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Nexus between financial innovation and economic growth in South Asia: evidence from ARDL and nonlinear ARDL approaches

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Abstract

This study examined the relationship between financial innovation and economic growth in Bangladesh, India, Pakistan, and Sri Lanka for the period Q1 1975 to Q4 2016. The autoregressive distributed lag (ARDL) bounds test was used to gauge long-run relationships, and the nonlinear ARDL (NARDL) test was used to explore asymmetry between financial innovation and economic growth in the sample of Asian countries. The findings from the bounds tests revealed long-run cointegration between financial innovation and economic growth in the sample countries. Furthermore, NARDL confirmed that positive changes in financial innovation linked positively with economic growth and vice versa in the long run. In the short run, however, the study found mixed behaviors in the case of positive and negative changes in financial innovation. To investigate directional causality, the Granger causality test under an error correction model was employed. The Granger causality results supported the feedback hypothesis in both the long run and short run. Thus, financial innovation boosts economic growth in the long run by stimulating financial service expansion, financial efficiency, capital accumulation, and efficient financial intermediation, which are essential for sustainable economic growth.

Keywords: Financial innovation, Economic growth, ARDL, NARDL, JEL, O52, C21

Introduction

In Schumpeter's development theory, finance and efficient financial institutions are crucial for sustainable economic growth, assuming that credit, money, and finance influence innovation processes (Knell 2015). Following Schumpeter's (1911) seminal work, other finance scholars—including, Goldsmith (1969), Greenwood and Jovanovic (1990), Gurley and Shaw (1955), and Patrick (1966)—advocated for financial efficiency to ensure the smooth flow of capital across countries, playing an intermediation role that is a critical determinant of economic growth. An efficient financial system is the outcome of financial institutional development in capital markets and the diversification of financial instruments (Ndlovu 2013). An efficient financial system can achieve, through the adoption and diffusion of technological improvements, new financial institutions, new financial intermediation, and efficiency in financial services (Wachter 2006; Saqib 2015). The nexus between financial sector development and economic growth has been well tested and documented in a large number of empirical studies

(e.g., Patrick 1966; Jung 1986; Gregorio and Guidotti 1995; Levine 1997; Rahman 2004; Khan et al. 2005; Ilhan 2008; Wadud 2009).

Finance researchers—including Arestis and Demetriades (1997), Demetriades and Luintel (1996), and King and Levine (1993b)—have suggested that the financial sector contributes to the economic growth of developed countries, greatly influencing the pursuit of continuous financial innovation in the financial system. Moreover, financial innovation provides opportunities for growth in the financial sector (Napier 2014), thus boosting economic growth. Financial innovation also allows for the expansion of financial services through the development of new financial institutions, financial instruments, financial reporting, technology, and market knowledge (Michalopoulos et al. 2009). According to Merton (1992) and Tufano (2003), financial innovation responds to problems and opportunities in the market as well as asymmetric information.

Over the past decade, many empirical studies have confirmed a positive association between financial innovation and economic growth (e.g., Lumpkin 2010; Sekhar 2013). Financial innovation helps economic growth by allowing for capital mobilization, efficient financial intermediation, capital accumulation, and enhanced overall efficiency in financial institutions. That is why financial innovation is treated as a prime catalyst for financial development (Laeven et al. 2015). As with other innovations, financial innovation is a continuous process of bringing about changes in the financial system through the improvement and diversification of financial products and processes (Sood and Ranjan 2015). Demetriades and Andrianova (2005) argued that emergence of new financial assets and services in the financial system improves banking-sector performance and capital-market development, eventually boosting economic growth in the host country. Schumpeter (1912, 1982), meanwhile, argued that robust financial systems comprise efficient financial institutions, diversified financial assets and services, comprehensive financial services coverage, efficient channels for economic resource mobilization, and available credit flows for investment across a country. Financial innovation made credit available in economies by way of new and hybrid forms of financial institutions (e.g., microfinance institutions) outside the framework of formal banking systems (Blair 2011).

Thus far, the existing empirical literature has highlighted a definite nexus between financial innovation and economic growth, and the effect of financial innovation is especially evident in developing countries. The present study is unique in that it aimed to investigate both symmetric and asymmetric relationships by applying newly developed autoregressive distributed lag (ARDL) bounds testing (Pesaran et al. 2001) and nonlinear ARDL (NARDL) (Shin et al. 2014) to cover a wide range of time series data, from Q1 1975 to Q4 2016. To our knowledge, this is the first research to investigate financial innovation's effect on economic growth in South Asian countries.

The rest of this paper proceeds as follows. Section "Literature review" provides a literature review concerning the nexus between financial innovation and economic growth. Section "Methods" presents the research data and the research model, as well as the econometric methodology used for analysis. Section "Data analysis and interpretation" concerns model estimation along with in-depth interpretation and discussion. Section "Conclusions and recommendations" concludes the paper and discusses the scope for further research.

Literature review

Financial sector development generates economic growth because an efficient financial sector mobilizes economic resources in an economy (Ndlovu 2013). Moreover, an efficient financial system drives the processes of creating wealth, trade, and, most importantly, capital formation (Ahmed 2006). Innovation in financial institutions enhances the level of efficiency, and efficient financial systems act as catalysts for economic development through financial development (Saad 2014; Michael et al. 2015).

In modern economies, innovation plays a key role in transforming a static economy into a dynamic one with the adoption and diffusion of technological advancement, new organizational structures, production processes, and management styles. Today, innovation not only involves the creation of new things but also provides solutions to ongoing problems in an economy (Kotsemir and Abroskin 2013).

Considering Schumpeterian endogenous growth theory, many empirical studies have shown that financial services promote economic growth (e.g., Aghion and Howitt 1990; Howitt 2000; Dosi et al. 2010; Phillips et al. 1999). King and Levine (1993a) argued that financial services expand financial activities, increase the rate of capital accumulation, and boost financial development; the introduction of new financial services in a financial system is the key output of financial innovation. The literature has also argued for financial innovation's role in financial development by way of improving financial efficiency in financial systems. Financial innovation assists financial development through the expansion of financial services by offering new financial products, optimizing economic resource mobilization through efficient payment mechanisms, reducing investment risks, and accelerating capital formation. Therefore, financial innovation is regarded as an engine of financial growth in both developed and developing countries (Miller 1986, 1992). Ahmed (2006) argued that financial-sector growth expedites cross-county trade, wealth creation, and capital accumulation in an economy. Ahmad and Malik (2009), meanwhile, argued that financial-sector development reduces asymmetric information costs and enhances resource mobilization, thus boosting economic growth.

Financial innovation is associated with the development of new financial instruments, corporate structures, financial institutions, and accounting and financial reporting techniques (Michalopoulos et al. 2011). Financial innovation is considered the "engine" driving a financial system toward its goal of improving the performance of what economists call the "real economy" (Merton 1992). Michalopoulos et al. (2011) measured financial innovation as the growth of financial development, using the growth rate of the ratio of bank credit to the private sector to the GDP as a proxy for financial innovation. However, since nothing is *completely* new, financial innovations often involve adaptations or modifications of existing products and processes that ensure efficiency and hence profitability.

Empirical research in finance has proposed four distinct hypotheses to explain the nexus between financial innovation and economic growth. First, the supply-leading hypothesis suggests that financial innovation can positively affect a country's economic growth (Beck 2010). This hypothesis suggests that financial innovation in a financial system accelerates economic growth by expediting the process of capital accumulation, enhancing efficiency in financial institutions, improving financial services, and making financial intermediation more efficient. Shittu (2012) found that efficient financial

intermediation significantly influenced economic growth in Nigeria. Second, the demand-leading hypothesis suggests that economic growth attracts financial innovation in an economy. This hypothesis suggests that the expansion of economic activities, real sector development, and increased domestic and international trade place pressure on financial systems to improve payment mechanisms, make financial institutions more efficient, and diversify financial assets to reduce investment risks. Third, the feedback hypothesis suggests bidirectional causality between financial innovation and economic growth. Bara and Mudxingiri (2016) and Bara et al. (2016), for example, confirmed bidirectional causality between financial innovation and economic growth. Lumpkin (2010) and Sekhar (2013), however, found no causality between financial innovation and economic growth.

Given both the positive and negative effects of financial innovation, many studies have explored the positive association between financial innovation and economic growth in a host country. Sood and Ranjan (2015), for example, studied India while Qamruzzaman and Jianguo (2017) studied Bangladesh. Despite the positive associations, negative aspects have also been found in the nexus between financial innovation and economic growth. Adu-Asare Idun and Aboagye (2014) used ARDL to explore the negative association between financial innovation and economic growth in Ghana. They argued that innovative financial products negatively influenced saving propensity in Ghana, encouraging the withdrawal of savings from banks and thus creating a problem of bank liquidity. Similarly, Ansong et al. (2011) argued that excessive financial innovation adversely affected banks with diversified financial products.

Financial innovation expedites the overall performance of financial systems through the emergence of new financial institutions, financial instruments, and new channels for providing services to an economy (Bourne and Attzs 2010).

Methods

Data

This study used quarterly time series data for the period Q1 1975 to Q4 2016. Data were collected from publicly available sources, including the World Development Indicators published by the World Bank (2017), the World Economic Outlook (2017) published by the IMF, the Bangladesh Economic Review published by the Ministry of Finance (2016), and the South Asian Economy published by the Asian Development Bank (2017). The econometric analysis package EViews 9.5 (2017) was used for data analysis.

We considered the growth rate of gross domestic product (GDP) per capital as a proxy for economic growth (Y), along with one independent variable as a proxy for financial innovation.

Financial innovation is a continuous process associated with the emergence of new financial institutions, new financial assets, improved financial services, and improved payment mechanisms (Sood and Ranjan 2015). It is not possible to gauge the effect of financial innovation on economic growth by considering only a single indicator; there is no agreed-upon proxy in the literature. Hence, researchers have used various proxies. Laeven et al. (2015) argued that financial innovation involves not only the emergence of new financial instruments and products but also developments in the financial

system via new financial reporting processes, improved credit rationing, and advancements in data processing. Therefore, the selection of proxies for financial innovation should cover wide-ranging aspects of the financial system.

Research in the past decade has used bank credit to the private sector as a proxy indicator for financial innovation (e.g., Adu-Asare Idun and Aboagye 2014; Michalopoulos et al. 2009). However, many empirical studies have used the ratio of broad-to-narrow money as a proxy for financial innovation (e.g., Bara and Mudxingiri 2016; Bara et al. 2016; Qamruzzaman and Jianguo 2017; Ansong et al. 2011; Mannah-Blankson and Belnye 2004). This study followed the same path for investigation.

We also used a set of macroeconomic variables as control variables to bring about robustness in estimation. These included trade openness (TO), gross capital formation (GCF), and domestic credit to private sector (DCP).

Trade openness (TO) indicates the extent to which an economy relies on international trade. It is calculated considering both imports and exports in relation to GDP. A higher ratio implies a profound reliance on international trade. TO positively influences the production level of an economy by creating opportunities to serve foreign over domestic markets. TO also helps increase productivity through technological advancement, knowledge sharing, and increased labor productivity.

Gross capital formation (GCF) is a key factor in economic growth. Solow (1957) argued that physical capital accumulation increases productivity in an economy. GCF refers to the net addition of physical capital or assets after deducting disposal. Empirical studies such as Ghali and Ahmed (1999), Levine and Renelt (1992), and Barro (1991) have confirmed positive associations between GCF and economic growth.

Domestic credit to private sector (DCP) signifies capital flow to the private sector from financial institutions in the form of loans, trade credits, and nonequity investments. Studies such as Were et al. (2012), Beck and Levine (2004), and Ang (2008) found positive contributions to economic growth via DCP. All of the variables were converted into natural logarithms to ensure accuracy and robustness in the estimations (Shahbaz et al. 2016). Table 1 summarizes the descriptive statistics of the research variables.

Autoregressive distributed lag (ARDL)

Based on our research variables, the generalized form of our study model can be represented as follows:

$$\overset{Economic\ Growth}{\widehat{Y}} = \overset{Financial\ Innovation}{\widehat{FI}}, \overbrace{TO, GCF, DCP}^{Macroeconomic\ Variables} \quad (1)$$

After transforming Eq. (1) into a linear form, it can be represented as follows:

$$lnY_t = \alpha_0 + \beta_1 lnFI_t + +\beta_2 \ln TO_t + \beta_3 lnGCF_t + \beta_4 lnDCP_t + \epsilon_t, \quad (2)$$

where Y is economic growth, FI is financial innovation, GCF is gross capital formation, TO is trade openness, and DCP is domestic credit to private sector. The model coefficients of $\beta 1$ to $\beta 4$ represent long-run elasticity, and ϵt is the error correction term. However, Eq. (2) can only represent the long-run impact on economic growth from an

Table 1 Summary of descriptive statistics of research variables

	Descriptive statistics					Correlation Matrix					
	lnY	lnFI	lnTO	lnGCF	lnDCP		lnY	lnFI	lnTO	lnGCF	lnDCP
Country: Bangladesh											
Mean	0.827	3.322	3.24	2.215	2.757	lnY	1				
Median	1.108	3.26	3.206	2.18	2.864	lnFI	0.395	1			
Maximum	2.046	4.166	3.873	4.992	3.782	lnTO	0.444	0.284	1		
Minimum	−3.177	2.122	2.397	0.426	0.65	lnGCF	0.261	−0.349	−0.175	1	
Std. Dev.	1.019	0.557	0.364	0.708	0.816	lnDCP	0.265	0.454	0.216	−0.031	1
Skewness	−1.972	−0.062	0.088	1.113	−0.83						
Kurtosis	7.494	1.966	2.278	7.74	2.978						
Observations	42	42	42	42	42						
Country: India											
Mean	1.314	3.821	3.046	2.031	3.282	lnY	1				
Median	1.455	3.763	2.928	2.322	3.186	lnFI	0.372	1			
Maximum	2.169	4.367	4.02	3.457	3.948	lnTO	0.317	0.235	1		
Minimum	−0.429	3.11	2.366	−2.948	2.54	lnGCF	0.264	0.176	0.283	1	
Std. Dev.	0.652	0.337	0.52	1.143	0.354	lnDCP	0.463	0.162	0.311	0.123	1
Skewness	−0.926	0.003	0.584	−2.512	0.475						
Kurtosis	3.083	2.311	1.942	10.919	2.668						
Observations	42	42	42	42	42						
Country: Pakistan											
Mean	0.503	3.79	3.515	1.519	3.16	lnY	1				
Median	0.722	3.774	3.517	1.576	3.186	lnFI	−0.05	1			
Maximum	1.9	4.075	3.661	2.919	3.394	lnTO	0.097	0.117	1		
Minimum	−2.415	3.516	3.322	−1.389	2.77	lnGCF	0.168	−0.066	0.076	1	
Std. Dev.	0.935	0.127	0.083	0.803	0.149	lnDCP	0.203	0.049	0.271	0.144	1
Skewness	−0.959	0.232	−0.456	−1.191	− 0.961						
Kurtosis	3.931	2.467	2.865	6.04	3.748						
Observations	42	42	42	42	42						
Country: Sr Lanka											
Mean	1.232	3.505	4.218	2.109	3.103	lnY	1				
Median	1.353	3.484	4.228	2.178	3.119	lnFI	0.272	1			
Maximum	2.118	3.85	4.484	4.411	3.571	lnTO	0.133	0.062	1		
Minimum	−2.026	2.887	3.836	−0.691	2.177	lnGCF	0.351	−0.197	− 0.016	1	
Std. Dev.	0.714	0.215	0.166	1.019	0.402	lnDCP	0.214	0.751	−0.083	−0.054	1
Skewness	−2.619	−0.975	− 0.619	− 0.457	−0.799						
Kurtosis	12.058	3.955	2.555	3.584	2.686						
Observations	42	42	42	42	42						

explanatory variable. To gauge long-run cointergration and short-run elasticities in the model, we used a cointergration test.

Various cointegration tests have been used in recent decades, including Engle and Granger (1987), based on residuals, and Johansen (1998, 1991, 1995) and Johansen and Juselius (1990), based on maximum likelihood tests. Earlier models had limitations with regard to the order of integration of variables. To address this issue, Pesaran and Shin

(1998) proposed a new cointegration model with greater flexibility in the variable integration order—namely, I(0) and/or I(1). This was further extended by Pesaran et al. (2001) and Narayan (2004). Moreover, the error correction term can be derived from ARDL through linear transformation. Thus, Eq. (2) can be rewritten in ARDL form as follows:

$$\begin{aligned}\Delta lnY_t = \alpha_0 &+ \sum_{i=1}^{n} \mu_1 \Delta \ \ln Y_{t-i} + \sum_{i=0}^{n} \mu_2 \Delta \ \ln FI_{t-i} + \sum_{i=0}^{n} \mu_3 \Delta lnTO_{t-i} + \sum_{i=0}^{n} \mu_4 \Delta lnGCF_t \\ &+ \sum_{i=0}^{n} \mu_5 \Delta lnDCP_t + \gamma_0 \ \ln Y_{t-1} + \gamma_1 lnFI_{t-1} + \gamma_2 lnTO_{t-1} + \gamma_3 \ \ln GCF_{t-1} \\ &+ \gamma_4 lnDCP_{t-1} + \omega_t \end{aligned} \tag{3}$$

Further, Eq. (3) can be rewritten into matrix form where each study variable serves as the dependent variable in the model (see Eq. (4)). To gauge the existence of long-run and short-run cointegration, we formulated hypotheses in both cases. For the long run, the null hypothesis ($H0$) is no cointergration existence [$H0 : \gamma 11 \ to \ \gamma 55 = 0$]. The alternative hypothesis ($H1$) is the existence of cointergration [$H0 : \gamma 11 \ to \ \gamma 55 \neq 0$]. For short-run, the null hypothesis ($H0$) is no short-run relationship [$H0 : \mu 11 \ to \ \mu 55 = 0$], and in the alternative hypothesis ($H1$), there is a short-run relation [$H0 : \mu 11 \ to \ \mu 55 \neq 0$]:

$$\begin{aligned}(1-B)\begin{bmatrix} lnY \\ lnFI \\ lnTO \\ lnGCF \\ lnDCP \end{bmatrix} &= \begin{bmatrix} \alpha_{01} \\ \alpha_{02} \\ \alpha_{03} \\ \alpha_{04} \\ \alpha_{04} \end{bmatrix} + \sum\nolimits_{i=1}^{k} 1-B \begin{bmatrix} lnY \\ lnFI \\ lnTO \\ lnGCF \\ lnDCP \end{bmatrix}_{t-i} \times \begin{bmatrix} \mu_{11} & \mu_{12} & \mu_{13} & \mu_{14} & \mu_{15} \\ \mu_{21} & \mu_{22} & \mu_{23} & \mu_{24} & \mu_{25} \\ \mu_{31} & \mu_{32} & \mu_{33} & \mu_{34} & \mu_{35} \\ \mu_{41} & \mu_{42} & \mu_{43} & \mu_{44} & \mu_{45} \\ \mu_{51} & \mu_{52} & \mu_{53} & \mu_{54} & \mu_{55} \end{bmatrix} \\ &+ \begin{bmatrix} lnY \\ lnFI \\ lnTO \\ lnGCF \\ lnDCP \end{bmatrix}_{t-1} \times \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} \end{bmatrix} + \begin{bmatrix} \omega \\ \omega \\ \omega \\ \omega \\ \omega \end{bmatrix}_t \end{aligned} \tag{4}$$

where Δ is the first difference operator, and the coefficients $\mu 1 \ to \ \mu 5$ and $\gamma 0 \ to \ \gamma 4$ represent short-run and long-run elasticities, respectively. In addition, $\alpha 0$ is the constant term, and ωt represents white noise.

Acceptance or rejection of the hypothesis is based on a comparison between the f-statistic and the critical value. We used the critical value proposed by Pesaran et al. (2001), Narayan (2004), and Narayan and Narayan (2005) to make a conclusive statement about cointegration. If the f-statistic was higher than the upper bound of the critical value, it indicated the existence of long-run associations among the variables.

Nonlinear ARDL approach

Estimating long-run association by applying the cointegration test is based on the symmetric assumption that the explanatory variable linearly influences the dependent variable. In reality, movements in a variable can change in either direction, positive or

negative. Considering positive and negative changes in an independent variable, we tried to investigate the asymmetric relationship between variables by applying the recently developed nonlinear ARDL approach proposed by Shin et al. (2014).

In the process of formulating nonlinear ARDL by considering the previous ARDL Eq. (4), we decomposed the independent variable into two additional sets of series based on positive and negative changes, following Delatte and López-Villavicencio (2012), Verheyen (2013), Bahmani-Oskooee and Mohammadian (2016), and Bahmani-Oskooee et al. (2005). We decomposed positive and negative changes for financial innovation (FI) denoted by FI+ and FI− as follows:

$$\begin{cases} POS(FI)_t = \sum_{L=1}^{t} lnFI_L^+ = \sum_{L=1}^{T} MAX(\triangle lnFI_L, 0) \\ NEG(FI)_t = \sum_{L=1}^{t} lnFI_k^- = \sum_{L=1}^{T} MIN(\triangle lnFI_L, 0) \end{cases} \tag{5}$$

Now, we can rewrite Eq. (3) in nonlinear form by incorporating a new series of positive and negative changes. The nonlinear ARDL is as follows:

$$\begin{aligned} \triangle lnY_t = {} & \alpha_0 + \sum_{i=1}^{n} \mu_1 \triangle lnY_{t-i} + \sum_{i=0}^{n} \mu_2^+ \triangle lnPOS(FI)_{t-i} + \sum_{i=0}^{n} \mu_2^- \triangle lnNEG(FI)_{t-i} \\ & + \sum_{i=0}^{n} \mu_3 \triangle lnTO_{t-i} + \sum_{i=0}^{n} \mu_4 \triangle lnGCF_t + \sum_{i=0}^{n} \mu_5 \triangle lnDCP_t + \gamma_0 lnY_{t-1} \\ & + \gamma_1^+ lnPOS(FI)_{t-1} + \gamma_1^- lnNEG(FI)_{t-1} + \gamma_2 lnTO_{t-1} + \gamma_3 lnGCF_{t-1} \\ & + \gamma_4 lnDCP_{t-1} + \omega_t \end{aligned} \tag{6}$$

In Eq. (6), the coefficients of $\mu 1$ *to* $\mu 5$ denote short-run elasticities, and the coefficients of $\gamma 0$ *to* $\gamma 4$ denote long-run elasticities in the model. To gauge both long-run and short-run asymmetric tests, we ran the Wald test. *Yt* represents economic growth, *It* represents financial innovation, *TOt* represents trade openness, *GCFt* represents gross capital formation, and *DCFt* represents domestic credit to private sector. Further, n represents optimal lag, which was determined using the Akaike information criterion (AIC). According to Shin et al. (2014), the confirmation of long-run cointegration using the bounds test approach is also applicable by comparing the f-statistic (Wald test) and the critical value, as proposed by Pesaran et al. (2001). The null hypothesis is $\gamma 0 = \gamma 1 + = \gamma 1 - = 0$.

Data analysis and interpretation

Unit root test

Investigating cointegration by applying ARDL bounds testing is not influenced by the order of integration of variables. However, empirical studies have suggested that the existence of a second-order integrated I(2) variable can produce spurious estimations in the regression model. Therefore, to ascertain the variable order of integration, we estimated the stationary test by applying the ADF test proposed by Dickey and Fuller (1979), the P-P test proposed by Phillips and Perron (1988), and the KPSS proposed by

Table 2 Unit root test estimation

	ADF			P-P			KPSS		
	At level	Δ	I	At level	Δ	I	At level	Δ	I
Bangladesh									
lnY	−3.90[b]	–	I(0)	–	−2.77[a]	I(0)	0.06	0.38[a]	I(1)
lnFI	−1.26	−5.95[a]	I(1)	−1.11	−7.52[a]	I(1)	0.19[b]	–	I(0)
lnDCP	− 1.03	−5.15[a]	I(1)	−0.89	−6.29[a]	I(1)	0.22[a]	–	I(0)
lnTO	−2.25	− 5.74[a]	I(1)	−1.17	− 7.09[a]	I(1)	0.17[b]	–	I(0)
lnGCF	−1.25	−4.96[b]	I(1)	−2.44	−3.86[b]	I(1)	0.11	0.21[b]	I(1)
India									
lnY	−4.96[b]	–	I(0)	−4.93[a]	–	I(0)	0.07	0.29[a]	I(1)
lnFI	− 3.17	−4.82[a]	I(1)	− 2.50	−4.74[a]	I(1)	0.08	0.39[a]	I(1)
lnDCP	−3.69[b]	–	I(0)	−3.69[b]	–	I(0)	0.11	0.15[b]	I(1)
lnTO	−3.19	− 3.66[b]	I(1)	− 3.41	−6.37[a]	I(1)	0.12	0.17[b]	I(1)
lnGCF	−2.39	−3.98[b]	I(1)	−1.98[c]	−6.60[a]	I(1)	0.09	0.19[b]	I(1)
Pakistan									
lnY	−4.75[b]		I(0)	−4.71[b]		I(0)	0.11	0.39[a]	I(1)
lnFI	−1.63	−5.6[a]	I(1)	−1.57	−5.85[a]	I(1)	0.08	0.55[a]	I(1)
lnDCP	−5.94		I(0)	−6.01[a]		I(0)	0.18	0.28[a]	I(1)
lnTO	−2.66	−7.1[a]	I(1)	−2.68	−7.46[a]	I(1)	0.10	0.47[a]	I(1)
lnGCF	−1.14	−5.71[b]	I(1)	−1.51	−5.72[a]	I(1)	0.09	0.42[a]	I(1)
SriLanka									
lnY	−4.68[a]		I(0)	−4.66[a]		I(0)	0.28[a]		I(0)
lnFI	−1.17	−7.91[a]	I(1)	−1.05	−7.76[a]	I(1)	0.12	0.37[b]	I(1)
lnDCP	−9.52[a]		I(0)	−8.94[a]		I(0)	0.47[a]		I(0)
lnTO	−1.018	−5.26[a]	I(1)	−1.28	−5.26[a]	I(1)	0.11	0.59[a]	I(1)
lnGCF	−1.68	−5.98[b]	I(1)	−1.33	−6.16[a]	I(1)	0.14	0.48[b]	I(1)

Note 1. Y for economic growth, FI for financial innovation, DCP for Domestic Credit to Private Sector, TO of Trade Openness, and GCF for Gross Capital Formation
Note 2. All the variables converted into the natural log for estimation
Note 3. ADF for Augmented Dickey-Fuller, P-P for Phillips-Perron, and KPSS for Kwiatkowski-Phillips-Schmidt-Shin
Note 4. [a]/[b]/[c] indicates significance level as 1, 5, and 10% respectively
Note 5. "I" for an order of integration, Δ for first difference operator,

Kwiatkowski et al. (1992). The stationary test estimations are shown in Table 2. The stationary test confirmed the nonexistence of second-order integrated variables, indicating that the order of variable integration was either at the level of I(0) or after the first difference I(1). Given such variable characteristics, we ran the cointegration test to ascertain long-run associations.

ARDL bounds testing

Cointegration

We investigated long-run association by applying the ARDL bounds testing approach proposed by Pesaran et al. (2001) under the symmetric assumption using Eq. (4), where each variable serves as the dependent variable. Table 2 shows the cointegration test results. When economic growth (Y) serves as the dependent variable, the f-statistics *FBD* = 16.95, *IND* = 13.40, *FPAK* = 14.66, and *FSL* = 8.91, which are higher than the critical value of the 1% level of significance. In addition, when the remaining variables

serve as the dependent variables in the model, the calculated f-statistics are less than the lower bound critical value (3.74). This suggests that the null hypothesis, no cointegration, cannot be accepted; rather, the study confirms the existence of long-run cointegration between FI, TO, GCF, and DCP.

Long-run and short-run estimation for the period Q1 1975 to Q4 2016

We confirmed long-run cointegration between economic growth and its determinant when economic growth (Y) serves as the dependent variable. Here, we estimate both long-run and short-run elasticities using Eq. (3). Table 3 shows the estimated results.

For the long run (see Table 4, Panel A), all explanatory variables were statistically significant and positively influenced economic growth, which is supported by previous literature. Among all repressors, the magnitude of the effect of financial innovation on economic growth is noteworthy. For instance, we found that a 1% increase in financial innovation could increase economic growth by 1.22% in Bangladesh, 1.795% in India, 1.17% in Pakistan, and 0.91% in Sri Lanka. This suggests that the emergence of financial innovation plays a decisive role in economic growth. Silve and Plekhanov (2014) suggested that financial innovation plays an essential role in the efficient mobilization of economic resources, efficient financial intermediation, and the emergence of high-quality financial institutions, thereby accelerating economic growth. Wachter (2006), meanwhile, argued that financial innovation contributes to economies by restructuring and transforming financial systems with innovative institutions and financial services.

The short-run model elasticities are presented in Table 4 (panel B). The coefficient of the error correction term ($ECTt-1$) represents the speed of adjustment toward long-run equilibrium from any short-run shock in the repressors. The error correction term $ECTt-1$ in each model was negative and statistically significant along with higher coefficients. This suggests that disequilibrium can adjust to the long run with higher speed, having any prior-year shock in the explanatory variables. We also found that the impact of financial innovation on economic growth was positively associated, having less significant elasticities.

As in previous empirical studies (e.g., Narayan and Narayan 2005; Qamruzzaman and Jianguo 2017; Paul 2014), we performed a model stability test through four residual diagnostic tests. The test for autocorrelation confirmed the absence of serial

Table 3 ARDL bound testing results

Model	Country							
	Bangladesh		India		Pakistan		Sri Lanka	
	F-stat	Remark	F-stat	Remark	F-stat	Remark	F-stat	Remark
F(*Y*) = (*Y*/*FI*, *TO*, *GCF*, *DCP*,	16.95	Present	13.40	Present	14.66	Present	8.91	Present
F(*FI*) = (*FI*/*Y*, *TO*, *GCF*, *DCP*)	2.17	Present	2.85	Present	1.15	Absent	1.18	Present
F(*TO*) = (*TO*/*Y*, *FI*, *GCF*, *DCP*)	3.19	Absent	1.65	Absent	3.15	Absent	2.17	Absent
F(*GCF*) = (*GCF*/*Y*, *FI TO*, *DCP*)	2.18	Absent	3.85	Absent	2.12	Absent	1.18	Absent
F(*DCP*) = (*DCP*/*Y*, *FI*, *TO*, *GCF*)	3.25	Absent	1.88	Absent	2.28	Absent	4.58	Absent
Critical value	K	1%						
Pesaran et al. (2001)	4	3.74	5.06					
Narayan (2004)	4	3.96	5.49					

Table 4 Long-run and short-run coefficients under ARDL

	Country							
Panel A: long-run estimation								
Dependent variable Y: Repressors	Bangladesh		India		Pakistan		Sri Lanka	
	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat	Coefficient	t-stat
lnFI	1.22[a]	2.69	1.79[a]	1.56	1.17[a]	2.80	0.91[a]	1.83
lnTO	0.43[b]	3.31	0.16[a]	0.68	0.33[a]	3.76	0.07[b]	0.98
lnGCF	0.16*	2.33	0.22[b]	−1.01	0.41*	1.96	0.14[b]	4.22
lnDCP	0.18[a]	2.51	0.04[b]	0.47	0.15[b]	1.45	0.47[a]	1.65
C	−3.09[a]	−0.12	−2.6	−0.21	− 3.21	−0.19	7.47	9.85
Panel B: Short-run estimation								
ECT_{t-1}	−0.93[b]	−8.43	− 0.97[a]	−5.39	− 0.95[a]	−4.64	− 0.75[a]	−5.98
ΔlnFI	0.22[a]	2.99	0.26[b]	0.83	0.11[b]	4.04	0.16[a]	1.59
ΔlnTO	0.36[b]	3.91	0.09	0.66	0.36[b]	3.97	0.19[b]	1.14
ΔlnGCF	0.09[b]	2.84	−0.16	−3.86	0.09[a]	1.72	0.08[a]	3.79
ΔlnDCP	0.16[b]	2.91	0.04[b]	0.40	−0.16	−1.58	0.04[a]	1.76
Panel C. Residual Diagnostic Test								
R^2	0.78		0.89		0.79		0.72	
δ	0.13		0.28		0.15		0.45	
$F^2_{statistics}$	25.25[a]		4.51[a]		1.61[a]		4.15[a]	
$x^2_{Autocorrelation}$	0.47[0.49]		0.97[0.85]		1.15[0.52]		0.89[0.25]	
$x^2_{Heteroskedasticity}$	1.87[017]		1.15[0.37]		1.82[0.41]		2.14[0.47]	
$x^2_{Normality}$	7.28[0.19]		6.94[0.29]		1.61[0.51]		1.89[0.18]	
x^2_{RESET}	1.54[013]		1.26[0.29]		0.69[0.48]		0.81[0.38]	

Note 1. [a]/[b] indicates 1% and 5% level of significance, respectively

correlation, and the heteroscedasticity test showed the model to be free of the problem of heteroscedasticity. The Jarque–Bera normality test suggested the errors were normally distributed. The RESET test confirmed the model construction and f-statistics, ensuring model prediction and accuracy. Finally, the adjusted *R*2 showed the model's ability to explain variance; 78, 89, 79, and 72% of variance could be explained by the proposed model for Bangladesh, India, Pakistan, and Sri Lanka, respectively.

Asymmetric estimation for the period 1975–2016

Table 5 shows the nonlinear ARDL estimation (Shin et al. 2014) using Eq. (3) (see section "Methods"). We found that FI, TO, GCF, and DCP explained economic growth in Bangladesh by 86%, India by 79%, Pakistan by 89%, and Sri Lanka by 83%, and the remaining variation was explained by the error correction term. Also, the residual diagnostic test confirmed the model was free of serial correlation ($x^2_{Autocorrelation}$), had no problem of heteroscedasticity ($x^2_{Heteroskedasticity}$), and had normal residual distribution ($x^2_{Normality}$). In addition, the Ramsay RESET test confirmed that the model's functional form was well established. The coefficient of *Fpss* indicated long-run cointergration f-statistics derived from the Wald test. We found that the f-statistic of each model was higher than the upper bound of the critical value at the 1% level of significance, extracted from the critical value proposed by Pesaran

Table 5 Non-linear ARDL estimation results

	Country							
	Bangladesh		India		Pakistan		Sri Lanka	
	coefficients	t-stat	coefficients	t-stat	coefficients	t-stat	coefficients	t-stat
Panel – A: Long-run Estimation								
C	−3.16[a]	−1.41	−26.65	−2.39	18.52[a]	1.33	−3.79[a]	−2.73
Y(−1)	−0.72[a]	−0.18	−2.29	−2.52	−0.76[a]	− 3.58	− 1.38[a]	−4.37
FI_P(− 1)	2.56[b]	2.60	5.38[b]	−2.27	4.92[a]	1.58	0.92[a]	1.76
FI_N(−1)	−4.07[b]	−3.51	−7.11[a]	− 1.96	−6.73[a]	− 1.61	−0.18[a]	−1.41
DCP(−1)	−8.09[a]	−5.74	16.73	2.16	−7.98[a]	−2.57	1.43	0.97
GCF(−1)	−4.52[b]	−5.42	−0.81	− 0.56	−0.83	−2.52	− 1.93	− 2.68
TO(− 1)	7.86[a]	5.17	−7.35	−1.37	1.74[a]	0.35	7.27	2.90
Panel – B: Short-run Estimation								
ΔY(−1)	−0.53[a]	−1.78	1.95[a]	3.39			0.78[b]	3.03
ΔY(−2)	−0.35	− 1.63	1.55[b]	3.58	−0.65	−2.68	1.20[b]	3.94
ΔY(−3)	− 0.55[b]	−3.15	−0.22[b]	− 0.04	−0.61[a]	− 1.78		
ΔY(−4)	−0.48[a]	4.16	−0.14[b]	− 0.39	− 0.77[b]	−2.63	−0.51[b]	−2.42
ΔFI_P(−1)	0.14[a]	3.84	.03[a]	1.93	0.78[a]		−2.10[a]	−4.29
ΔFI_P(−2)	0.39[a]	1.88	0.58[a]	1.19	0.9[b]	1.60	−1.77[b]	−3.97
ΔFI_P(− 3)	0.01[a]	0.87	1.74[b]	1.02	0.07[b]	0.91	−0.49[b]	−1.67
ΔFI_P(−4)	0.71[a]	2.24	1.54[b]	2.44	0.04[a]	2.19	−3.42[a]	−2.33
ΔFI_N(−1)	0.07[a]	1.54	−0.87[b]	−1.89	− 0.58[a]	− 0.82	1.41[b]	1.21
ΔFI_N(−2)	−0.96[a]	−2.73	− 0.65[b]	− 2.13	− 1.78[a]	− 1.52	5.76[b]	2.98
ΔFI_N(−3)	− 1.04[b]	− 2.72	− 0.67[b]	− 0.94	− 0.33[a]	− 0.92	1.14[b]	1.08
ΔFI_N(−4)	0.96[a]	3.32	− 1.12[a]	− 1.42	− 2.93[a]	−2.06	− 14.88	−1.54
ΔDCP(−1)	6.66[b]	3.42			17.21*	2.81	−5.43[b]	−3.57
ΔDCP(−2)	2.97[b]	1.98	−13.87[b]	−2.22			−5.29[b]	−3.86
ΔDCP(−3)					12.70[a]	2.59	−1.67[b]	− 1.37
ΔDCP(−4)	−6.29[b]	−4.15	− 1.21[b]	−2.48	17.21*	2.81	−3.97[b]	−2.53
ΔGCF(−1)	3.41[b]	5.34					1.35[b]	2.62
ΔGCF(−2)	1.46[b]	3.35			0.40[b]	1.36	0.22[b]	0.68
ΔGCF(−3)	1.04[b]	4.38	0.16[b]	1.11	0.81[a]	2.18	0.33[a]	1.29
ΔGCF(−4)			0.57[b]	1.95	0.25	1.03	−1.45[a]	−0.17
ΔTO(−1)	−4.12[b]	−4.57	− 4.48	− 1.13	8.96[b]	2.28		
ΔTO(−2)	−2.61	−2.96	17.21	1.72	11.74[b]	3.72		
ΔTO(−3)	−3.11[b]	−3.89	3.70	0.77	2.95[b]	0.93		
ΔTO(−4)	−3.46[b]	−4.45	10.99	2.12	14.03[b]	3.57		
Panel – C: Symmetric Estimation								
F_{pss}	19.43		15.79		13.72		9.15	
L_{EX}^{+}	3.47[a]		2.43[a]		6.47[a]		0.67[a]	
L_{EX}^{-}	−5.65[a]		−3.10[a]		10.50[a]		−0.13[b]	
W_{LR}	4.78(0.002)		1.33(0.003)		2.70(0.009)		1.17(0.001)	
W_{SR}	12.17(0.004)		6.29(0.007)		6.18(0.004)		5.55(0.008)	

Table 5 Non-linear ARDL estimation results *(Continued)*

	Country							
	Bangladesh		India		Pakistan		Sri Lanka	
	coefficients	t-stat	coefficients	t-stat	coefficients	t-stat	coefficients	t-stat
Panel – D: Residual Diagnostic and Model Stability Test								
R^2	0.86		0.79		0.89		0.83	
δ	0.27		0.32		0.21		0.44	
$F^2_{statistics}$	10.42[a]		5.28[a]		3.07[a]		3.73[b]	
$x^2_{Autocorrelation}$	2.20(0.18)		5.84(0.24)		4.84(0.45)		6.75(0.59)	
$x^2_{Heteroskedasticity}$	1.96(0.26)		1.40(0.49)		1.19(0.18)		1.49(0.18)	
$x^2_{Normality}$	1.61(0.41)		1.51(0.77)		1.14(0.56)		1.64(0.43)	
x^2_{RESET}	1.19(0.34)		0.97(0.23)		6.29(0.18)		3.29(0.18)	

Note 1. The superscript "+" and "-" indicate positive and negative changes, respectively
Note 2. F_{pss} for F-statistics from Wald test for long-run cointegration
Note 3. L^+_{FI} and L^-_{FI} for long-run coefficients for financial innovation positive and negative changes
Note 4. W_{LR} refers to the Wald test of long-run symmetry\
Note 5. W_{SR} refers to the Wald test of the additive short-run symmetry condition
Note 6. [a] and [b] denote significance at the 1 and 5%, levels, respectively

et al. (2001). This confirms the existence of long-run cointergration between FI, TO, GCF, and DCP and economic growth for the period Q1 1975 to Q4 2016. This finding is consistent with earlier ARDL tests (see Table 2).

Next, we investigated the existence of an asymmetric relationship between financial innovation and economic growth by applying the Wald test. In the Table 5 (panel C), *WLR* indicates the Wald test statistic for long-run symmetry, and *WSR* indicates the Wald test statistic for short-run symmetry. For the long run, the null hypothesis regarding the existence of a symmetric relationship was rejected at the 1% level of significance. Specifically, the Wald statistics were $(BD) = 4.78$ $(p = 0.002)$ for Bangladesh, $W\ (BD) = 1.33$ $(p = 0.003)$ for India, $WLR\ (BD) = 2.70$ $(p = 0.009)$ for Pakistan, and $WLR\ (BD) = 1.17$ $(p = 0.001)$ for Sri Lanka. It is evident that the associated *p*-values were less than 1%. Thus, we can conclude the existence of an asymmetric relationship in the long run between the examined variables. For the short run, the null hypothesis was also rejected regarding symmetric relationships at the 1% level of significance. Specifically, the Wald statistics were $(BD) = 12.17$ $(p = 0.006)$ for Bangladesh, $W\ (IND) = 6.29$ $(p = 0.007$ for India), $WSR\ (PAK) = 6.18$ $(p = 0.004)$ for Pakistan, and $WSR\ (SL) = 5.55$ $(p = 0.008)$ for Sri Lanka. These findings suggest the existence of an asymmetric relationship between financial innovation and economic growth in Bangladesh, India, Pakistan, and Sri Lanka.

For the long-run estimations (see Table 5, panel A), we found that a positive shock in financial innovation was positively linked with economic growth in Bangladesh, India, Pakistan, and Sri Lanka while a negative shock was negatively linked with economic growth. This indicates that financial innovation in a financial system can stimulate economic growth. According to Chou (2007) and Chou and Chin (2011), financial innovation brings changes to a financial system that increase financial efficiency and increase saving propensity among the population by offering new and improved financial assets; this eventually aids capital formation and thus boosts economic growth. Mishra (2010), moreover, argued that financial innovation promotes the economic growth of emerging economies through welfare enhancement. For the short run (see Table 4,

panel C), we found that a positive shock in financial innovation influenced economic growth in Bangladesh, India, and Pakistan but not Sri Lanka. Meanwhile, a negative shock in financial innovation produced mixed associations regarding economic growth in the sample countries.

Granger causality test

The existence of long-run cointegration was confirmed by ARDL and NARDL. This suggests the existence of at least one directional causality in the model—in the long run, the short run, or both. To ascertain directional causality between the set of variables, a Granger causality test was conducted under an error correction model (ECM). Table 6 shows the causality test results.

For long-run causality, the error correction term ECT (− 1) should be negative and statistically significant. Some ECTs (− 1) were negative and statistically significant at the 1% and 5% levels of significance. The findings confirmed the existence of long-run causality in the model. In particular, when economic growth (Y) served as a dependent variable in the equation, the ECT coefficient was negative and significant. Thus, we can conclude that in the long run, economic growth can cause the adoption and diffusion of innovative financial products through the development of efficient financial institutions. This is in line with Bara and Mudxingiri (2016) Table 6.

As with long-run causality, in the short run, different directional causality was observed between the variable sets of each country. Table 7 shows the summary of short-run causality.

For Bangladesh. The study unveiled bidirectional causality between financial innovation and economic growth [FI←→Y] and financial innovation and gross capital formation [FI←→GCF]. On the other hand, study also exposed unidirectional causality from economic growth to trade openness [Y→], gross capital formation to economic growth [GCF→Y], domestic credit to private sector to economic growth [DCP → Y], financial innovation to domestic credit to private sector [FI→DCP], and trade openness to Gross capital formation [TO→GCF].

For India. Study divulged bidirectional causality between economic growth and financial innovation [Y←→ FI]. Furthermore, we observed unidirectional causality from trade openness to economic growth [Y ← TO], economic growth to gross capital formation [Y → GCF], financial innovation to trade openness [FI → TO], financial innovation to gross capital formation [FI → GCF], domestic credit to private sector to financial innovation [FI ← DCP], and trade openness to domestic credit to private sector [TO → DCP].

For Pakistan study revealed directional causality between economic growth and financial innovation [Y ←→ FI] and financial innovation and gross capital formation [FI ←→ GCF]. Study also exposed unidirectional causality from economic growth to trade openness [Y → TO], gross capital formation to economic growth [Y ← GCF], trade openness to gross capital formation [Y ← GCF], gross capital formation to domestic credit to private sector [FI ←→ GCF], trade openness to gross capital formation [TO → GCF], and gross capital formation to domestic credit to private sector [GCF → DCP].

For Sri Lanka, the study uncovered bidirectional causality between economic growth and financial innovation [Y ←→ FI] and economic growth and gross capital formation

Table 6 Granger-causality results

	Short-run Causality					Long-run causality	
	ΔlnY_{t-1}	$\Delta lnFI_{t-1}$	$\Delta lnTO_{t-1}$	$\Delta lnGCF_{t-1}$	$\Delta lnDCP_{t-1}$	ECT(−1)	Inference
Bangladesh							
ΔlnY_{t-1}		5.856***	4.047	7.742**	6.988**	−1.28***	Long-run causality
$\Delta lnFI_{t-1}$	0.781**		2.482	1.441**	4.114	−0.15***	Long-run causality
$\Delta lnTO_{t-1}$	0.081**	0.075		1.03	0.315	−0.64**	Long-run causality
$\Delta lnGCF_{t-1}$	3.465	7.858**	4.664*		5.047	0.406	
$\Delta lnDCP_{t-1}$	4.647	13.825***	2.393	1.369		0.062	
India							
ΔlnY_{t-1}		9.213**	0.586**	2.083	2.672	−0.58**	Long-run causality
$\Delta lnFI_{t-1}$	0.076**		2.542	0.571	2.47**	−0.44**	Long-run causality
$\Delta lnTO_{t-1}$	2.624	2.759		0.209**	2.094	0.92	
$\Delta lnGCF_{t-1}$	0.961**	0.152**	0.24		2.388	−0.88***	Long-run causality
$\Delta lnDCP_{t-1}$	1.194	3.188	7.55**	5.611		−0.95	
Pakistan							
ΔlnY_{t-1}		0.343**	1.553	6.018**	0.281	−0.13***	Long-run causality
$\Delta lnFI_{t-1}$	4.892**		0.351	2.141**	3.966	−0.84**	Long-run causality
$\Delta lnTO_{t-1}$	4.813**	1.648		6.163	4.078	−0.044**	Long-run causality
$\Delta lnGCF_{t-1}$	1.232	4.686**	1.966**		4.028	0.095	
$\Delta lnDCP_{t-1}$	1.253	4.522	11.838	9.383**		0.035	
Sri Lanka							
ΔlnY_{t-1}		3.473**	2.801	0.751**	2.022	−0.48**	Long-run causality
$\Delta lnFI_{t-1}$	2.917**		4.362**	0.19	1.531	−0.36**	Long-run causality
$\Delta lnTO_{t-1}$	0.282	6.766		4.992**	2.468	0.43	
$\Delta lnGCF_{t-1}$	5.286**	6.297**	5.843		2.886	−0.99**	Long-run causality
$\Delta lnDCP_{t-1}$	4.419**	2.62	1.705**	2.016		0.67	

Note 1: ***, **, and * indicates significant level at 1%, 5%, and10% respectively

[Y ⟷ GCF]. Furthermore, study revealed unidirectional causality from economic growth to domestic credit to private sector [Y → DCP], trade openness to financial innovation [FI ← TO], financial innovation to gross capital formation [FI → GCF], gross capital formation to trade openness [TO ← GCF], and gross capital formation to domestic credit to private sector [GCF → DCP].

Table 7 Summary of Short-run causality

Causality	Bangladesh	India	Pakistan	Sri Lanka
Y VS FI	Y ⟷ FI	Y ⟷ FI	Y ⟷ FI	Y ⟷ FI
Y VS TO	Y → TO	Y ← TO	Y → TO	
Y vs GCF	Y ← GCF	Y → GCF	Y ← GCF	Y ⟷ GCF
Y vs. DCP	Y ← DCP			Y → DCP
FI VS TO		FI → TO		FI ← TO
FI vs GCF	FI ⟷ GCF	FI → GCF	FI ⟷ GCF	FI → GCF
FI vs. DCP	FI → DCP	FI ← DCP		
TO vs GCF	TO → GCF	TO ← GCF	TO → GCF	TO ← GCF
TO vs. DCP		TO → DCP		
GCF vs. DCP			GCF → DCP	GCF → DCP

Note: "→" for unidirectional causality, "←➔" for Bidirectional causality, and "-" for no causality

Conclusions and recommendations

Efficient financial institutions not only optimize economic resources by channelizing across the country but also expedite economic development through efficient payment mechanisms and intermediation processes. Over the past decade, South Asian economies have experienced financial development with the emergence of improved and innovative financial assets and services via financial innovation. Merton (1992) characterized financial innovation as the engine driving financial systems toward improving the performance of real economies for sustainable development.

The present study investigated long-run cointegration between financial innovation and economic growth along with a set of macroeconomic variables for the period Q1 1975 to Q4 2016. To discover the long-run relationships between financial innovation and economic growth in Bangladesh, India, Pakistan, and Sri Lanka, we used the ARDL bounds testing approach proposed by Pesaran et al. (2001). We also estimated the existence of nonlinearity using the nonlinear ARDL approach proposed by Shin et al. (2014). The F-statistics in the ARDL bounds testing approach were higher than the upper bound of the critical value at the 1% level of significance, adopted from Pesaran et al. (2001). Thus, we can conclude that financial innovation stimulates economic growth in the long run. We also observed that the elasticities of financial innovation toward economic growth were positively influenced in both the short-run and long-run periods. These findings align with Mwinzi (2014), Qamruzzaman and Jianguo (2017), and Beck et al. (2014). Chou and Chin (2011) suggested that financial innovation increases the volume of financial product variety along with efficient financial services, eventually promoting financial-development-led economic growth. This implies that financial innovation is positively linked with economic growth. Furthermore, Moyo et al. (2014) argued that financial innovation is the ultimate result of financial reform, promoting financial efficiency in the financial system and leading to sustainable economic growth.

The NARDL findings also support the existence of long-run relationships. They also reject the null hypothesis regarding the nonexistence of an asymmetric relationship between financial innovation and economic growth, both in the short run and the long run. Thus, we can infer an asymmetric relationship between financial innovation and economic growth. In addition, we observed positive changes in financial innovation positively linked in both the long run and short run. These findings suggest that any improvement in financial innovation can bring about positive changes in the economy. However, negative changes in financial innovation were adversely linked with economic growth. Yet, the elasticities toward economic growth were minimal and statistically insignificant for the short run. In the long run, however, the effect was statistically significant at the 1% and 5% levels.

Arnaboldi and Rossignoli (2013) argued that financial innovation is a double-edged sword that can promote sustainable economic growth through developing the financial sector while also having a dark side (Beck et al. 2016). However, the negative effect of financial innovation on economic growth is still low and scarcely identified in empirical studies.

To establish directional causality, we used the Granger causality test under an error correction model. Bidirectional causality was found between financial innovation and economic growth in Bangladesh, India, Pakistan, and Sri Lanka for the period Q1 1975

to Q4 2016. This finding supports the feedback hypothesis between financial innovation and economic growth in the long run. This finding aligns with Ajide (2015). For short-run causality, we observed bidirectional causality between financial innovation and economic growth in Bangladesh, India, Pakistan, and Sri Lanka. This supports the feedback hypothesis for the short run as well. Thus, we can assume that growth in Bangladesh, India, Pakistan, and Sri Lanka can be caused by the evolution and adoption of financial innovation in the financial system.

In particular, financial innovation can influence economic growth by providing an efficient financial system along with financial diversification. Meanwhile, economic growth puts pressure on the financial system to create innovative financial assets and services to mitigate the demand for financial services. The positive link between financial innovation and economic growth suggests that Bangladesh, India, Pakistan, and Sri Lanka should encourage financial innovation in their financial systems. Their financial sectors should develop financial institutions that can introduce innovative financial products and services that will diffuse throughout the economy. Thus, their governments should formulate financial policies to promote financial innovation, development, and inclusion while minimizing risk levels to ensure stability in the financial sector.

Accordingly, bank-based and market-based financial development needs to proceed effectively and efficiently to obtain the maximum benefits from financial innovation. As such, the governments of Bangladesh, India, Pakistan, and Sri Lanka should pay particular attention to infrastructural development, financial transparency, technological advancement, and regional cooperation in financial reforms.

Abbreviations

ADF: For Augmented Dickey-Fuller; ARDL: Autoregressive Distributed Lagged; DCP: Domestic Credit to Private Sector; FI: Financial Innovation; GCF: Gross Capital Formation; KPSS: Kwiatkowski-Phillips-Schmidt-Shin; NARDL: Nonlinear Autoregressive Distributed Lagged; P-P: Phillips-Perron; TO: Trade Openness,

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Availability of data and materials

Upon request in future, we, at this moment, confirming that all the pertinent information will be disclosed for further use.

Authors' contributions

The concept and design of this article come from Professor WJ and after that data collection, empirical study review of conceptual development and drafting done by Md. Q and finally critical review and import intellectual content assessment is done by Professor Wei Jianguo and effort by authors in the article, the ration of contribution equally likely. Both authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Ethics approval and consent to participate

This study purely based on secondary data and there is no involvement with any sort of animal or special group human being. Therefore, we assure that in this research, the possibility of hamper participant privacy is negative.

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