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MODERATOR EFFECT OF TECHNOLOGICAL ADVANCEMENT ON FINANCIAL DEVELOPMENT AND ECONOMIC GROWTH NEXUS IN ASIAN COUNTRIES

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ABSTRACT

The examination of the nexus between Financial Development (FD), Technological Advancement (TA), Human Capital (HC), and Private Consumption (PC) to Economic Growth (EG) has gained substantial attention in both empirical and theoretical academia since the early nineteenth century. Scholars affirm that FD, HC, PC, and TA are crucial factors in determining optimal resource allocation and efficient utilization required to achieve sustainable EG. This study investigates the nexus of FD, HC, and PC with EG in Asian countries, with TA serving as the moderator. Data from 35 countries were collected annually over 15 years, spanning from 2005 to 2019. Using short panel data analysis, due to the higher number of cross-sections (35) compared to time intervals (15), the findings confirm

TA's significant moderator effect in both short and long-run time scenarios. Additionally, a significant negative relationship with EG is observed for FD and PC, while TA and HC are identified as promoters of EG. The study underscores the importance of investing in TA while concurrently developing the quality of the labor force. Policymakers are encouraged to prioritize technology development and the introduction of innovative techniques. However, caution is advised in FD projects, necessitating strategies to reduce domestic private consumption.

Keywords: Financial development, technological advancements, economic growth, short panel data analysis.

INTRODUCTION

The investigation into the interconnection between Financial Development (FD) and Economic Growth (EG) has received considerable attention in both the theoretical and empirical literature over the past few decades. Scholars, since the early nineteenth century, have dedicated their efforts to understanding the key determinants of EG in countries. Initially, in the early 1950s, scholars identified labour and capital as pivotal domestic production sources. However, technological revolution has prompted the inclusion of technological innovations as a catalyst for economic development. Scholars not only affirmed technology's crucial role in accelerating economic development but also emphasized its miraculous impact on economic and social development.

Furthermore, experts argue that Financial Development (FD) plays a vital role in economies, contributing to the reduction of poverty, unemployment, and income inequality. This, in turn, addresses economic challenges and enhances the overall living conditions of people (Comin & Nanda, 2019; Beck, 2016). The Supply Leading Theory asserts a strong nexus between FD and EG, emphasizing FD's role in improving productivity and facilitating the allocation of funds to the real sector. Aligned with the Finance-led Hypothesis theory, scholars argue that FD lubricates domestic savings flow and enhances the allocation of capital to the real sector (Sharma & Kautish, 2020; Bist, 2018; Tursoy & Faisal, 2018).

Despite the abundance of studies in this area, scholars continue to grapple with unraveling the puzzle surrounding the precise relationship

between FD and EG. While generally acknowledged as a crucial factor for EG, contradictory conclusions persist among scholars regarding the nexus of FD and EG. Several scholars contend that FD and EG have an advantageous connection (Sobiech, 2019; Olayungbo & Quadri, 2019). However, an alternative perspective argues against the notion of a positive association and posits that the association fluctuates due to microeconomic and macroeconomic causes. They contend that the relationship between FD and EG is contingent upon country-specific variables such as income level, labour force, population, and the developmental stage of the country (whether it is developed, developing, or underdeveloped). Additionally, the political environment of the country and macro-level factors, such as global market share, the flow of foreign direct investments, and global economic downturns, also play a role in this nexus (Benczur et al., 2019; Doumbia, 2016; Asteriou & Spanos, 2019; Ruiz, 2018; Beser & Kilic, 2017).

In addition, researchers argue that excessive financial development can result in decreased economic growth by diverting human capital from the real sector to other financial services, thereby causing an economic downturn (Rahaman et al., 2020; Siddikee & Rahman, 2020; Naveed & Mahmood, 2019; Alomari et al., 2019). It is argued that establishing a meaningful correlation between FD and EG can be challenging, as Bara and Mudxingiri (2016) and Nwani and Orie (2016) suggest. In addition, several studies have demonstrated varied outcomes, with a detrimental impact observed in the short term but a beneficial effect in the long term (Ehigiamusoe et al., 2019; Naveed & Mahmood, 2019; Qamruzzaman & Jianguo, 2018; Nyasha & Odhiambo, 2017). Beyond the association between FD and EG, experts also emphasize the importance of examining the linearity of this relationship. One school of thought points to the linear relationship between FD and EG, while another group of scholars argues that there is no significant linear correlation (Benczur et al., 2019; Doumbia, 2016).

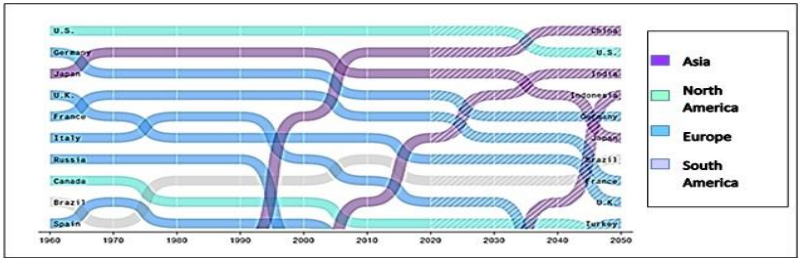
Moreover, technological development serves as a driving force in accelerating gross domestic production (GDP) by improving FD and Human Capital (HC) productivity (Kihombo et al., 2021; Alshubiri et al., 2019; Chung et al., 2019; Bist, 2018). The continuous evolution of technology in the finance sector facilitates the efficient and effective transfer of funds and resources, thereby fostering the establishment of new ventures and systems through foreign direct investments (Qamruzzaman & Jianguo, 2018).

Additionally, technological developments in the finance sector have reduced the cost of obtaining timely information for rational investment decisions, thereby attracting investments Kihombo et al., 2021). The efficient allocation of funds to required capital assets and improvements in production tools enhance the efficiency and effectiveness of the production sector, ultimately boosting gross domestic production (Abeka et al., 2021; Kihombo et al., 2021; Alshubiri et al., 2019). Technological advancement affects the manufacturing sector and financial services and adds to the improvement of human capital (Alomari et al., 2019). Advancements and technological progress in tools, materials, and techniques enhance the efficiency and efficacy of the workforce, resulting in enhanced production (Othman et al., 2022). Moreover, technical progress directly impacts consumption habits, leading to a decrease in waste and having a substantial effect on individual consumption.

In light of the above points raised, the scope of this study has focused on the Asian continent countries since Asia is the world's largest and most populous and diversified continent. Moreover, the World Economic Forum Annual Meeting report in 2020 revealed that by 2030, Asia will contribute more than 60 per cent to the Global GDP. In addition, Asia has experienced unprecedented economic and technological growth in the last couple of decades, and the GDP per capita has increased by twofold within the last fifty years (Japanese Times, 2020). In contrast, IMF 2019 prediction reports stated that Asia held 40 per cent of global consumption. These facts provide strong evidence to prove the importance of studying the economic behavior of Asia since it will direct the global economy in due course.

Figure 1

World Dominant Economies



Note. The source is Bloomberg Business Week 2020 November 11 Report

As can be seen from Figure 1, China by 2050 is projected to surpass the United States in terms of economic size and become the largest economy in the world. Moreover, Japan 2030 will possess the third-largest economy, with India following in the ranks subsequently. India is projected to become the world's third-largest economy by 2050. Hence, this substantiates the significance of assessing and examining the behavioral transformation in Asia since Asia is poised to emerge as the preeminent global economy shortly. In light of these theoretical and empirical gaps, an in-depth econometric analysis is imperative to identify the true relationship between FD and EG, considering the roles of HC and Private Consumption (PC), while accounting for the moderating influence of technological advancement in Asian countries.

The rest of this paper has been organized into four sections. Section 2 provides an overview of the existing research studies, while Section 3 explains the methodology used in the study. Subsequently, Section 4 elucidates the findings. Section 5 is dedicated to the concluding remarks and the practical consequences.

LITERATURE REVIEW

Theoretical Review

Almost all scholars accept that the finance sector, human capital, and domestic consumption substantially interfere with a country's economic development. At the same time, technological advancement improves the productivity of all the sectors of an economy. Schumpeter (1911) explained that financial sector development positively contributes to economic growth, leading to new venture capital and real sector development. Hence, Supply-leading theory has posited that economic development happens and depends on financial development. Because well-functioning financial services make transferring funds from excess to deficit easy, which in turn directs more and more investments to the production sector. Furthermore, it lubricates the flow of funds from the finance sector to the real sector, while reducing the transaction cost and cost of capital.

However, scholars started to hold a contradicting view and have highlighted that rather than financial development leading to economic

growth, countries sometimes change their fiscal policies. This is to cater to the high demand from economic development and to have sophisticated financial services to transfer funds from one sector to another. Hence, from the early 1950s scholars became engaged in a hot debate that economic development pulls financial development rather than financial development pushing economic growth. For example, Joan Violet Maurice Robinson in 1952 proposed a new theory and highlighted that it was not financial development that led to economic growth, but economic growth would bring about financial development. The key argument that she brought to the table was that a well-developed economy demanded a better financial service to facilitate the smooth functioning of economic activities and allocation of funds to the real sector while making the fund flow from excess to deficit.

In addition, Robinson (1952) highlighted that a full-employment level could only be achieved by pumping money into the economy through government expenditure. Therefore, the government had to demand and develop better fiscal policies to maintain a smooth financial system. However, in 1956, Robert Solow and Trevor Swan highlighted the importance of technological advances for economic growth and claimed that economic growth resulted from labor, capital, and technology. Then, in 1957, Rober M. Solow explained that in addition to labour and capital, technical changes were a key factor in determining production. He elaborated on the technical changes whenever there was any shift occurring in the production flow. Hence, technical changes might slow down production, speed up production, or improve the production process due to the changes in human capital and techniques. Continuing the discussion, Nelson and Winter in 1982, highlighted the importance of a national innovation system for a country. They showed that scientific discoveries were the result of evolving scientific and technological knowledge and its practical applications.

Furthermore, Professor Paul Romer in 1994 introduced his theory, which was a development of the Cobb-Douglas production function, highlighting that labour and capital were the main variables in gross domestic production. However, Paul Romer (1994) modified the Cobb-Douglas production function. He argued that research and development, education, innovations, technological advancements,

the finance sector, and entrepreneurship significantly influenced economic growth in the long run. These factors were different from labour and capital resources since they improved productivity and directed capital resources to the real sector. Further, technological improvements would increase the productivity and efficiency of resource utilization.

Empirical Review

The present study followed the approach of an empirical review to assess the relationship of financial development, technological advancements, human capital, and private consumption to economic growth. The empirical findings are sequenced according to the discussion of the variables used in the study, as follows:

Financial Development and Economic Growth

There have been intense debates among scholars regarding the Financial Development (FD) and Economic Growth (EG) nexus from the early nineteenth century. One line of thought among scholars pointed out that FD positively affected the EG (Rahaman et al., 2022; Hewage et al., 2022). Wang (2019) and Sobiech (2019) stated that financial deepening via improving financial services and financial institutions would make a positive contribution to increasing GDP. Furthermore, Comin and Nanda (2019) have stated that development in financial services would create opportunities to increase production capacity and investments in the industrial sector, and that could reduce poverty, income inequality, and unemployment. In addition, Karlsson et al. (2021) found that FD would have a long-run positive influence on EG for countries with above-middle-income status. Hence, scholars have highlighted that the effect has an inverse U shape, and after a certain threshold level, FD would decline the EG and this would lead to an economic recession (Ioannou & Wojcik, 2021; Ruiz, 2018).

However, another school of thought argues that FD has negative consequences since investments in the financial system might not produce the expected return to the economies and might sometimes reduce the investment opportunities for high-return investments (Rahman et al., 2020; Ouyang & Li, 2018). Moreover, Ioannou and Wojcik (2021) stated that excess development in the financial sector negatively impacted economic growth. Prochniak and Wasiak (2017)

found that too much expansion in the financial sector with excessive lending and a high rate of nonperforming loans made a significant negative return on GDP growth. Furthermore, Siddikee and Rahman (2020) claimed that too much financial development drew human capital away from the real sector to financial services and created a scarcity of skilled laborers in the industrial sector. Hence, academics have stressed that unstable financial markets and over-expansion of the financial system would hurt the economy and create financial crises (Chen et al., 2020; Ogbonna et al., 2020; Awad & Karaki, 2019). In addition, Rahman, Faisal, Sami, and Schneider (2021) stated that financial liberalization in a poor economic regulatory environment would negatively contribute to economic growth.

Meanwhile, some scholars found that FD showed a negative relationship in the short run but a positive influence in the long run (Ehigiamusoe et al., 2019; Naveed & Mahmood, 2019; Qamruzzaman & Jianguo, 2018). Hence, it has not been very easy to understand how FD influences the EG. Furthermore, scholars have had heated arguments about the direction of the influence. Some say FD had a unidirectional influence and showed that FD led to EG (Rahaman et al., 2022; Abeka et al., 2021; Hossin, 2020; Bist & Bista, 2018; Shahbaz et al., 2018), while another intellectual argued in the opposite direction (Atil et al., 2020; Pradhan et al., 2017). However, some scholars stated that the relationship was bidirectional (Olayungbo & Quadri, 2019; Qamruzzaman & Jianguo, 2018). In contrast, some studies have proved that FD and EG did not have significant linearity, and the key reasons for the non-linearity were the micro-economic and macro-economic variables like political stability, economic stability, global market share, trade openness, and per capita income (Zhao & Gong, 2021; Benczur et al., 2019).

Even though there have been contradictory thoughts on the influence and direction of the relationship, there is a common agreement among scholars that FD is crucial, which determines the EG. Hence, the history of investigating the relationship between FD and EG runs over to the early nineteenth century. In 1911, Schumpeter stated that a well-functioning financial system made capital allocation easy. Later on, many academics confirmed that effective allocation of capital resources to productive projects would strengthen the economic condition of countries (Bist & Bista, 2018; Guru & Yadav, 2018; Puatwoe & Piabuo, 2017; Murari, 2017).

Hence, scholars have also claimed that banking sector developments would make it easy for the private sector to obtain credit facilities for venture capital (Biplob & Halder, 2018). They were smoothing the cash flow in the stock and bond markets, which would then lead to economic growth in the long run (Sharma & Kautish, 2020; Qamruzzaman & Jianguo, 2017). Furthermore, it would attract investments and reduce the cost of capital (Alimi & Adediran, 2020; Bist, 2018). In addition, it could lubricate the fund flow from excess to deficits and improve the domestic product capacity (Abeka et al., 2021; Rahman et al., 2020; Ogbonna et al., 2020; Haini, 2020).

Technological Advancements in Economic Growth

The term "Technological Advancement" has been defined by field experts differently. McDonough (2016) defines technological advancement as "A change in the way a product or service is produced or delivered that reduces the resource input requirements for production or delivery". The Canada Revenue Agency (CRA) defines Technological Advancement as; "Scientific or technological advancement is the generation or discovery of Knowledge that advances the understanding of science or technology".

Many scholars have proved that Technological Advancements (TA) generate many opportunities for investors and producers to enter into global markets since it improves the production capacity while reducing informational and production costs and leads to a boost in Economic Growth (EG) (Othman et al., 2023; Abeka et al., 2021; Kihombo et al., 2021; Alshubiri et al., 2019; Qamruzzaman & Jianguo, 2018).

With TA, physical and human capital productivity improves by enriching the worker's knowledge, skill, and competency. According to the Solow growth model introduced by Robert Solow in 1956, technology plays a vital role in the economy in addition to human capital and physical capital, since TA contributes to more than 80 per cent of the economic development of a country.

In contrast, technological developments in the finance sector make it easy to transfer funds from the finance sector to the real sector with high efficiency and accuracy by making available funds for new investments (Song & Appiah-Otoo, 2022; Abeka et al., 2021;

Khurana, 2018). When the banking sector joins with new technology, innovations in bank products and the transaction system get efficient and easy (Mansoro, 2009). With new bank products, banks can provide their service to the customers with high quality to meet the customer needs. Nenavath and Mishra (2023) explained that technological advancements in the green finance sector would improve the quality of economic growth. Solow growth has highlighted the importance of technology to EG and explained that more than 80 per cent of the improvement in economies came from TA.

Human Capital and Economic Growth

Human capital (HC) makes for the higher productivity of economic resources because it includes a country's educated and skilled labor force. Cobb-Douglas's production theory explains that human capital is one of the key determinants of economic growth (EG). Hence, scholars claim that adequate HC capital should achieve sustainable economic development (Rahaman et al., 2020; Oyinlola & Adedeji, 2019; Bist, 2018; Zhou, 2018).

Furthermore, one school of scholars explains that human capital positively contributes to EG (Saroj et al., 2023; Rahaman et al., 2022). Moreover, Nguyen (2022) confirms the positive relationship between HC and EG in transition countries, while Hashani et al. (2022) stress that HC positively affects EG in Western Balkan countries. Moreover, the efficiency of the labor market is one of the significant factors in developing the economic condition (Alomari et al., 2019). Therefore, Zhang et al. (2023) revealed that a country with a high human development index would result in a high EG. Furthermore, Tahir et al. (2020) stressed that it was not the stock of human capital that significantly influenced the EG, but how countries utilized their labor force to achieve sustainable development that would matter for high economic development. In contrast, some scholars claim that absorbing too many highly skilled laborers for the production sector badly affects it, since it generates a vacuum in the skilled labor force for other sectors (Pumain & Rozenblat, 2018).

Private Consumption and Economic Growth

Private consumption represents household final consumption and the non-profit institutions serving household consumption in a country,

which is one of the key factors that significantly affects a country's economic status. John Maynard Keynes, the founder of Keynesian economics and the father of modern macroeconomics, believes demand pulls the economy. Hence, higher consumption leads to higher demand, which motivates the production sector to produce more. In short, private consumption makes a significant positive contribution to economic growth.

In addition, studies carried out in several countries by Alper (2018) underscored that private consumption positively affected EG in Brazil, Russia, India, South Africa, and Turkey. Hashani et al. (2022) also claimed that PC and EG showed a positive relationship in Western Balkan countries. Furthermore, Jain (2022) confirmed that demand-led economic growth in BRICS economies, and Keho (2021) revealed that household consumption motivated the high production that positively led to economic growth in Cote d'Ivoire. Koyuncu and Unal (2020) also showed that PC had a positive long-run influence on the EG in Turkey. Furthermore, studies by Rafiy et al. (2018) and Tampubolon and Adelakun (2021) agreed that improved PC would cause an increase in EG in Indonesia. Tampubolon and Loh (2020) also provided empirical evidence that private consumption showed a positive significant short and long-run influence over the EG in North Sumatra.

METHODOLOGY

The Population and the Sample of the Study

The population of this study was the 48 countries in the Asian continent. From this total, the sample selected for analysis was based on data availability. Hence, after evaluating the data availability for the entire study period, the final sample consisted of 35 countries. Further, annual data of sample countries were gathered for 15 years from 2005 to 2019.

Variable selection

Variable selection, proxy determination, and data collection were done based on previous scholarly works and are illustrated in Table 1. The data collection sources are presented in Table 2.

Table 1

Key Variables

Type of Variable	Variable Name	Definition	Proxy and the calculation mechanism	Key literature
Dependent variables	Economic Growth (EG)	Increase in Real Gross Domestic Production	Real Gross Domestic Production Per Capita Adjusted to Purchase Power Parity RGDP (PPP) and take the Real GDP Difference over two consecutive periods as a percentage of real DGP in the base year	Rahaman et al., 2020; Bist, 2018; Tursoy & Faisal, 2018; Puatwoe & Piabuo, 2017
Independent Variable	Financial development (FD)	Development in markets, financial institutions, and instruments	Financial development was proxied by Financial Development Index which was calculated as financial market development and financial institutional development. Considering how deep, accessible, and efficient are they.	Rahaman, et al., 2020; Haini, 2020; Wang, 2019; Swamy & Dharani, 2019; Bist, 2018
Moderating variable	Technological Advancement (TA)	Measure the development of technology in a country	Technology Achievement Index (TAI) which includes patents granted per capita, receipts of royalty and license fees from abroad, internet users, high technology exports, electricity consumption, telephone subscribers, gross enrollment ratio, and gross enrollment in science	Qamruzzaman & Jianguo, 2018; Incekara, Guz, & Scngun, 2017
Control Variables1	Human Capital (HC)	The educated and skilled labour force of a country	The economically active population (age above 15 years) as a percentage of the total population	Rahaman et al., 2020; Oyinlola & Adedeji, 2019; Bist, 2018
Control Variables2	Private consumption (PC)	Final consumption expenditure for goods and services including the durable products of households formerly named private consumption	Households' final consumption expenditure (% of GDP)	Kaharudin and Ab-Rahaman, 2022; Edinak et al., 2022

Note. Identification of key variables drawn from the literature review carried out in the present study.

Table 2

Data Collection Sources

Variable Name	Data collection Source
Economic Growth (EG)	World Development Indicators (WDI, 2021)
Financial development (FD)	IMF Financial Development Time-series Database
Technological Advancement (TA)	European Patent Office (EPO) World Development Indicators, International Telecommunication Union (ITU) United Nations Development Programme (UNDP) International Telecommunication Union (ITU)
Human Capital (HC)	World Development indicators
Private consumption (PC)	World Development indicators

Note. Data collection sources were identified from the literature review carried out in the present study.

Data Analysis

The study followed the panel data analysis technique to estimate the relationship between Financial Development (FD), Human Capital (HC), and Private Consumption (PC) with Economic Growth (EG) when there is a moderating effect of Technological Advancements (TA) over the economic growth when interaction with financial development. Since the number of cross-sections (35 countries) is greater than the time intervals (15 years), the study used the short panel data analysis technique of the Generalized Method of Moment (Bond, 2001). The final analytical tool was the Blundell and Bond Two-step System Generalize Method of Movement (BB Twostep GMM). Furthermore, the study followed the cross-sectional dependency test and unit root test as preliminary analytical techniques before occupying the co-integration test of BB Twostep GMM to examine the long-run and short-run effect of FD, HC, PC, and TA over EG.

Testing Cross-sectional Dependency and Unit Root

The study followed four types of cross-section dependency tests to examine whether there was an interrelationship between cross-sections. Here, the study used the Breush-Pagan Lagrange Multiplier (Breush-Pagan LM test), Pesaran scaled Lagrange Multiplier (Pesaran scaled LM test), Bias-corrected scaled Lagrange Multiplier (Bias-corrected scaled LM test), and finally the Pesaran cross-section dependent test.

Moreover, two sets of tests are available to examine the panel unit root; the first-generation tests are used when there is no cross-sectional dependency, while the second-generation panel unit root tests are utilized when there is a cross-sectional dependency. Hence, the study followed the second-generation panel unit root tests since there was cross-sectional dependency among the Asian countries. The key techniques used were the Cross-sectionally augmented Im-Pesaran-Shin (CIPS) test in 2003 and the Cross-sectionally augmented Dickey-Fuller test (CADF) introduced by Pesaran in 2007.

Panel Co-Integration Test

Panel co-integration shows explanatory variables' long-run and short-run influence on the response variable. Since the data set is a short panel, the study followed the dynamic short-panel co-integration technique of the Generalized Method of the moment.

Robustness Check

A robustness check was done with sensitivity analysis to ensure the validity of the final model. Even though there are two approaches in sensitivity analysis, either to change the sample or the variables, this study has used the first option. The sample size changed since the variable was selected after a deep literature review.

EMPIRICAL RESULTS AND DISCUSSION

Examining the Cross-section Dependency

Identifying the cross-sectional dependency is crucial in determining the appropriate analysis technique to investigate the co-integration among independent and dependent variables. Hence, the study has used four tests to examine the cross-sectional dependency and the results are as shown in Table 3.

Table 3

Cross-section Dependency

	Breusch-Pagan LM	Pesaran scaled LM	Bias-corrected scaled LM	Pesaran CD
EG	1449.235***	24.763***	23.513***	22.983***
FD	3222.024***	76.154***	74.904***	17.450***
TA	6106.322***	159.765***	158.515***	58.561***
HC	2658.392***	59.815***	58.565***	-0.593
PC	2792.118***	63.691***	62.441***	-1.142

Note. [1]***, ** and * show significance at the 1%, 5% and 10% levels, respectively.
[2]Source of data is the EViews Output prepared by the researchers.

Table 3 shows that there was a cross-sectional interdependency among Asian countries. Hence, this requires following the second-generation panel unit root test to examine the stationarity of the data series.

Unit Root Test

Panel stationarity was examined with two types of second-generation panel unit root tests since data series present an interdependency. The test statistics are shown in Table 4.

Table 4

Unit Root Test

Variable	CIPS		CADF	
	Level	First Difference	Level	First Difference
EG	-2.510***	-3.720***	-5.335***	-4.567**
FD	-2.031	-4.416***	-3.356*	-6.162***
TA	-2.623***	-3.722***	-1.236	-4.556**
FD.TA	-2.262**	-3.616***	-3.646**	-2.815
HC	-1.336	-2.427***	-0.884	-1.344
PC	-1.606	-2.805***	-2.370	-3.578*

Note. [1]***, ** and * show significance at the 1%, 5% and 10% levels, respectively. [2]Source of data is the EViews Output prepared by the researchers.

Table 4 illustrates that all the variables present stationarity at their first difference since Cross-sectionally augmented Im-Pesaran-Shin (CIPS) test statistics confirmed that the data series did not follow a unit root at the first difference level. Furthermore, Cross-sectionally Augment Dickey-Fuller test (CADF) test statistics showed that all the variables except HC and FD.TA got stationary at first difference. Thus, the study moves forward with analyzing the co-integration among the variables.

Co-integration *Analysis*

To estimate the long-run and short-run relationships among variables, the key technique available is the co-integration analysis. Despite several short panel co-integration techniques, the study used the Blundell and Bond Twostep System Generalized Method of Moment (GMM).

Blundell and Bond Twostep System GMM

The Blundell and Bond Two-step System Generalized Method of Moment (GMM) with the inclusion of a time dummy variable has proved to be more effective and resilient than the analysis conducted without a time dummy (Roodman, 2009; Bond, 2001). Consequently, the BB Two-step System GMM with a time dummy was adopted in this study to explore the short-run and long-run associations between

independent and dependent variables. The corresponding test statistics are presented in Table 5.

Table 5

BB Two-step System GMM

Number of instruments						33
Number of groups						35
Number of Observations						490
Observation per group			Min			14
			Average			14
			Maximum			14
F (19, 33)						536.88
Prob > F						0.000
Variable	Coef.	Std. Err.	t-stat	P> |t|	[95% conf.	Interval]
EG (-1)	0.462	0.036	12.82	0.000	0.389	0.536
FD	-0.135	0.041	-3.32	0.002	-0.218	-0.052
TA	0.242	0.090	2.70	0.011	0.060	0.425
FD.TA	0.105	0.007	15.03	0.000	0.091	0.120
HC	0.082	0.036	2.25	0.031	0.008	0.155
PC	-0.154	0.041	-3.77	0.001	-0.237	-0.071
2006	-0.261	0.390	-0.67	0.508	-1.052	0.531
2008	-3.078	0.552	-5.58	0.000	-4.199	-1.957
2009	-4.707	0.360	-13.08	0.000	-5.438	-3.975
2010	0.487	0.648	0.75	0.458	-0.830	1.804
2011	-2.724	0.846	-3.22	0.003	-4.443	-1.004
2012	-3.693	0.876	-4.22	0.000	-5.474	-1.913
2013	-3.340	0.967	-3.46	0.001	-5.304	-1.375
2014	-3.204	0.731	-4.38	0.000	-4.690	-1.718
2015	-3.361	0.859	-3.91	0.000	-5.107	-1.615
2016	-3.149	0.863	-3.65	0.001	-4.904	-1.393
2017	-2.641	0.927	-2.85	0.007	-4.525	-0.757
2018	-3.763	0.926	-4.06	0.000	-5.645	-1.882
2019	-4.088	0.863	-4.74	0.000	-5.843	-2.334
Constant	2.418	4.086	0.59	0.558	-5.886	10.723
Arellano-Bond test for (AR2) in first difference: Z= -0.99 Pr > Z						0.323
Sargan test of over id. Restrictions: Chi2 (13) = 19.98 Pr> chi2						0.096
Hansen test of over id. Restrictions: Chi2 (13) = 13.35 Pr> chi2						0.421

Note. Prepared by the researchers using STATA Output

Table 5 presents the outcomes from the analysis and illustrates that all the explanatory variables significantly affected EG in Asian countries. Furthermore, FD, TA, and HC had a significant (95%) confidence level, while moderator variables (FD.A) and PC were significant at a (99%) confidence level. In addition, most of the time, variables presented a significant negative effect over the EG, and all the time, dummy variables, except in 2006 and 2010, were significant at either the (99%) or (95%) significant levels.

In addition, the results from the analysis confirmed that the final model was valid enough to interpret the relationship between explanatory and response variables. This was because the F statistic value was significant and the probability value was less than 0.05. Furthermore, the number of instruments (33) was less than the number of groups (35), confirming the sufficiency and aptness of the instruments in the model. This has been further confirmed by Hansen and Sargan test values as both coefficients were less than 1. In addition, there was no serial correlation since the AR (2) statistic value was greater than 0.05.

Therefore, all the test values showed evidence that the fitted model was valid and best fit to interpret the moderator effect of TA towards the FD and EG nexus while presenting the core relationship between explanatory variables and EG. Thus, the outcomes showed that FD and PC had a significant adverse relationship with EG, while TA, HC, and moderator variables presented an affirmative connection with EG. This indicates that in the short run, all the variables were important and had a substantive influence over the EG, while FD and PC made a diminishing marginal return to the EG of Asian countries. High domestic consumption declines the growth rate as it reduces domestic savings and over-investment to improve the financial systems resulting the negative returns. Conversely, improving technology and human capital increases the gross domestic production, and the moderator role of technological advancements promotes the EG of Asian countries.

Blundell and Bond Short Run and Long Run Estimations

Table 6 presents the summary statistics for short-run and long-run relationships between explanatory variables and EG.

Table 6

Short Run and Long Run Estimations

Variable	Short Run	Long Run
	Coefficient Value	Coefficient Value
FD	-0.135**	-0.252***
TA	0.242**	0.451**
FD.TA	0.105***	0.196***
HC	0.082**	0.152**
PC	-0.154***	-0.287***

Note. ***, ** and * show significance at the 1%, 5% and 10% levels, respectively. Prepared by researchers with STATA output

Table 6 presents the summary statistics for the short-run and long-run relationship between variables. According to the coefficient values, Financial Development (FD) and Private Consumption (PC) reduced the Economic Growth (EG) of Asian countries. Furthermore, the coefficient values of FD showed that EG declined by 0.135 per cent in the short run and 0.252 per cent in the long run if the FD index increased by one unit. Hence, this finding provides a good guide for the policymakers, which is that improving financial services and investment in FD diminished marginal returns to the EG of Asian Countries.

Even though the findings contradicted the supply-leading theory of Joseph Schumpeter (1911), Ioannou and Wojcik (2021) have confirmed that FD would follow a negative connection with EG. Furthermore, some intellectuals have argued that FD was an utter waste of money since FD had a diminishing marginal return after it passed the threshold level (Naveed & Mahmood, 2019; Ouyang & Li, 2018; Ruiz, 2018). Hence, in a study by Benczur et al. (2019), it was reported that the marginal return of FD would depend on income level. Thus, it is clear that FD and EG have a positive relationship when the country is in a lower or middle-income cluster. However, when a country reaches the high-income category, the relationship between FD and EG becomes negative. Hence, Ioannou and Wojcik (2021) and Ruiz (2018) concluded that the nexus of FD and EG followed an inverted U shape. In sum, it is necessary to analyze countries' income levels while developing policies and strategies.

Moreover, the finding showed that a 1 percent increase in PC leads to a reduction in the EG by 0.154 per cent in the short run and 0.287

per cent in the long run. This indicates that high consumption patterns adversely affect gross domestic production, reducing domestic savings and forcing the government to direct their capital reserves from investments to import or manufacture consumable goods. Therefore, government reserves weaken and have to take loans for capital expenditure at higher rates, creating a financial crisis. The same explanation is found in Solow's Growth Theory, where Solow and Trevor shown how a reduction of investments in capital projects causes a reduction in the gross domestic production of such a country. Furthermore, endogenous growth theory and Cobb-Douglas production theory have highlighted the same argument and stressed that capital is one of the crucial factors for production. Hence, there is a consensus that the decline of the capital reserves of a country will badly affect the EG. Similarly, Handriyani et al. (2018) have shown that there was a negative relationship between household consumption and EG. Thus, policymakers must be vigilant about changes in domestic consumption patterns and make short-term, mid-term, and long-term strategic plans to manage domestic private consumption.

TA has a significant positive relationship with the EG of Asian countries. For example, in the short run, EG had increased by 0.242 per cent when TA increased by one index point. However, in the long run, the improvement of EG was 0.451 per cent. This has provided empirical proof that investments in technology development projects improved the productivity and capacity of the domestic production sectors, in turn boosting the GDP of Asian countries. According to Solow, growth theory, endogenous growth theory, and Evolutionary Institutional theory have shown that TA was one of the crucial factors in determining the EG. Furthermore, there was a significant positive contribution by TA to EG.

On the same page, Ratnapuri and Inayati (2019) have stated that TA was a significant factor in achieving sustainable EG. Furthermore, Song and Appiah-Otoo (2022) have stressed that TA would create many investment and development opportunities for investors to enter high markets since TA reduces production costs and transaction costs. In addition, the development of technology gears up the production capacity, production efficiency, and the utilization of resources. Moreover, TA reduces the cost of gathering timely information while increasing the effectiveness of investments (Kihomobo et al., 2021; Qamruzzaman & Jianguo, 2018). Therefore, more investors are attracted to the industrial sector, which will in turn improve the GDP. Hence, Khurana (2018) was of the view that TA promoted

investments, initiated new ventures, and established production houses in emerging industrial zones. Moreover, Alomari et al. (2019) have highlighted that technological readiness positively influenced EG, while Ali (2017) showed that technological progress assisted in achieving higher EG in Southeast Asian countries.

Apart from the individual effect of FD and TA on EG, the moderator effect of TA while interacting with FD follows a positive relationship with EG. For example, a one-unit increase of interaction effect among FD and TA results in the EG being increased by 0.105 per cent in the short run and 0.196 per cent in the long run.

Hence, the technological diffusion of the financial sector and improvement in the quality of financial services will attract foreign and local investments and improve the industrial sector since it leads to easy fund transfer from the finance sector to the real sector (Obeng-Amponsah & Owusu, 2023). Moreover, within the Solow growth model and Evolutionary Institutional theory framework, the Endogenous Growth model asserts that technology plays a pivotal role in economic growth, exerting a substantial influence on the promotion of overall economic development. In agreement with the theoretical background, Cho and Chen (2021) explained that improving the banking sector's technology would improve the quality of the finance sector while reducing transaction costs and improving the transaction volume. Furthermore, Abeka et al. (2021) found that using telecommunication infrastructure improved FD's effectiveness to EG in sub-Saharan African countries. Similarly, Alimi and Adediran (2020) pointed out that ICT would have an interactive effect of promoting EG, while FD would have a positive effect on EG.

In addition, the findings show that a 1 percent improvement in HC causes an increase in the EG by 0.082 per cent in the short run and 0.152 per cent in the long run. This is obvious since an effective and high-quality labor force improves production quality and capacity. Thus, production sector expansions and high production capacity make it easy to capture new markets and improve the marginal return (Ahmad et al., (2023). According to Cobb-Douglas production theory, endogenous growth theory, and Solow theory, the highly skilled labor force is one of the significant factors of production.

Hence, scholars have highlighted that developing the quality of the labor force is one of the key requirements for any country to achieve sustainable economic growth (Ali et al., 2021; Rahim et

al., 2021). Furthermore, Nguyen (2022) and Widarni and Bawono (2021) have also shown that human capital significantly contributed to EG. Moreover, Zhang et al. (2023) stressed that a high human development index would cause a high EG. Oliinyk et al. (2021) have also pointed out that a healthy and skilled labor force would be vital to a high human development index. Thus, Xu and Li (2020) reiterated that a country should focus on employee training programs, moral development programs, and knowledge enhancement programs to develop the labor force while improving the health services in a country. Given the foregoing points raised by previous studies, the following are the final Short and Long-run models of the study, as represented by Equation (1) and Equation (2).

Final Models;

Short Run model;

$$EG_{it} = -0.135FD_{i,t} + 0.242TA_{i,t} + 0.105FD.TA_{i,t} + 0.082HC_{i,t} - 0.154\,PC_{i,t} + \varepsilon_{it} \quad (1)$$

Long run model;

$$EG_{it} = -0.252FD_{i,t} + 0.451TA_{i,t} + 0.196FD.TA_{i,t} + 0.152HC_{i,t} - 0.287\,PC_{i,t} + \varepsilon_{it} \quad (2)$$

Robustness Check - With 14 and 18 Years

To assess the validity of the final models, the study followed the sensitivity analysis for 14 years and 18 years. The results are shown in Table 7.

Table 7

Short Run and Long Run Estimations with 14 years and 18 years

Variable	14 Years		18 Years	
	Short Run Coeff. Value	Long Run Coeff. Value	Short Run Coeff. Value	Long Run Coeff. Value
FD	-0.088*	-0.165*	-0.107**	-0.196**
TA	0.233**	0.437**	0.067	0.123
FD.TA	0.122***	0.229***	0.086***	0.158***
HC	0.051	0.096	0.092**	0.168**
PC	-0.101**	-0.189**	-0.169***	-0.310***

Note. ***, ** and * show significance at the 1%, 5% and 10% levels, respectively. Prepared by the researchers with STATA output

Table 7 presents the sensitivity analysis results for 14 years and 18 years. The outcomes confirm the validity of the model. Further, the analysis results for 14 years indicated that FD and PC had a negative connection with EG, while TA, as an individual variable and moderator, presented an affirmative relationship with EG. However, HC did not significantly influence EG when the number of years was reduced. This indicates that in the short term, the influence of HC towards the EG became insignificant since the technology had captured the labor market. Therefore, there is an insignificant effect of labor capital for the EG of Asian countries less than fifteen years.

Furthermore, the analysis results for 18 years show that FD and PC hurt EG while the development of HC and moderator variables promoted EG. Interestingly, TA had no significant effect on the EG of Asian countries for 18 years. This indicates that when the time frame gets increased, the effect of TA over the EG becomes insignificant while HC becomes a crucial factor to EG. This may result from countries identifying the negative consequences of TA and replacing HC for TA sectors to outweigh the adverse consequences of TA.

CONCLUSION, POLICY IMPLICATION AND KEY CONTRIBUTION

The study investigated the moderating impact of technological advancement on the relationship between FD (financial development) and EG (economic growth) in Asian countries. This was done by analyzing 15 years of data from 35 Asian countries. The study examined financial development (FD) and technological advancement (TA) as the major variables, while human capital (HC) and private consumption (PC) were treated as control variables. The study examined the interaction between TA and FD to assess the moderating influence of TA on the relationship between FD and EG. The primary analytical method employed in the study was the Generalised Method of Moment (GMM), specifically following Blundell and Bond's Two-step System GMM approach. A time dummy variable was included in the analysis to enhance its robustness.

The findings have verified that all the independent variables substantially impacted EG during both the short-term and long-term periods. Furthermore, the results indicate negative associations

between FD and EG and between PC and EG in both the short-term and long-term periods. In addition, the influence of TA on EG was positive, and both TA and HC had a positive association with EG when considered individually in Asian countries.

POLICY IMPLICATION AND RECOMMENDATIONS

The analysis has revealed that the moderator variable, Technological Advancement (TA), positively influenced EG in Asian countries. Consequently, policymakers must prioritize the development of technology in the finance sector to foster sustainable economic growth. This suggests a need to redirect investments from traditional financial services towards technological innovations. Strategic planners should invest in research and development projects, creating new financial products infused with technology to enhance financial transactions and transactional efficiency. Aligning with the findings of Cho and Chen (2021), one cannot help but emphasize the importance of technological development in the banking system and improving the quality of financial services to achieve higher transaction volumes. Moreover, the findings also aligned with those of Alshubiri et al. (2019), who similarly emphasized the positive consequences of Information and Communication Technology development in the finance sector for EG. In addition, studies by Abeka et al. (2021) and Mohamad and Ismail (2007) provided support for the idea that telecommunication infrastructure improves the effectiveness of FD in promoting EG.

Despite the positive moderating effect of TA on the FD and EG nexus, a standalone negative connection was observed between FD and EG. Therefore, policymakers should craft unique investment strategies tailored to individual countries, evaluating the level of FD before designing investment plans. Building on the work of Ioannou and Wojcik (2021) and Ruiz (2018), who highlighted the varying impact of FD on EG based on income levels, policymakers need to consider income thresholds (Loannou & Wojcik, 2020; Cheng et al., 2020; Bist, 2018). Until a country achieves a middle-income status, FD tends to have a positive relationship, changing to a negative one afterward. Hence, policy decisions on FD projects should be income-sensitive.

Moreover, the increase in Private Consumption (PC) is linked to a decline in EG, as high PC reduces domestic saving capacity and

capital reserves. Policymakers should focus on developing strategies to minimize PC and improve domestic savings. This necessitates a strategic approach to attract foreign investments in the production sector for improved consumable goods production within the country. Furthermore, developed countries must be encouraged to extend assistance to developing nations in meeting the demand for consumable goods.

Key Contribution

The empirical literature review has shown that there is a lack of investigation into the moderating impact of technological advancement (TA) on financial development (FD) and economic growth (EG) in Asian countries. Although Solow's Growth Theory, Endogenous Growth Theory, and Evolutionary Institutional Theory emphasize the importance of technological advancement (TA) in fostering economic growth (EG), they do not address the specific impact of TA in conjunction with financial development (FD) on EG. Therefore, it is crucial for policymakers and future research by academics to thoroughly explore the moderator effect of TA on the relationship between FD and EG. This will allow them to establish policy decisions and design strategic plans to promote sustainable EG.

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