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Technology and Economic Growth: Role of Financial Development in South Asian Countries

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ABSTRACT

Financial development plays an instrumental role in the process of economic growth and development through mobilization of savings and creating investment opportunities. Financial development also leads to enhance the level of technology by providing finance to entrepreneurs for technological innovations which leads to economic growth. This study examines the impact of financial development and technology on economic growth of selected South Asian countries over the time span 1984-2017. Due to endogeneity problem, the empirical model used in the study is estimated by System Generalized Method of Moment (System GMM). Empirical results indicated that financial development, technology and human capital have positive and significant impact on economic growth in developing South Asian countries. To attain a sustainable economic growth, South Asian countries should put their efforts to develop their financial market that stimulates economic growth by providing finance to entrepreneurs for innovations.

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1. Introduction

Sustainable growth is the main goal of developing countries (Munir and Mehmood, 2018). There are different factors that determine economic growth, of which financial development is the important one. Moreover in early 1910s, economists believe that the banking sector development causes technological innovation by identifying entrepreneurs and providing them finance to introduce innovative products to facilitate production process (Schumpeter, 1912). Indeed, financial sector pools the savings of the household and allocates these savings to investment associated with highest returns. The financial sector development would overcome the adverse selection problem prevailing in credit market (King and Levine, 1993).

Intuitively, differences in the growth rate of different countries are due differences in the quantity and quality of services provided by financial sectors (McKinnon, 1973; Shaw; 1973). Unlike the positive effect of financial sector on economic growth, it is also believed that financial sector has trivial effect on the rate of investment in physical capital, and thus has minor impacts on sustainable growth (Solow, 1957). It is widely believed that financial development is the true indicator of future rates of economic growth, physical capital accumulation and high-tech innovations (Levine, 1997), Financial development reduces information and transaction cost by providing level playing field to the banks that affect savings, investment, technological changes and hence economic growth.

Therefore financial sector provides finance to entrepreneurs to make technological innovations in the form of new formula or blueprint to produce goods and services. In other words, financial development reduces information and transactions cost by facilitating the risk, mobilizing savings and allocating resources towards more productive investment (Sabir and Qayyum, 2018). Therefore financial development impacts economic growth through capital accumulation and technological innovations (Levine, 1997). Financial development affects capital accumulation through saving rates but steady state growth can be altered through either changing savings or reallocating savings among capital technological innovations. Nevertheless financial development impacts technological innovations which leads to increasing returns in production that results in sustainable growth (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1992).

Many developing countries have under gone the process of massive financial restructuring and liberalization since 1990. At the same time, some of these countries have achieved high rate of economic growth, whereas others have lagged behind. However differences in their economic growth can be due to many factor, many economists believe that financial development significantly contributes in economic growth process (Ahmed and Ansari, 1998). The empirical literature suggests a positive association between financial development and economic growth (McKinnon, 1973; King & Levine, 1993; Calderon & Liu, 2003). These empirical studies show that financial development effects economic growth through technological innovation channel (Levine et al. 2002). Moreover, a various studies find a non-monotonic connection between financial development and economic growth in high and middle income countries (Arcand et al., 2012; Law & Singh, 2014; Pagano et al., 2012), yet the influence of financial development and technological innovations on economic development and growth is not being studied for South Asian countries. The objective of this study is to examine the effect of financial development and technological innovations on the economic growth of South Asian countries.

This study uses panel date of South Asian countries over the time period 1991-2017. There exists a problem of endogeneity in the financial development and other explanatory variables. Similarly the growth regression can have the serial correlation problem, heteroscedasticity and omitted variable bias, therefore this study uses system Generalized Method of Moment of Arellano and Bond (1991), and Blundell and Bond (1998) to tackle these problems. The rest of the study is organized as follows. Section 2 describes theoretical framework of financial development, technological innovation and economic growth. Section 3 explains methodology and data sources whereas section 4 is about results and discussion. Conclusion and policy recommendations are presented in section 5.

2. Theoretical Framework

This study assume that output is produced by using physical capital and human capital and production function is specified by Cobb-Douglas function

$$Y_{it} = K_{it}^{\propto}(A_{it}H_{it})^{\beta} \qquad \beta = 1 - \alpha, \;\; 0 < \alpha < 1 \qquad (1)$$

Where Y is the output in country i (i=1,2,…,N) at time t (t=1,2,…,T), K is the stock of physical capital, H is the human capital, and A is the labor-augmenting technology that raises exogenously at the rate of x. let assume that individual develop human capital by spending time on acquiring new skills instead of working. Let g is the segment of time spent by raw unskilled labor to learn and accumulate skills to produce human capital H in the economy or country. Therefore it can be written as

$$H_{it} = e^{\gamma g}L_{it} \qquad \gamma > 0 \qquad (2)$$

Where γ is a constant and L is the unskilled labor, if $g = 0$, then $H = L$, implies that all labor is uneducated. Therefore by increasing g, a unit of unskilled labor rises skilled labor H. Moreover, Labor grows exogenously at the rate of n and technology grows exogenously at the rate of x and financial development.

$$L_{it} = L^{\circ}e^{nt}$$
$$A_{it} = A^{\circ}e^{xt+FD_{it}\theta} \qquad (3)$$

Where FD is the level of financial development in country i at time period t and θ is the vector of coefficient of financial development. In this growth model, the labor augmenting technology associates not only with technological innovations determined by x but also on financial sector development. For instance, financial

intermediaries increase the efficiency or productivity of A to enhance economic growth in two ways: 1) Collecting information to assess different projects; and 2) encouraging individuals to invest in riskier projects but in more dynamic technologies through risk sharing. Therefore to unscramble the productivity shocks, financial sector choose the technology which is most suitable to rectify the shocks. Thus savings channelled through financial sector are distributed more proficiently towards productive investment which rises economic growth (Pagano, 1993).

In a Neoclassical theoretical framework, the impacts of level of financial development on economic growth can be temporary, i.e. $\frac{dFD_{it}}{dt} = 0$ is supposed to be in steady state. However the level of financial development can vary country to country in the balanced state which implies that level of GDP per capita can also differ across countries. Thus different countries can converge to different steady states depending on their initial level of savings and financial development. In the steady state, output or income per unit of effective labor is constant but output per person or labor grows exogenously at the rate of x. Therefore output per unit of labor or worker can be written as

$$\frac{Y_{it}}{A_{it}L_{it}} = \frac{K_{it}^{\propto}(A_{it}H_{it})^{\beta}}{A_{it}L_{it}} \qquad (4)$$

$$y_{it} = A_{it}k_{it}^{\propto}h_{it}^{\beta} \qquad (5)$$

Where $h = e^{\gamma g}$. People save and devote constant fraction of their output to accumulate human capital. We assume that human capital grows exogenously at the rate of g.
Taking logs of the both sides of equation

$$lny_{it} = lnA_{it} + \propto lnk_{it} + \beta lnh_{it} \qquad (6)$$

Using equation above, we obtain

$$lny_{it} = lnA^{\circ} + \beta lnxt + \beta\theta lnFD_{it} + \propto lnk_{it} + \beta\gamma g_{it} + U_{it} \qquad (7)$$

Where FD is the financial development, g is the human capital development over the time and U is an error term which is normally distributed. We also estimate the combine effects of technological innovation and financial development on economic growth by using interaction between financial development and technological innovation as follows.

$$lny_{it} = lnA^{\circ} + \beta lnx_{it}t + \beta\theta lnFD_{it} + \propto lnk_{it} + \beta\gamma g_{it} + \varphi lnx_{it} * lnFD_{it} + V_{it} \qquad (8)$$

Where V is the error term. Both equations (7) and (8) provide the foundation for econometric models. These equations can be written in reduced form as follows

$$lny_{it} = a_{\circ i} + a_{1i}lnx_{it} + b_{2i}lnFD_{it} + b_{3i}lnk_{it} + b_{4i}g_{it} + U_{it} \qquad (10)$$

$$lny_{it} = a_{\circ i} + a_{1i}lnx_{it} + a_{2i}lnFD_{it} + a_{3i}lnk_{it} + a_{4i}g_{it} + a_{5i}lnx_{it} * lnFD_{it} + V_{it} \qquad (11)$$

Where a's are the parameters to be estimated, FD and x are financial development and technology respectively.

3. Methodology and Data

This study investigates the nexus between financial development, technological innovations and economic growth, and our modelling framework in the framework of Mankiw, Romer and Weil (1992) is

$$\Delta lny_{it} = a_{\circ} + a_1 lny_{it-1} + a_2\Delta lny_{it-1} + a_3 lnx_{it} + a_4 lnFD_{it} + a_5 lnk_{it} + a_6 HC_{it} + V_{it} \qquad (12)$$

$$\Delta lny_{it} = a_{\circ} + a_1 lny_{it-1} + a_2\Delta lny_{it-1} + a_3 lnx_{it} + a_4 lnFD_{it} + a_5 lnk_{it} + a_6 HC_{it} + a_7 lnx_{it} * lnFD_{it} + V_{it} \qquad (13)$$

For constancy of parameter across the time period of a panel data set, lagged levels of GDP per capita are taken with fixed one lag: lny_{it-1} rather than taking the initial value of GDP per capita. A significant number of previous studies employ cross sectional techniques to estimate the economic growth regression (Barro, 1991; King and Levine, 1993a) and fixed effect dummy variable least square method is used to control country explicit effects. Unfortunately neither cross sectional techniques nor fixed effect models tackle the problem of endogeneity in the

economic growth regression (Caselli et al., 1996; Seven and Yetkiner, 2016). For instance, presence of $\ln y_{it-1}$ and $\Delta \ln y_{it-1}$ also indicates that fixed and random effects panel estimators are biased and inconsistent. Moreover, due to endogeneity problem in the financial development variable, omitted variable bias, autocorrelation and cross sectional heterogeneity, this study uses generalized method of moment introduced by Arellano and Bond (1991) and Blundell and Bond (1998). Since the use of exogenous instruments should enable us to produce consistent estimators using mother of all techniques GMM. There are three benefits of using GMM: 1) this method produces unbiased and consistent estimators of the regression parameters, in which explanatory variables are not strictly predetermined that can correlate with past or current values of random terms, and heteroscedasticity and autocorrelation exist within the model (Roodman, 2009a). 2) System GMM fixes the problem of endogeneity as it uses the instruments which are unassociated with fixed effects while potentially circumventing the dynamic panel bias. 3) System GMM can be used for short time period and large cross sectional units.

The system GMM consists of set of equation in which equation in first difference is instrumented with lagged level variables and system of equations in level are instrumented with lagged first difference. The efficiency of System GMM depends on the assumptions that there is no autocorrelation in the error term and instruments are not interconnected with error term. These issues and problems are fixed by using two well-known tests: Arellano and Bond test for autocorrelation which explores the first and second order autocorrelation in the first difference and Hansen (1982) test is used to check the condition of over-identifying restriction for the validity of instruments. If both of the tests are satisfied, then estimates of the unknown parameters are reliable and efficient.

This study uses panel data of South Asian countries1 over the time period 1991-2017. Data of Bhutan and Maldives are not available and we have skipped it from the sample. Chosen time period covers an era of financial development and economic development in South Asian countries. This time period, money growth and investment increase in this region. Therefore economic growth increases. This study uses gross domestic product per capita (GDPPC) as a dependent variable. A number of studies have used this variable as a dependent variable (Choi 2006; Shahbaz and Aamir 2008; Nawaz and Khawaja 2016). This study uses credit to private sector by commercial banks percentage of GDP as a proxy for financial development. Domestic credit to private sector by commercial banks is considered as financial assets which are provided to the private investors by commercial banks through exchange credits, purchase of bonds and securities, provision of loans and other accounts receivable that establish a claim of repayment. Beck et al. (2007), Jaumotte et al. (2013) and Demirguc et al. (2009) took domestic credit to private sector as a percentage of GDP as a measure of financial development.

Technology is the formula or blue print to combine factors of production to produce goods and services. To measure technological innovation different proxies have been used in empirical economic literature such as patents registered by residents, patents registered by non-residents, trademarks registered, intellectual property rights and research and development (R&D) expenditures etc. (Ginarte and Park, 1997; Jalles, 2010). This study used patents by residents, patents by non-residents and import of machinery and equipment as proxies for technology. Human capital is a measure of the monetary value of a worker's skill. It is considered as one of the significant determinant of economic prosperity for a longer time period. Benhabib and Spiegel (1994), and Cohen and Soto, (2007) used average year of schooling as proxy for human capital. However this study uses the education index of UNDP to examine the effect of human capital on economic growth and development.

Physical capital such as buildings, roads, dams, hospitals, schools, colleges, computers etc. are also used in production process. In existing empirical literature, different proxies have been used for physical capital such as gross fixed capital formation as percentage of GDP and investment to GDP ratio (Hosseini and Leelavathi, 2013). Therefore this study also uses gross fixed capital formation as a proxy for physical capital. A system in which all trade distortions are eradicated for free mobility of goods and services across the countries is called trade openness. Balanika (2012) stated that trade openness is a channel which stimulates foreign direct investment (FDI), capital inputs, and goods and services flow towards host countries. Perhaps trade openness can affect economic growth positively because it generates employment opportunities which help poor segment of population to increase their income levels and it also causes reduction in poverty. To measure trade openness this study uses exports plus imports as percentage of GDP as a proxy for trade openness. In economic literature inflations rate has been measured as percentage change in consumer price index. Increase in inflation hurts growth process because it acts like a tax on commodities. Due to inflation, aggregate demand decreases, employment reduces, output decreases and income decreases. In this study, inflation is used to macroeconomic stability in the economy. In this study panel

1 Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka

data of 6 South Asian Countries for time period 1996 to 2015 are used. Most of the data for variables2 is taken from World Development Indicators (WDI). Data of human capital is taken from UNDP database and data of imports of machinery is taken from UN Com Trade3. Descriptive statistics of the variables are given in table 1

Table 1: Descriptive Statistics

Variables	obs.	Mean	Std. Dev.	Min	Max
Ln(GDP per capita)	135	6.807	0.583	5.914	8.254
Credit	135	31.483	13.633	8.799	80.996
Ln(Patent by non-resident)	135	5.830	2.388	0.000	10.446
Ln(Patent by resident)	135	4.587	2.223	-0.020	9.488
Ln(Physical capital)	135	23.722	1.622	21.380	27.465
inflation	135	7.791	3.753	2.007	22.565
Tade openness	135	43.776	16.454	17.172	88.636
Education index	135	0.437	0.151	0.210	0.751
Ln(imports)	135	17.920	1.795	13.184	20.773

Source: Calculated by Author

4. Results and Discussion

We estimate equations (12) and (13) by employing system GMM due to potential problem of endogeneity in financial development variable, measures of technological innovations and human capital and results are reported in table 2. Coefficients of trade openness, domestic credit provided by commercial banks to private sector (credit), education index and patents registered by residents are positive and statistically significant. These results imply that credit provided by banks to private sector has positive and statistically significant influence on economic growth.

Table 2: Financial development, Residents Patent and GDP per capita

Variables	GMM	GMM
ln(GDP per capita)t-1	0.873***	0.728***
	(0.000)	(0.000)
Trade Openness	0.001*	0.001*
	(0.082)	(0.068)
Credit by banks	0.002*	0.014***
	(0.079)	(0.004)
Ln(Physical capital)	0.021***	0.012***
	(0.000)	(0.002)
Inflation	-0.004	-0.001
	(0.403)	(0.792)
Education index	0.159***	0.510**
	(0.000)	(0.016)
ln(Patents registered by resident)	0.005	0.190**
	(0.433)	(0.033)
ln(Patents registered by resident)*credit		0.002*
		(0.101)
Constant	0.298***	0.109***
	(0.003)	(0.001)
Sargan Test	0.161	0.148
AR(1)	0.000	0.000
AR(2)	0.752	0.179

Source: Author's own estimation. Note that *, ** and *** represent 10%, 5% and 1% level of significance respectively. Small parenthesis indicates P-values.

Further, 1 percent increases in credit increases GDP per capita by 0.002 percent. This means that financial development increases demand for credit by private investors, investment increases, employment increases, productivity increases and hence GDP per capita increases. Moreover human capital, which is measure with education index, has positive and significant effect on GDP per capita. One percent rise in human capital increases

2 See appendix A

3 Correlation matrix is given in Appendix

GDP per capita by 0.159 percentage points. We can notice that the magnitude of coefficient of human capital is greater than the financial development, which implies that human capital development contributes more in the GDP per capita determination than financial development. We consider human capital as a vital engine of economic growth. Moreover patents registered by residents has positive but insignificant determinant of GDP per capita in South Asian countries.

We get the intuition from this analysis that technological sector is least developed in South Asian countries and it is not playing significant role in the economic growth process. It would be worth emphasized that there exists a diffusion of technology from developed countries to developing countries like South Asian countries. These countries are making less fraction of their GDP on research and development sector, therefore, this research and development sector has no impact on GDP per capita. Trade openness and physical capital are positively affecting GDP per capita. However inflation has negative and insignificant impact on GDP per capita. Moreover we also use interaction term of patents registered by residents and financial development in the growth regression. The coefficient of interaction term is positive and statistically significant which implies that financial development encourages technological innovations which increases GDP per capita of the country. This implies that financial development and technological innovations are complementary to each other and both these variables work together to determine economic growth (King and Levine, 1995). In order to see that the foreign technology diffusion, we consider patents registered by non-resident and import of machinery in place of patents registered by residents. It is important to note that former is an indicator of knowledge diffusion and the latter is a proxy of technology diffusion. Table 3 provides the summarized results of system GMM for financial development, technological innovations and GDP per capita.

The results show that our variables of interest such as financial development, technology and human capital are significantly correlated with GDP per capita in South Asian countries. This outcome is plausible with our expectations which proposes that credit provided by banks to private sectors is the source which has enhanced private investment in these countries. Therefore, we can say that financial development has positive effect on economic growth of South Asian countries. Table 2 shows that patents application registered by non-resident has positive and statistically significant impact on economic growth. This corroborates with multinational corporations (MNCs) research and development activities in South Asian region along with the participation of industrial sector in global research and development sector.

Table 3: Financial development, Non-Residents Patent and GDP per capita

Variables	GMM	GMM
Ln(GDP per capita)t-1	0.877***	0.781***
	(0.000)	(0.000)
Trade Openness	0.001*	0.002*
	(0.054)	(0.065)
Private Credit by banks	0.002*	0.001*
	(0.077)	(0.101)
Ln(Physical capital)	0.018***	0.010**
	(0.000)	(0.039)
Inflation	-0.003	-0.001
	(0.403)	(0.882)
Education index	0.102***	0.454**
	(0.000)	(0.016)
ln(Patents registered by non-resident)	0.012*	0.004*
	(0.088)	(0.105)
ln(Patents registered by non-resident)*credit		0.001*
		(0.073)
Constant	0.285**	0.014*
	(0.028)	(0.101)
Sargan Test	0.192	0.136
AR(1)	0.000	0.017
AR(2)	0.693	0.464

Source: Author's own estimation. Note that *, ** and *** represent 10%, 5% and 1% level of significance respectively. Small parenthesis indicates P-values.

For instance, FDI in South Asian countries such as Bangladesh, India, Nepal, Pakistan, and Sri-Lanka has increased which is the major source of technology from developed countries to developing South Asian countries. This diffusion of knowledge or knowledge through either MNCs or FDI has emerging impact on the productivity of our labor and capital which are significantly affecting economic growth. We can hypothesize that diffusion of technology is playing vital role in the process of economic growth than the domestic technology. A coefficient of human capital is again positive and statistically significant. Human capital is the responsive factor which plays an essential role in the absorption of diffused technology and to enhance research and development within the country. Human capital development has spill over impacts on economic development and growth of the country. Interaction term of patents filed by non-resident and financial development is included in the growth equation. Table 3 indicates that interaction term has positive and significant impact on economic growth.

Table 4: Financial development, imports of machinery and GDP per capita

Variables	GMM	GMM
Ln(GDP)t-1	0.819***	0.747***
	(0.000)	(0.000)
Trade Openness	0.001*	0.001*
	(0.102)	(0.101)
Domestic Credit by Banks	0.001**	0.002***
	(0.047)	(0.009)
Ln(Physical capital)	0.010***	0.010***
	(0.000)	(0.000)
Inflation	-0.001	0.000
	(0.203)	(0.309)
Education index	0.119***	0.417**
	(0.000)	(0.012)
ln(imports)	0.013**	0.007*
	(0.026)	(0.063)
ln(Imports)* Domestic Credit by Banks		0.001**
		(0.050)
Constant	0.060**	0.021**
	(0.022)	(0.013)
Sargan Test	0.114	0.115
AR(1)	0.000	0.000
AR(2)	0.972	0.138

Source: Author's own estimation. Note that *, ** and *** represent 10%, 5% and 1% level of significance respectively. Small parenthesis indicates P-values.

Further, we use imports of machinery and equipment as measure of technological diffusion in place of patents. It is truth that developed countries are technological leaders around the globe. Therefore it is necessary to import technology from developed countries to less developed countries where technology is unavailable. We assume that a country which is more open to the import of technology can derive greater benefits from foreign technology that enhances economic growth due to increase in productivity of other factors of production (Kim et al., 2011). The results with import of machinery and equipment are reported in table 4. Financial development and human capital have positive and statistically significant impacts on GDP per capita. Interesting result is that the import of machinery and equipment has positive effect on GDP per capita. This implies that the countries which are importing better technology goods are in fact importing technological progress that improves the production efficiency (Romer, 1990). Moreover import of foreign technology in the form of machinery and equipment used in production of goods and services increase total factor productivity.

Therefore we can draw a corollary that import of technology from developed countries has spill-overs to developing countries in the sense that trade increases economic growth in developing Asian countries. Interaction term of financial development and technological innovation has positive and statistically significant impact on economic growth which ensures that both financial development and technological innovations are complementary to each other. Rest of the variables appears with expected signs. We can conclude this section of the study by say that financial development, human capital and diffused technology are significantly contributing in the economic

growth of South Asian countries. Moreover, local research and development is not playing significant role in enhancing economic growth of these selected countries.

5. Conclusions

In this study, we have theoretically and empirically estimated the impact of financial development and technology on economic growth of South Asian countries over the time span 1991-2017. This study used system GMM due to the problem of endogeneity, heteroscedasticity, serial correlation and omitted variable bias. This study extended the augmented Solow Growth model by incorporating the financial development, technological innovations and their interaction term. This study used domestic credit to private sector by banks as percent of GDP is used as a proxy of financial development, patents registered by residents, patents registered by non-resident and imports of machinery and equipment as alternate proxies for technological innovations and education index as a proxy for human capital. The results showed that financial development has growth enhancing impact on South Asian countries and human capital development is significantly contributing in economic growth and development. However domestic technological innovations measured with patents registered by local residents has insignificant impact on economic growth. This is due to the reason that South Asian countries are least developed due to lack of technological innovations. Interaction term of financial development and technology has positive effects on economic growth which means that financial development along with technology determine economic growth in South Asian countries.

Moreover diffusion of technology or knowledge measured with patents registered by non-residents is an important element of economic growth in South Asian countries. Their interaction term is positive and significant as well. This shows that diffusion of technology from developed countries to developing countries enhances economic growth due to developed financial structures. Similarly, import of machinery and equipment is used as proxy for the diffusion of technology and it impacts economic growth positively due to increase in the total factor productivity. Moreover interaction term of imports of machinery and equipment is positive which confirms their complementary impact on economic growth. Here we suggest following policy recommendations; Policy makers in South Asian countries should further reform financial sector to boost economic growth. Second policy makers should mitigate the constraint to credit extension for private sector. Private sector investment can lead to high economic growth and development in South Asian countries. Third policy makers should focus on enterprise credit rather than consumer credit. Enterprise credit leads to increase entrepreneurs which make investment and hen employment increases and then growth. Fourth, there is a need to enhance investment in research and development sector which can play a catalytic role in the development of South Asian economies.

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