6: Results of unit root test, continued

	PP					
	Only Intercept		Intercept and trend		None	
	Level	Difference	Level	Difference	Level	Difference
Variables						
LINPA	-4.40***	-16.20***	-5.22***	-20.04***	0.54	-15.38***
LTVST	-1.56	-6.58***	-3.02	-6.50***	-1.83*	-6.49***
LBCTBD	-2.56	-3.36**	-2.74	-3.96**	1.17	-3.32***
LDMBA	-1.31	-5.33***	-1.95	-5.36***	4.17	-3.59***
LPCBDMB	-2.50	-4.72***	-2.93	-4.96***	2.99	-3.29***
GSESE	0.32	-6.26***	-2.30	-6.25***	2.62	-5.28***

Note: *** denotes significance at 1%, ** denotes significance at 5% and * denotes significance at 10%.

The long term and short-term results of the relationship between the LINPA and its determinants are provided respectively in table 8 and 9 below. Since the results derived from the unrestricted version of ARDL model are sensitive to the lag length selection, therefore the SBC information criteria are used to select the appropriate lag length. The information criteria suggest one lag. The estimated F-values are provided in table 7 which test the presence of Co-integration among variables.

Table 7 shows the existence of Co-integration at a 1% significance level for lags from 0 to 1, as the estimated F values are greater than its critical values. These results suggest the rejection of null-hypothesis of no Co-integration among log of innovations patent application and its underlying determinants.

Table 7: The bound test values of UECM for Innovations patent application

Lags	**F- Values.**
0	F (5, 38) = 5.97***
1	F (5, 38) = 8.62.59***

Critical values are taken from Pesaran et al. (2001). *** indicates significance at 1%.

Equation (6) is estimated to obtain the long-term coefficients. The normalized long-run coefficients and their t-values along with the standard errors are given below in table 8. The coefficient of gross student enrolment rate, secondary education is (negative and insignificant) is found to be inconsistent with (Toivanen & Väänänen, 2013) who argued that right educational policy is the key to increase the number of inventors. But it is the right educational policy and not the gross student enrolment rate at the secondary level that maters for innovation in the country. Similarly, Junge et al. (2012) find that education with more than 16 years of education increases the probability of adopting innovation practices. Two conclusions can be drawn. First, this thesis should use the proxy for the right educational policy in Bangladesh to know whether it matters for innovation practices. Second, this thesis should test the number of educated people having more than 16 years of education in Bangladesh as a determinant of innovation. Moreover, these studies indicate that it is not the gross student enrollment rate at the secondary level that supports the innovation practices in Bangladesh. This thesis should look for other proxies that are examined in the literature for other countries.

The finding that bank credit to bank deposits (LBCTBD), the total value of shares traded (LTVST), private credit by deposit money banks and other financial institutions (LPCBDMB) and deposit money bank assets (LDMBA) has a positive and significant impact on innovation patent applications is consistent with (Kapidani, & Luci, 2019).

However, the extant effect is different for different variables. For example, the magnitude of the positive impact of private credit by deposit money banks and other financial institutions (LPCBDMB) and deposit money bank assets (LDMBA) is higher as compared to bank credit to bank deposits (LBCTBD) and the total value of shares traded (LTVST). A positive and significant relationship of banking sector development indicators such as bank credit to bank deposit and deposit money bank assets are expected prior with the view that the banking sector in developing countries is the main intermediaries of the financial system. These results suggest that the development of financial sector (whether banking or non-banking) is critical to the number of patent applications in Bangladesh.

Table 8: Long run estimated coefficients for innovations patent applications

Variable	Coefficient	Std. Error	t-Statistic	Prob.
GSESE	-0.29271	0.454857	-0.643538	0.5249
LBCTBD	0.516067	0.199409	2.587991	0.0149
LTVST	0.186231	0.088661	2.100488	0.0445
LPCBDMB	1.665956	0.644886	2.583334	0.0151
LDMBA	1.614048	0.684547	2.357833	0.0253
Breusch-Godfrey Serial Correlation LM Test				
F-statistic	0.640453	Prob. F (2,27)	0.5349	
Obs*R-squared	1.721107	Prob. Chi-Square (2)	0.4229	
Heteroskedasticity Test: Breusch-Pagan-Godfrey				
F-statistic	1.656150	Prob. F (9,28)	0.1475	
Obs*R-squared	13.20123	Prob. Chi-Square (9)	0.1537	
Scaled explained SS	8.902002	Prob. Chi-Square (9)	0.4464	

The error correction version of the ARDL model, i.e., estimates of equation (7) is given in table 9. The lag coefficient of innovations patent application has a direct and significant impact on its own, validates that its past value determines the current level of innovation patent application in Bangladesh. Excluding lag dependent variable may cause omitted bias, and the results may not be reliable.

Another interesting part of the short-run results is the significance of the error correction term and the negative sign associated with it. The error correction term indicates how much time it will take to reach the equilibrium in the long run if there is a discrepancy in the short run. In other words, it represents per period adjustment to the long-run equilibrium. Since the error term's coefficient is -0.274, negative and significant, it means per period (the period is the year in our case) adjustment to the long-run equilibrium is about 27 percent.

Two other dissimilarities could be found in short-run results as compared to long-run results. First, though the impact of bank credit to bank deposits on innovation patent application is significant but carries negative sign. This means that in the short-run bank credit to bank deposits reduces the number of patent applications, but in short-run it has a positive effect. Maybe there is a U-shaped relationship between bank credit to bank deposits, and innovation patent applications in Bangladesh, and the room is open to exploring this kind of relationship. Second, the impact of the total value of shares traded on innovation patents in the short run is insignificant but significant in the long run suggesting that a persistent performance in the total value shares traded is necessary for increasing the innovation patent application.

Table 9: Short-run estimates for innovations patent applications

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Δ (LINPA (-1))	0.30**	0.146	1.981	0.0351
Δ(GSESE)	0.401	0.146	1.369	0.2941
Δ(LBCTBD)	-0.237**	0.073	-3.246	0.0121
Δ(LTVST)	0.072	0.073	0.958	0.4415
Δ(LPCBDMB)	0.581**	0.233	2.489	0.0421
Δ(LDMBA)	0.235**	0.102	2.303	0.0253
CointEq (-1)	-0.274**	0.122	-2.234	0.0325

Note: The significance of the estimates at 1%, 5% and 10% are represented respectively by *, **and ***

4.2 Diagnostic tests

The diagnostic tests are performed to know whether the model fits data well or not. The bottom section of Table 8, present the F versions of the LM test for autocorrelation along with chi-square and the Breusch-Pagan-Godfrey test for Heteroscedasticity... Results of the tests suggest that there is no problem of serial correlation and Heteroscedasticity. For parameter, constancy the CUSUM and CUSUM tests developed by (Brown et al. 1975) are conducted. Figure 1 and figure 2 shows that cumulative sums and cumulative sums of squares of recursive residuals are well within their 95% confidence band, thus suggesting the models' parameter stability.

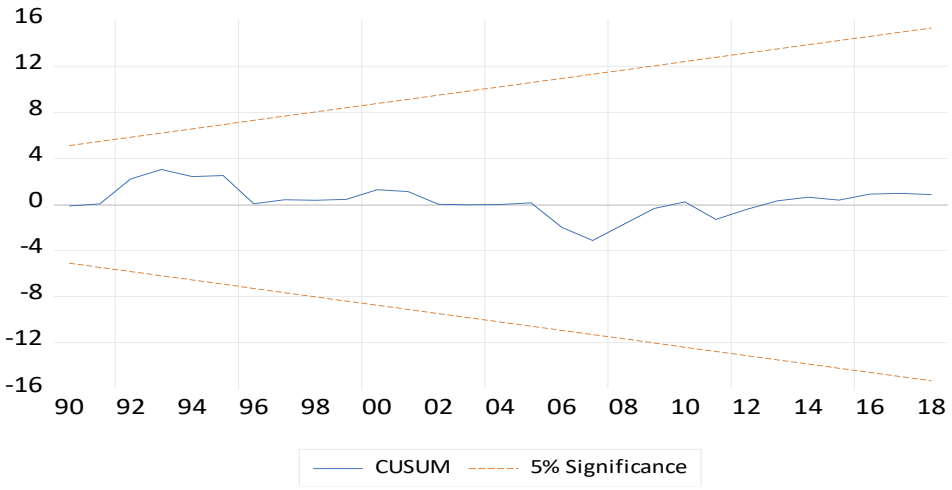

Figure 1: Coefficients stability test for estimated ARDL (CUSUM Test)

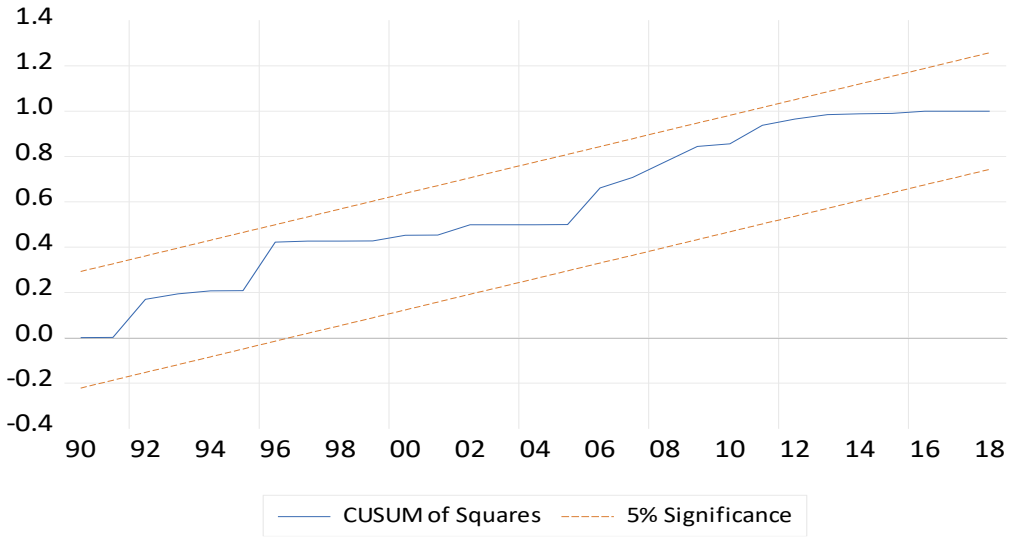

Figure 2: Coefficients stability test for estimated ARDL (CUSUM of squares Test)

Chapter 5

CONCLUSION

5.1 Conclusion

Although a plethora of work can be found to investigate the impact of financial sector development on economic growth, and other macroeconomic variables. However, the literature is very scant to investigate the subject relationship among financial sector development and innovation patent applications in general and in Bangladesh in particular. The current literature also examines the impact of financial sector development on innovations in panel data framework while ignoring its relationship in a single country framework. On this backdrop, this thesis investigated the long-run dynamic relationship between financial sector developments on innovation patent application using time series data from Bangladesh from 1980 to 2018. Two kinds of statistical analysis are used in this thesis. Descriptive statistics and regression analysis. Three regression analyses are further divided into three parts. Bound test approach to co-integration, to quantify the relationship between financial sector development and innovation, both long run and short-run analysis are used.

Empirical results from bound test to co-integration indicate a long-run relationship between financial sector development and innovation. This thesis found that gross student enrolment rate, secondary education do not contribute to innovations in Bangladesh. There could be multiple reasons for this; this thesis combed the literature and found that it could be the right educational policy that promotes innovation along

with higher education more than 16 years of schooling. Though the magnitude is different but bank credit to bank deposits (LBCTBD),the total value of shares traded (LTVST), private credit by deposit money banks and other financial institutions (LPCBDMB) and deposit money bank assets (LDMBA) all contribute positively to innovation patent applications in Bangladesh. The negative and significant coefficient of error correction term suggests that the system will converge to long-run equilibrium. In the short run, though the impact of bank credit to bank deposits on innovation patent application is significant carries negative sign suggesting that there may be a U-shaped relationship between bank credit to bank deposits and innovation patent application in Bangladesh.

5.2 Policy Implications/Recommendations

Several implications can be deduced from the findings of this thesis. First and foremost is that in Bangladesh, the focus should be given to the stability of their financial system by restoring investors' confidence, protecting its depositors and market, and resolving the credit crunch problem. It is also essential to focus on higher education and technical education as education at the secondary level does not contribute to innovation in Bangladesh. Another important area to which the country should divert its attention is to build an effective regulatory capital framework. Regulation instruments such as portfolio restrictions and reserve requirements, deposited interest rate ceiling, deposited insurance and capital requirement, and entry and merger restrictions if utilized properly and effectively can help resolve market failure and strengthen the whole financial infrastructure vice versa.

REFERENCES

Aayale, J. (2016). Financial development and technological innovation as a channel for economic growth in morocco. *International Journal of Economics, Commerce and Management. 12(4).*

Allen, F., Gu, X., & Kowalewski, O. (2018). Financial structure, economic growth and development. *In Handbook of finance and development. Edward Elgar Publishing.*

Amore, M. D., Schneider, C., & Žaldokas, A. (2013). Credit supply and corporate innovation. *Journal of Financial Economics, 109(3), 835-855*.

Aristizabal-Ramirez, M., Botero-Franco, M. C., & Canavire-Bacarreza, G. (2017). Does financial development promote innovation in developing economies? An empirical analysis. *Review of Development Economics, 21(3), 475-496.*

Ayyagari, M., Demirgüç-Kunt, A., & Maksimovic, V. (2011). Firm innovation in emerging markets: The role of finance, governance, and competition. *Journal of Financial and Quantitative Analysis, 46(6), 1545-1580.*

Bagehot, W. (1873). *Lombard Street: a description of the money market. New York: Scribner, Armstrong & Co.*

Barro, R. J. (1997). *Determinants of economic growth: a cross-country empirical study.* Lionel Robbins Lectures. In Cambridge, MA: MIT Press.

Beck, T., & Levine, R. (2004). Stock markets, banks, and growth: Panel evidence. *Journal of Banking & Finance, 28(3), 423-442.*

Benfratello, L., Schiantarelli, F., & Sembenelli, A. (2008). Banks and innovation: Microeconometric evidence on Italian firms. *Journal of Financial Economics, 90(2), 197-217.*

Brown, R. L., Durbin, J., & Evans, J. M. (1975). Techniques for testing the constancy of regression relationships over time. *Journal of the Royal Statistical Society: Series B (Methodological), 37(2), 149-163.*

Brynjolfsson, E., & Saunders, A. (2010). *Wired for innovation: How information technology is reshaping the economy. Mit Press.*

Chava, S., Nanda, V., & Xiao, S. C. (2017). Lending to innovative firms. *The Review of Corporate Finance Studies, 6(2), 234-289.*

Chava, S., Oettl, A., Subramanian, A., & Subramanian, K. V. (2013). *Banking deregulation and innovation. Journal of Financial economics, 109(3), 759-774.*

Chinn, M. D., & Fairlie, R. W. (2007). The determinants of the global digital divide: a cross-country analysis of computer and internet penetration. *Oxford Economic Papers, 59(1), 16-*

Chung, P. T., Sun, S., & Vo, D. T. H. (2019). How Does Financial Development Interact with Economic Growth in Five ASEAN Countries? *The Singapore Economic Review, 64(03), 441-460.*

Cornaggia, J., Mao, Y., Tian, X., & Wolfe, B. (2015). Does banking competition affect innovation? *Journal of financial economics, 115(1), 189-209.*

De Mel, S., McKenzie, D., & Woodruff, C. (2009). Innovative firms or innovative owners? determinants of innovation in micro, small, and medium enterprises. *ZA Discussion Papers 3962. Institute for the Study of Labor (IZA).*

De la Fuente, A., & Marin, J. (1996). Innovation, bank monitoring, and endogenous financial development. *Journal of Monetary Economics, 38(2), 269-301.*

Dutta, D. K., Li, J., & Merenda, M. (2011). Fostering entrepreneurship: impact of specialization and diversity in education. *International Entrepreneurship and Management Journal, 7(2), 163-179.*

Engle, R. F., and Granger, C. W. (1987). Co-integration and error correction representation, estimation and testing. *Econometrica, 55, 251–276.*

Ferreira, D., Manso, G., & Silva, A. C. (2014). Incentives to innovate and the decision to go public or private. *The Review of Financial Studies, 27(1), 256-300.*

Gendron, G. (2004). Practitioners' Perspectives on Entrepreneurship Education: *An Interview with Steve Case, Matt Goldman, Tom Golisano, Geraldine* Laybourne, Jeff Taylor, and Alan Webber. *Academy of Management Learning & Education, 3(3), 302-314.*

Gries, T., Kraft, M., & Meierrieks, D. (2011). Financial deepening, trade openness and economic growth in Latin America and the Caribbean. *Applied Economics, 43(30), 4729-4739.*

Griliches, Z., Hall, B. H., & Pakes, A. (1991). R&D, patents, and market value revisited: is there a second (technological opportunity) factor? *Economics of Innovation and new technology, 1(3), 183-201.*

Herrera, A. M., & Minetti, R. (2007). Informed finance and technological change: Evidence from credit relationships. *Journal of Financial Economics, 83(1), 223-269.*

Ho, C. Y., Huang, S., Shi, H., & Wu, J. (2017). Financial deepening and innovation efficiency: The role of political institutions. *ADBI Working Paper Series. No. 694*

Holmstrom, B. (1989). Agency costs and innovation. *Journal of Economic Behavior & Organization, 12(3), 305-327.*

Hombert, J., & Matray, A. (2016). The real effects of lending relationships on innovative firms and inventor mobility. *The Review of Financial Studies, 30(7), 2413-2445*.

Hsu, P. H., Tian, X., & Xu, Y. (2014). Financial development and innovation: Cross-country evidence. *Journal of Financial Economics, 112(1), 116-135*

Igan, D., Kutan, A. M., & Mirzaei, A. (2020). The real effects of capital inflows in emerging markets. *Journal of Banking & Finance, 119, 105933.*

Johansen, S. (1991). Estimation and Hypothesis Testing of Co-integration Vectors in Gaussian Vector Autoregressive Models. *Econometrica, 59(6), 1551-1580.*

Jones, C. I. (1995). R & D-based models of economic growth. *Journal of political Economy, 103(4), 759-784.*

Jorgenson, D. W., Ho, M. S., & Stiroh, K. (2005). Productivity: Information Technology and the American Growth Resurgence, Vol. 3. In Washington, United States> *Library Congress Cataloguing-in-Publication Data.*

Junge, M., Severgnini, B., & Sørensen, A. (2012). Evidence on the Impact of Education on Innovation and Productivity (No. 2-2012). *Department of Economics, Copenhagen Business School working paper.*

Kapidani, M., & Luci, E. (2019). The Effects on innovation from financial sector development: evidence from developing countries. *Journal of Competitiveness, 11(2), 84.*

Kiiski, S., & Pohjola, M. (2002). Cross-country diffusion of the Internet. *Information Economics and Policy, 14(2), 297-310.*

Laeven, L., Levine, R., & Michalopoulos, S. (2015). Financial innovation and endogenous growth. *Journal of Financial Intermediation, 24(1), 1-24.*

Levine, R. (1997). Financial development and economic growth: views and agenda. *Journal of economic literature, 35(2), 688-726.*

Levine, R. (2005). Finance and growth: theory and evidence. *Handbook of economic growth, 1, 865-934.*

Loukil, K. (2020). The Impact of Financial Development on Innovation Activities in Emerging and Developing Countries. *Business and Economic Research, 10(1), 112-119.*

Manso, G. (2011). Motivating innovation. *The Journal of Finance, 66(5), 1823-1860.*

Maskus, K. E., Neumann, R., & Seidel, T. (2012). How national and international financial development affect industrial R&D. *European Economic Review, 56(1), 72-83.*

Havik, K., McMorrow, K., Röger, W., & Turrini, A. (2008). The EU-US total factor productivity gap: An industry perspective. *European Commission, Directorate-General for Economic and Financial Affairs.*

Meierrieks, D. (2014). Financial development and innovation: Are there evidence of a Schumpeterian finance-innovation nexus*? Annals of Economics & Finance, 15(2).*

Moguillansky, G. (2006). Innovation, the missing link in Latin american countries. *Journal of economic issues, 40(2), 343-357.*

Nanda, R., & Nicholas, T. (2014). Did bank distress stifle innovation during the Great Depression? *Journal of Financial Economics, 114(2), 273-292.*

Pakes, A. (1985). On patents, R & D, and the stock market rate of return. *Journal of political economy, 93(2), 390-409.*

Pesaran, H. M., Shin, Y., Smith, R. J. (2001). Bounds testing approaches to the analysis of Long-run relationships. *Journal of Applied Econometrics, 16, 289–326.*

Phillips, P. C., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75(2), 335-346.*

Porter, M. E. (1992). Capital disadvantage: America's failing capital investment system. *Harvard business review, 70(5), 65.*

Qamruzzaman, M., & Jianguo, W. (2017). Financial innovation and economic growth in Bangladesh. *Financial Innovation, 3(1), 19.*

Rajan, R. G., & Zingales, L. (1998). Financial dependence and growth. *The American Economic Review. 88(3), 559-586.*

Romer, P. M. (1990). Endogenous Technological Change; *Journal of Political Economy, 98(5, Part 2), S71-S102.*

Romer, P. M. (2001). Should the government subsidize supply or demand in the market for scientists and engineers? *Innovation policy and the economy, 1, 221-252.*

Sauermann, H., & Cohen, W. M. (2010). What makes them tick? Employee motives and firm innovation. *Management science, 56(12), 2134-2153.*

Schumpeter, J. A. (1982). The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle (1912/1934). *Transaction Publishers. –1982.–January, 1, 244.*

Schumpeter, J. (1911). The Theory of Economics Development. Cambridge, MA: *Harvard University Press*

Shiller, R. C. (2000). Irrational exuberance. *Philosophy and Public Policy Quarterly, 20(1), 18-23.*

Solow, R. M. (1957). Technical change and the aggregate production function. *The review of Economics and Statistics, 39(3), 312-320.*

Tadesse, S. A. (2005). Financial development and technology. *Available at SSRN 681562.*

Tee, L. T., Low, S. W., Kew, S. R., & Ghazali, N. A. (2014). Financial development and innovation activity: *Evidence from selected East Asian countries. Prague Economic Papers, 23(2), 162-180.*

Toivanen, O., Väänänen, L. (2013). Does education lead to more innovation? Center for Economic Policy Research (CEPR). *https://voxeu.org/article/does-education-lead-more-innovation-0*

Uzawa, H. (1965). Optimum technical change in an aggregative model of economic growth. *International economic review, 6(1), 18-31.*