IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

IMPACT OF FINANCIAL AND TECHNOLOGICAL DEVELOPMENT ON ECONOMIC GROWTH IN INDIA: AN ECONOMETRIC ANALYSIS

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Abstract: The primary purpose of the recent study is to examine the association between technological development, financial development, and economic growth in India, a non-linear and asymmetric framework. This study is based on the Non-linear autoregressive distributed lags model (NARDL) and Hetemi J asymmetric causality tests to explore nonlinearities in the vital interaction among the variables. The study revealed a cointegrating link between technological development, financial development, and economic growth in the long run. The findings suggest that a positive shock in financial development increases economic growth (coefficient value 1.91 at 1% significance level) and technological development a negative shock will harm economic performance (coefficient value -0.11 at 1% significance level). The results of this study can significantly facilitate stakeholders and policymakers in devising short-term and long-term policies for financial development and technological innovation to achieve sustainable long-run economic growth in India.

Index Terms - Technological development, financial development, Economic growth, Econometric Analysis, cointegrating link, India.

I. INTRODUCTION

Finance and technology are both key factors for the economic growth of any country. Generally, it is contended that for the expansion of the economy, the financial sector must be well developed along with the adoption of advanced technologies. Without the latest technology development, none of the sectors can understand and fulfill the needs of the customers. The financial sector of a country enables the utilization of savings, thus converting it into capital essential for economic growth (Ghildiyal et al., 2015). In the past three decades, this field has attracted the attention of many researchers, and a large no. of studies have been done on the same. (Hicks, 1969), (McKinnon, 1973) and (Shaw, 1973) clarified the association between financial development and economic growth, presenting the substantial influence of financial development on economic growth. Levine claimed that financial development assists in detecting improved investment opportunities, lessens productive costs, mobilizes savings, improves technological innovation, and augments the risk-taking capacity of investors (Levine, 1997).

Along with financial development, technological development plays an important role in the country's economic growth. Margaret Mead defines technological development as "the introduction of new tools and new technical procedures" (Mead, 1953). Innovation in the field of technology can change the business prospects to accomplish predetermined goals. After the demonetization and Covid-19, people understood the need for technology, and digital payment methods are used as a primary source of transactions because of the cash crunch. Usage of the latest technologies has increased significantly, also bringing transparency in each transaction and indirectly flourishing the economic growth of the country.

In the past few years, fintech has become a new buzzword; fintech is the association between finance and technology for improving the traditional financial services provided. According to EY Fintech Adoption Index 2019, even though India's financial technology sector is not over a decade old in the country but the adoption rate is 87% compared to the global average of 64%. Financial technology adoption worldwide has been due to its proven ability and technology acceptance at a very low cost. The main reasons for the early adoption of this technology include ease of internet access, availability of digital mobile devices, acceptance of the latest technology, etc. Fintech basically fulfills the elementary needs of regular customers in an easier and more precise way. Most of the top-reaching companies in India want to become a single-shop solution for the day-to-day needs of a normal customer. However, as per the International Monetary Fund's (IMF's) world economic outlook report predicted that India will become a 5 trillion USD economy by 2028-29 (Bhalla, 2022).

But in some aspects, the figures are worrying, as per global study states that in India, 76% of adults are financially illiterate, and they do not know how to manage their funds properly. And the growth of the country is in the hands of its citizens; they have to be financially literate, and government should also take some obligatory measures to educate them. Financial literacy, financial inclusion, and financial stability are the topmost aspects of a rising and efficient economy.

This paper is divided into several sections. The first section is consisting an Introduction to Financial and Technological development and a brief overview of fintech and its relationship with the growth of the Indian economy. The second section provides a detailed survey of the literature on financial and technological development and economic growth based on theoretical and empirical studies. In the third section, the details of the data and methodology used in this study are considered after section four includes results and discussion taken on the basis of the analysis conducted on the financial and technological development in relation to the growth of the Indian economy. The conclusion and Policy Implication of the study is presented in the fifth section.

II. THEORETICAL FRAMEWORK AND REVIEW OF LITERATURE

2.1 Studies on Financial and Technological Development and economic growth

Investment in the latest invention, continuous research and development, and economic, technological progression can provide a viable advantage. Therefore, it eventually improves economic growth. In the current period, customers demand innovative activities to keep pace with the shifting economic conditions around the world. Hence, innovation is the main compound of delivering changes in the economy.

In the financial development works of literature, it was studied the influence of the financial sector developments on economic growth in India after the reform period and established the relationship between financial development and economic growth in the structure of an endogenous growth model (Ghildiyal et al., 2015); the assembly between innovation and economic growth represented by (Solow, 1956). Later, (Schumpeter, 1911) conveys new insight into how innovations encourage economic growth, exclusively technological innovation in the economy. Lina Ajeet Kaushal, in her study, explained that Financial Development (Private credit and money supply) has a formative impact on Trade Openness by successfully assigning resources to encourage productivity growth simultaneously with technological upgradation. Also, she added Neo classical growth model is an element of technological change (Kaushal, 2015).

In other studies, it was identified that when growth is brought back and becomes sustainable, financial development perhaps leads to continued and robust economic growth (Pinshi, 2020) (Organization for Economic Co-operation and Development Staff, 2002) explains that innovation can be considered as all the scientific, technological, financial and commercial actions required to create, advanced new product, and services in the economy. Along with Financial innovation, the technological development in the financial system quickens access to information and effective payment intermediation across the country. Also, the main reason behind financial innovation is the evolvement of financial instruments, financial markets, financial technologies, and effective allocation of capital which speed up economic growth. (Valverde & Fernández, 2007). Sumaira and Robeena, in this paper, evaluated only the bank-based financial development index and measured its effect on economic growth. The study finds that the policy is paramount for improving the development of the financial market and essential for any developing country's growth rate. The study suggests that policymakers improve the banking system in relation to regulation and supervision, which further improves the link of financial development to economic growth (Sumaira & Bibi, 2022). The study focused that a resourceful and effective financial system is essential for financial development. The financial system is the association of financial markets, institutions, and a parameter that productively organizes economic activities (Saqib et al., 2015).

Finally, the study on financial development, technological development, and economic growth of present literature does not afford any convincing evidence of empirical studies concentrating on investigating the connection between them. Thus, this study tries to focus on the existing research gap and proceeds to investigate their relationship in the Indian economy.

III. METHODOLOGY AND DATA DESCRIPTION

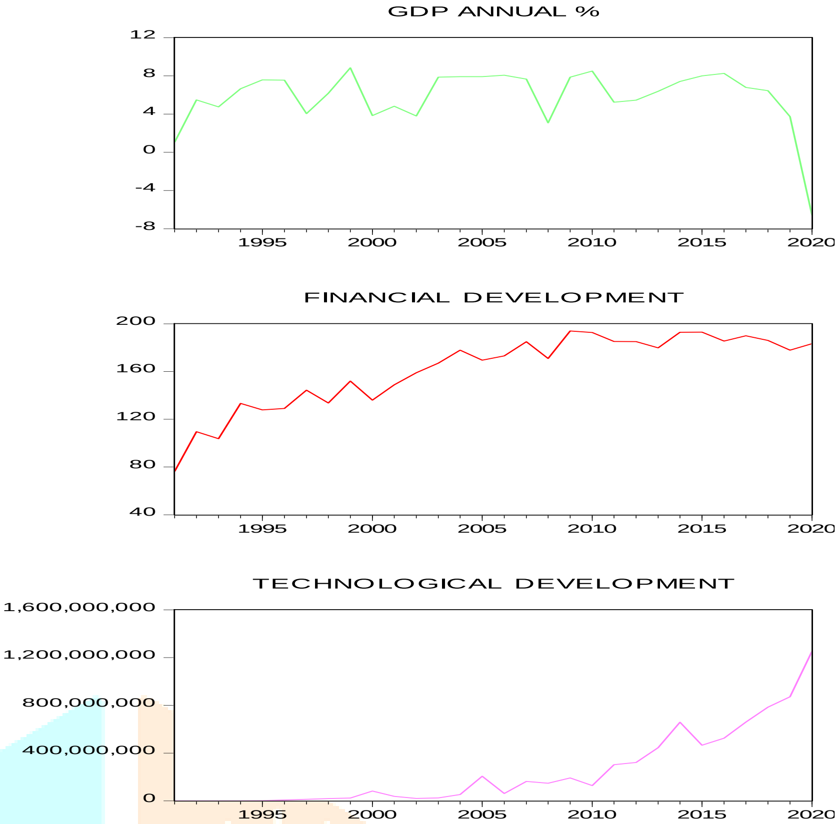
3.1 Model Specification and Data

This study analyzed the unequal impacts of fintech on economic growth in India using secondary time-series data collected from various public resources between 1991 and 2020. The dependent variable is the GDP at constant 2010 prices, a measure of economic growth. The two independent variables in our explanation are financial and technological development. Figure 1. depicts the trend of economic growth and financial and technological development. In this study, the over-fitting of the model is prevented by using technological and financial progress as the control variables. Financial development has been cited in prior studies as a crucial factor in determining economic growth (Bist, 2018); (Hamdi et al., 2014); (Hussain & Chakraborty, 2012); (Kumar et al., 2020); (Mammadov & Ahmadov, 2021); (Mtar & Belazreg, 2021); (Raghutla, 2020); (Sethi & Acharya, 2018). We use domestic credit to the private sector (percentage of GDP) as a proxy for financial development. In order to statistically investigate the impact of financial and technical development on the economic growth process, the following basic specification was employed in this study.

$$EG=f(FD, TD) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where TD refers to the technical development index, FD is for financial development, and EG means per capita gross domestic product, which is used as a proxy for economic growth. Taking into consideration resident patents and R&D investment as a proportion of GDP, the TD (technological development index) is produced utilizing these two key aspects of technical achievements for India. In a manner similar to other experiments, we also created FD using four substitutes for financial development. They are broad money, domestic listed companies, domestic lending to the private sector, and gross capital formation as a percentage of GDP. The natural logarithm of each variable is used.

The impact of financial and technical development on economic growth is illustrated by the following equation:



Source: Author's calculation

Table1.

Variables Description

Variable	**Description**	**Unit**	**Source**
lnGDP	Gross Domestic Product at constant price	US$	WB
lnFD	Domestic credit to the private sector (% of GDP)	Percentage	WB
lnFD	Broad Money	Percentage	WB
lnFD	Domestic Listed Companies	Percentage	WB
lnFD	Domestic lending to the private sector	Percentage	WB
lnTD	R&D expenditure as a percentage of GDP	Percentage	WB
lnTD	Resident Patents (% of GDP)	Percentage	WB

Source: Authors' compilation from World Bank

Table 2.

Summary Statistics

Variables	**Observations**	**Mean**	***SD***	**Minimum**	**Maximum**
lnGDP	5.82	5.82	3.02	-6.59	8.84
lnFD	161.38	161.38	30.84	76.28	194.00
lnTD	2.49	2.49	3.22	292.15	1.25

Source: Authors' calculation

$$EG = f(FD, TD) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..1$$

The following equation can be expressed in log-log form to examine the asymmetric long-run effect of FDI on economic growth.

$$\Delta LNEG = \alpha_0 + \alpha_1 LNEG_{t-1} + \beta_1^+ LNTD_{t-1}^+ + \beta_2^- LNTD_{t-1}^- + \beta_3^+ LNFD_{t-1}^+ + \beta_4^- LNTD_{t-1}^- + \sum_{i=1}^{p} \alpha_1 \Delta LNEG_{t-1} + \sum_{i=1}^{q} \alpha_2 \Delta LNTD_{t-1}^+ + \sum_{i=1}^{q} \alpha_3 \Delta LNTD_{t-1}^- + \sum_{i=1}^{r} \alpha_4 \Delta LNFD_{t-1}^+ + \sum_{i=1}^{s} \alpha_5 \Delta LNFD_{t-1}^- + u_t \dots\dots\dots\dots 2$$

Where p, q, r, and s are the optimal lag orders for the dependent and independent variables, which will be chosen by the Akaike information criterion (AIC), and αi signifies short-run coefficients, and βi represents long-run coefficients. The bound testing method developed by (Shin et al., 2014) is then used to test for the presence of cointegration among the variables using the estimated NARDL. Wald's F-statistic, established by (Pesaran, 2001), is a test statistic to determine if long-run non-linear cointegration among the variables exists.

Wald's F statistic verifies that the null hypothesis,

$\beta_1^+ = \beta_2^- = \beta_3^+ = \beta_4^- = 0$ against the alternative hypothesis of no cointegration,

$\beta_1^+ \neq \beta_2^- \neq \beta_3^+ \neq \beta_4^- \neq 0$ If we reject the null hypothesis, we have evidence of long-run cointegration among the selected variables.

We may examine, in the above equation, whether independent factors have symmetric or asymmetric impacts on the dependent variable over the long and short terms using equation (2). While long-run analysis is used to gauge the reaction time and pace of the adjustment towards an equilibrium level, short-run analysis is used to evaluate the immediate effects of independent variable changes on the dependent variable. Based on L+ββ =ρ and L−β−=ρ the long-term asymmetry coefficients are computed. The link between these variables in the long-run equilibrium is measured by these long-run coefficients, which account for both positive and negative changes in the independent variables. Where $\alpha_0$is the intercept and coefficients, i.e., α_1,, and α_2 show indicate the long run.

3.2 Hatemi–J Asymmetric Causality

The Hatemi-J test for causality is used to determine the direction of the asymmetric causality Hatemi-J (2012a, b). The test is distinctive in that it distinguishes between the causal effects of positive and negative shocks. The variables may be defined as a random walk process as follows to determine the asymmetric causal link between EG, FD, and TD:

$EG_t = EG_{t-1} + \varepsilon_t = EG_0 + \sum_{i=1}^{t} \varepsilon_i$.....3

$FD_t = FD_{t-1} + \varepsilon_t = FD_0 + \sum_{i=1}^{t} \varepsilon_j$.....3

$TD_t = TD_{t-1} + \varepsilon_t = TD_0 + \sum_{i=1}^{t} \varepsilon_k$.....3

where the constants EG_0, FD_0 and TD_0 initial values of the variables and ε_i, ε_j and ε_k the white noise residuals. Positive and negative shocks are given by $\varepsilon_1^+ = \max(\varepsilon_t, o)$, $\varepsilon_1^{'+} = \max(\varepsilon_t, o)$,$\varepsilon_1^- = \min(\varepsilon_t, o)$, $\varepsilon_1^{'-} = \min(\varepsilon_t, o)$, Hence, the residuals may be represented as the sum of positive and negative shocks as $\varepsilon_i = \varepsilon_1^+$, ε_1^- and $\varepsilon'_i = \varepsilon_1^{'+}$, $\varepsilon_1^{'-}$ Due to this EGt, FDt, and TDt may be defined as :

$$EG_t = EG_{t-1} + \varepsilon_t = EG_0 + \sum_{i=1}^{t} \epsilon_i^+ + \sum_{i=1}^{t} \epsilon_i^-$$
$$FD_t = FD_{t-1} + \varepsilon_t = FD_0 + \sum_{i=1}^{t} \epsilon_J^+ + \sum_{i=1}^{t} \epsilon_J^-$$
$$TD_t = TD_{t-1} + \varepsilon_t = TD_0 + \sum_{i=1}^{t} \epsilon_K^+ + \sum_{i=1}^{t} \epsilon_K^-$$

Finally, the positive and negative shocks in variables are defined in cumulative form as follows:

$$EG_t^+ = \sum_{i=1}^{t} \epsilon_i^+ = EG_t^- = \sum_{i=1}^{t} \epsilon_i^- = FD_t^+ = \sum_{i=1}^{t} \epsilon_J^+ = FD_t^- = \sum_{i=1}^{t} \epsilon_i^- = TD_t^+ = \sum_{i=1}^{t} \epsilon_K^+ = TD_t^- = \sum_{i=1}^{t} \epsilon_K^-$$

In the following step, the causal linkages between the above components are examined. Assuming the vector $Z_t^+ = (EG_t^+, FD_t^+, TD_t^+)$.....9

where v is a vector of intercepts, uþ t is a vector of residual terms, and the matrix Ar is a matrix of parameters for lag order r(r 5 1–p). Hatemi-J (2012b) considered the Toda–Yamamoto procedure (toda & yamamoto, 1995) to examine asymmetric causation between variables. A unit root test is used as the initial phase of the process to determine the highest degree of variable integration ðdmaxÞ. The next step is to use the model information criteria to determine the vector autoregression system's optimal lag length (k). The vector autoregression system of ðk þ dmaxÞth order is subsequently calculated. The conventional Wald test is then used to determine whether there is a causal relationship between the variates. The model information criterion put forward by (Hatemi-J, 2003) is taken into consideration to discover the optimal lag lengths in accordance with Hatemi-J (2012a, b). The Wald constraint on the autoregressive parameters tests the null hypothesis of no causality. The Wald statistic follows an asymmetric χ2 distribution.

IV. RESULT AND DISCUSSION

We must make sure that the variables under consideration are not integrated in an order greater than one because the prior study conducted tests for cointegration. Consequently, we employed the Ng-Perron unit root test to evaluate the series' integration characteristics (Ng et al., 2001). Table 2. displays the outcomes of the stationarity tests. All of the variables are non-stationary at levels, according to the findings. Once the variables have been differentiated, stationary tests may be run on the differentiated variables. The findings demonstrate that all variables were found to be stationary at the initial difference. Therefore, it is worthwhile drawing the conclusion that all of the study's variables are integrated of order one, i.e., I (1). As a result, the study approaches cointegration using an ARDL (autoregressive distributed lag) technique.

Table 2.

Unit root test (Ng–Perron test)

Variables	MZa	MZt	MSB	MPT
EG	-9.04	-1.45	0.16	12.17
LEG	-6.10	-1.74	0.28	4.01
FD	-1.68	0.68	0.40	35.95
LFD	0.215	0.217	1.00	59.50
TD	-2.02	-0.50	0.24	21.78
LTD	0.26	0.17	0.67	30.93

The structural break in the series is not taken into consideration by the Ng-Perron stationary test. As a result, we used the ADF unit root test with an unknown structural break to resolve this issue (Carrion-I-Silvestre et al., 2009). The findings in Table 3. imply that variables are non-stationary at the level of the presence of structural breaks in economic growth, financial development, and technical development, which happened in 2002, 2001, and 1996, respectively. All variables are discovered to be difference stationary after taking the first difference, i.e. (1). As a result, both test results show that non-linear ARDL can be used because none of the series is I (2), which would cause the NARDL to crash (Ouattara, 2004). The findings of Pesaran et al. F-test's Wald's are then used to verify the long-run cointegration among the selected variables. (2001) Table 4. shows that, at the 1% level of significance, the computed F-value is larger than the top band. As a result, it may be said that there is unequal cointegration between financial development, technical advancement, and economic growth. Table 5. shows a similar relationship between the dependent variable and the long-term estimates of NARDL. According to the findings, a positive shock to technical advancement spurs economic growth, whereas a negative shock reduces economic performance. Similar to how a long-term positive shock to financial development strengthens the economy, a long-term negative shock weakens it. The outcomes of the short-run and long-run asymmetric non-linear ARDL coefficients are shown in Table 6. According to our short-run estimates, a shock to technical advancement in the prior era (lag 1) is adversely connected to economic growth in the present period (with a coefficient of -0.008), whereas a negative shock was negatively related to economic growth (with a constant coefficient of -6.04). Both coefficients have a 1% significance level and are statistically significant. The results of the diagnostic tests are shown in Table 7's lower section. The SERIAL test implies there is no problem with serial correlation, the DW test for autocorrelation confirmed the absence of serial correlation, and the WHITE test for heteroscedasticity shows the model is free of the problem with heteroscedasticity. The Ramsay RESET test confirmed that the model's functional form was well established.

Table 3.
Unit root analysis with structural breaks

Variable	Level			First difference		
	t- statistics	Prob	Break year	t- statistics	Prob	Break year
LEG	-7.53	<0.01	2002	-8.91	<0.01	2008
LFD	-5.90	<0.01	2001	-12.94	<0.01	1996
LTD	-2.84	>0.76	1994	-6.37	<0.01	1996

Table 4.
Bounds test for non-linear cointegration

STATISTICS	Value	Significance	Lower	Upper
F- statistics	23.60	10	3.17	4.14
K	2	5	3.79	4.85
		1	5.15	6.36

Additionally, the stability of long-run and short-run parameters has also been examined in the current study using the cumulative sum (CUSUM) and cumulative sum of square (CUSUMSQ) tests. At a 5% level of significance, the cumulative sum (CUSUM) and cumulative sum of square (CUSUMSQ) plots (Figures 2 and 3) are in between critical bounds. This demonstrates that models appear to be consistent and appropriately stated. The findings of the Hatemi-J Asymmetric Causality Test are presented in Table 7. The table indicates that FD shocks that are positive or negative lead to economic growth (negatively). Only positive shocks in the case of TD result in positive shocks to India's GDP. Thus, our findings are consistent with the theory that economic growth in a nation is caused by an increase in financial and technological development and that technological development is a necessary corollary to financial development (Shamim, 2007). Additionally, the causality conclusion demonstrates that there is

unidirectional causation from bad economic growth to negative technical progress as well as bidirectional causality between technological development and economic growth. Therefore, the country's favorable economic growth advances technical development, but it also has a detrimental effect on technological development. Therefore, policymakers should be careful about negative economic growth in the country. More stress should be given to more technological development for better financial development and better economic growth in the economy.

Table 5.
Long Run NARDL

Variable	Coefficient	Std. Error	t-statistics	Prob.
LFD	1.91	0.68	2.79	0.01
LTD	-0.11	0.05	-2.16	0.04

Specifically, the present study proposes to address two research questions: (1) To what extent do technological development and financial development boost economic growth? (2) How do the dynamic relationships vary across technological development, financial development, and economic growth in India? In the present context, the study employs a NARDL and Hetemi-J asymmetric causality test to explore nonlinearities in the dynamic interaction among the variables.

Table 6.
Short Run NARDL

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-6.04	0.69	-8.65	0.00
D(LTD)	-0.00	0.07	-0.11	0.90
CointEq(-1)*	-1.04	0.11	-8.77	0.00

Table 7.
Diagnostics Test Statistics

R square	0.75	
Adjusted R square	0.73	
DW	1.96	
χ2 SERIAL	0.003	0.95
χ2 Arch	1.86	0.17
χ2 WHITE	16.25	0.29
χ2 Remsay	0.095	0.75

Figure 1.
CUSUM TEST

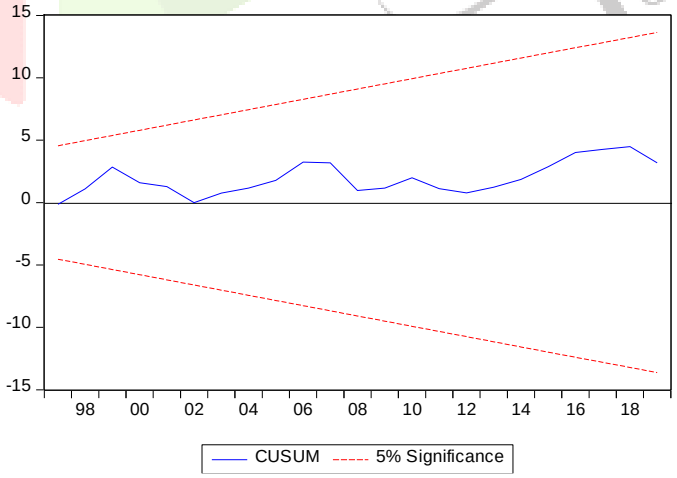


Figure 2.
CUSUMSQ

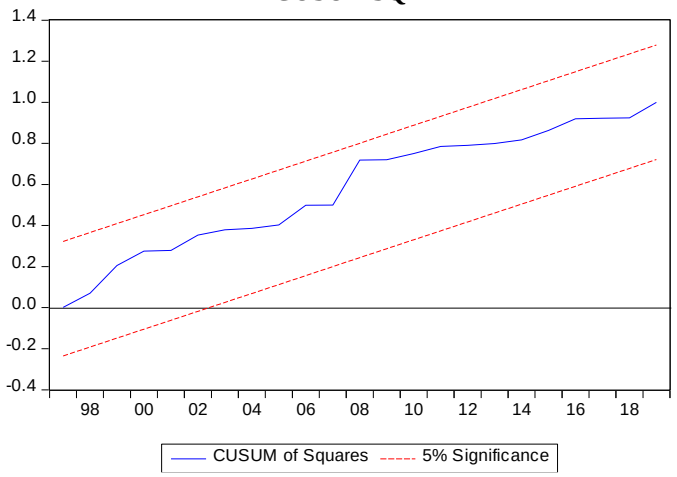


Table 8.
A non-linear and asymmetric relationship

Causality Direction	Test Value	Prob	VAR Order
EG ----------TD	6.02**	0.01	1
LEG ----------LTD	1.65	0.19	1
TD----------EG	0.24	0.61	1
LTD----------LEG	0.00	0.98	1
TD ----------FD	0.0005	0.95	1
LTD ----------LFD	3.30	0.06	1
FD----------EG	0.16	0.68	1
LFD----------LEG	1.91	0.16	1
EG ----------FD	1.14	0.28	1
LEG ----------LFD	2.10	0.14	1
FD----------EG	3.69**	0.05	1

V. CONCLUSION AND POLICY IMPLICATIONS

According to the study, a negative shock to technological development would be associated with slower economic growth in the short term of asymmetric non-linear ARDL. Similar to how the positive shock in financial development with one lag is improving the performance of the economy. This suggests that a financial system's financial innovation can promote economic growth. A negative shock to financial development, on the other hand, has a negative impact on economic growth. According to the long-term projections of the NARDL findings, a positive shock to technological development promotes economic growth, whereas a positive shock to economic performance has the opposite effect. Additionally, the causality results demonstrate that there is unidirectional causation from negative economic growth to negative technological development as well as bidirectional causality between technological development and economic growth. As a result, the country's good economic growth promotes technological development, although the adverse effects of economic expansion on technological advancement also exist.

Therefore, policymakers should be cautious about the negative economic growth of the country. In order to improve financial development and economic growth, greater emphasis should be placed on technological progress. Based on the empirical results of the current study and in line with (Claessens & Fan, 2002), it can be deduced that investing in the ICT sector is crucial if developing nations are to take advantage of chances to advance even with a shaky banking system. The degree of connectedness seems to explain the point of take-off, and analysis shows that there is a positive relationship between financial development and technical development that should lead to rapid growth. Additionally, when employed as tools for financial development indicators, connectedness through technology development factors boosts economic growth. Therefore, policies directed at enhancing a nation's connectivity environment are likely to encourage higher financial development and more chances for emerging nations to benefit from technological advancement. More significantly, online banking and online brokerage will dominate all other online financial services thanks to cellular phones and the Internet. Because of the limited scope of this research, the role of technological development in economic growth needs to be reemphasized. Future studies on e-finance technologies and ICT can cover a wide range of topics, from how they affect financial institutions' profit margins to how they affect the real sector's productivity.

Additionally, future studies should seek the appropriate development strategy for all countries in general and for developing economies in particular. Additionally, because systematic information has been hard to get and the financial services business is still in its infancy, there is a significant knowledge vacuum on the Internet-based activities of this sector. As a result, this study may be used as a baseline for future studies that examine the effect of ICT on financial and economic growth, bridging the obvious gap in the literature.

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