Original Research Article

Evaluation Review
2022, Vol. 46(6) 779–803

DOI: 10.1177/0193841X221112547
journals.sagepub.com/home/erx
SAGE

Toward the Fourth Industrial Revolution among E7 Economies: Assessment of the Combined Impact of Institutional Quality, Bank Funding, and Foreign Direct Investment

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Abstract

Technological innovation and its paradigm, that is, the Fourth Industrial Revolution-4IR, have shown strong impact on income levels of adopters across the globe. To this end, this analysis examines the impact of bank funding and institutional quality on technological advancement. This study adds additional variables such as high-technology exports and foreign direct

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investment (FDI) as control variable. Our study period spans from 2000 to 2018 on an annual frequency for E7 economies (Brazil, Indonesia, Mexico, India, Turkey, Russia, and China). This study leverages on cross-sectional ARDL, Augmented Mean Group (AMG), and Common Correlated Effects Mean Group Estimates (CCEMG) estimation techniques to examine long-run relationship between the outlined variables. Empirical findings show that institution quality, bank finance, income, high-technology exports, and foreign direct investments exert a positive effect on advancements in technology. Furthermore, the interaction between bank finance and institution quality on technological advancement is also positive and statistically significant. Based on the findings, it is concluded that large-scale funding is crucial for businesses to leverage revolutionary technology. Likewise, access to large capital sources if made easier encourages technology affordance as well as innovation and operational excellence. Thus, economies with established legal and financial systems stand to offer businesses such security, which encourages business innovation. Consequently, E7 economies ought to improve their financial and legal systems to boost financial security, creativity, and competitiveness of businesses.

Keywords
technological novelty, bank funding, Fourth Industrial Revolution, institutional quality, E7, economies

Introduction

The role of technical systems to facilitate efficiency and productivity of productive resource as well as revenue growth has largely been bolstered by the emergence of the industry 4.0 revolution. This situation is similar to the phenomenal transformations introduced by the robotics paradigm and the digital revolution that have fundamentally altered diverse sectors of many economies, including the financial sectors, manufacturing, and the general service industries (Su et al., 2020, Wang et al., 2020). According to expert assessment of these paradigms, the implementation of these emerging technological paradigms has tripled the world's wealth (Wang et al., 2020). The Fourth Industrial Revolution like other technological advancements has introduced substantial disruptions and economic consequences extending into financial systems. By far, it introduces significant reduction in enforcement and implementation of policy and streamlines resource allocation and use, which has impacted the quality and efficiency of institutions such as banks (Schwab, 2017). These developments have made the issue of continuous technological progress a subject of great interest to all classes of researchers

and practitioners. For instance, to economist, it is due to its economic development consequences and its potential to raise standards of human development.

While to the environmental economists, it is their ability to drive the allocation and efficient use of resources like energy to facilitate efficient production and sustainable environments (Anwar et al., 2021). In essence, technological advancements are crucial to development due to the ability to facilitate adjustments to resource use and allocation and drive the green development and sufficient energy conservation to achieve utilization and output efficiency (Miao et al., 2017; Sinha et al., 2022). This will achieve a leapfrog development toward the global objectives of clean energy economic growth. Adequate finances are important basis for the development of technologically inclined economies (Kirikkaleli & Adebayo, 2021). With the rapid rate of development and pressure to expand economically, the huge demand for energy and resources highlight the need for more efficiency and clean production mechanisms. However, not many economies, emerging economies in particular, have successfully innovated with technology nor achieved many of these developments with technology. Chen et al. (2021) argue that an inadequacy of funds presents a strong challenge that impacts the utilization of technologies and economic development. Further, beyond the challenge of funding for technological innovation, a strand of scholars further highlights circumstances, such as limited human resources and limited direct investment into research and development (Kochanova et al., 2016). While others also believe a solid institutional structure is a prerequisite for achieving the full benefits of technological innovations (Su, Cai et al., 2021), in essence, established and quality institutions possess the drive to incentivize investments in technology that can ultimately facilitate valuable benefits through innovation (Su et al., 2020). Some studies have explored the connection between quality of institutions and their impact on technological innovation (Bloom et al., 2016; Law et al., 2018), whereas a few others have extended this examination to include the role of financial system as a mechanism for facilitating both institutional quality and innovation and efficiency. Law et al. (2018) argue that a functioning financial structure offers productive units more capacity to expand investments in order to innovate. In our opinion, this link highlights a close link between funding efficiency and technological innovations. Despite this fact, it is still quite obvious that many exist which struggle with innovation. Thus, properly posed, some economies are still less innovative even in the face of the current technological revolution compared to others. It is imperative to understand how economic units can improve their utilization efficiency through reliance on technological innovation for green transformational development. At present, economic development and utilization efficiency of many countries is characterized by low efficiency levels and lower clean technology utilization levels (Chen et al., 2021, Yong et al.,

2019). The World Bank report on innovation paradox indicates that adopting better firm managerial and organizational practices are overlooked components critical to innovating in products, processes, and quality upgrades (World Bank Report, 2017). Thus, weak institutional capabilities, weak enabling environments, and limited funding affect developing economies ability to recognize and adopt new technologies. This weakens the consideration for faster economic development using technological innovation (Chen et al., 2021). There is a paucity of understanding of the mechanisms underlying the effectiveness of institutional capabilities and technological innovation for development among specific developing or emerging economies like Brazil, India, and Indonesia, the E7 states (Khan et al., 2020; Owen et al., 2018).

Hence, this study seeks to empirically explore the impact of mechanisms as bank funding and institutional efficiency on technological innovation over the period 2000 to 2018 among the emerging 7 economies. Technological innovations create a competitive climate among economies, which can be further improved by the performance of banks (Adeleye et al., 2020, Morganti et al., 2014, Wang et al., 2020). Hicks (1969) positions that bank finance is essential to influencing technological development, for any forthcoming work in technological creativity nurturing. Hicks (1969), thus, concluded that new capital investment options demanded new technologies for innovation and costly innovation programs. Therefore, intentionality in financing bank operations can play an essential role in influencing technological development and productivity. Thus, it is concluded that the variations in technological innovation between institutions is the result of R&D and capability differences (Lucas & Moll, 2011).

Thus, institutional quality may drive innovation (Acemoglu & Johnson, 2005). It again offers institutions the opportunity to expand innovation. Moreover, institutions with established innovative structure guard their ownership privileges and thus have a healthy system that promotes innovation (Robinson & Acemoglu, 2012). In addition, institutional efficiency also promotes innovation (Moe, 2005). Another important factor differentiating the extent of innovation among countries is the consistency of policies. Contrasted to weak regimes, stable governance promotes the principle of continuity in policymaking and can facilitate innovation. Therefore, for effective innovation, institutional quality is crucial. Thus, the differences in innovation performance between countries exist in their legal system, organizational effectiveness, technology, and rights protection, an indication that economies with strong and consistent policy-making processes are more likely to innovate. Robust institutions empower nations to adopt sustainable institutional protection of property rights, which significantly minimizes imitation expenses. Therefore, good institutional property rights (IPR)

security is also an essential factor in the promotion and protection of innovation (Falvey et al., 2006).

These findings, although not exhaustive, suggest quality institutions and bank funding have roles to play in the process of innovation. It is also worth noting that the direct relationship between bank funding and innovation as well as institutional effectiveness has mainly been assessed from an empirical perspective and has also sought the nonlinear effect of institutional effectiveness (Lucas & Moll, 2011). This current analysis however purposes to examine the impact of banking finance and institutional efficiency on technological advances for emerging E7 countries while controlling for other significant factors, such as high technology exports and income. These factors to the best of our review have been nascently explored in the literature. In addition, this analysis extends the literature by employing a new methodological design different from the existing trend of studies that have attempted similar examinations. This study applies second-generation estimations such as cross-sectional ARDL to assess the short-run and long-run relationship and an Augmented Mean Group (AMG) and Common Correlated Effect Mean Group (CCEMG) techniques for robustness checks. The correlation between financial and institutional quality will allow for the quantification of the joint impact of the two independent variables on technological innovation, for example, by how much positive impact of bank funding is exerted on technological innovation as institutional productivity increases. Further, in the face of the influence of the other factors, including export of high-tech technology and foreign direct investment, the current estimation procedure employed will offer a robust estimation of the impacts on technological innovation.

Literature Review

Drawing on prior studies, the significance of technological advancement on efficiency is well established and illustrated (Marr, 2018; Paramati et al., 2022, Umar et al., 2020). Many scholars have sought to examine the factors that have driven technological advancement across organization (Chen et al., 2021). As such, our review of many of these works highlights factors such as foreign direct investment, economic liberalization, research and development, cost of technology acquisition, state and national strategies, and financing adequacy as the most prevalent that explain the adoption and advancement of technological innovation (Law et al., 2018). The motivation of most of these studies in the literature has sparsely been viewed from three broad categories: the institutional category (state of play, corruption, and the security of ownership rights), economic profits (FDI inflows and international trade and information spillovers), and finance source (bank funding, as well as a financial advance). Furthermore, the unit of analysis of these works is also

viewed from two major categories. In that, the study of technological innovation and its factors has been identified to be studied either at the meso- (organizational or institutional) level or at the macro- or country level (Song et al., 2022). Conceive that, by far, a large portion of these have focused on the institutional level of analysis although a significant number of attempts exist on the macro-level analysis. For instance, in their empirical study, Khan et al. (2020) assessed the role of institutional consistency in evolving technological innovation (Khan et al., 2020). Recently, technological innovation and technology use has attracted much attention particularly in the energy sector. Scopus (2021) determines there have been over 38,700 research publications on the topic of smart grid technologies in the energy sector. Moreover, bank financing is influencing economic development and wealth generation, as most empirical research has taken account of time series and panel data systems (Loutskina & Strahan, 2015). Moreover, researchers have also played an important role in the impact of bank finance on technical innovation (Hertwich et al., 2015a; Law et al., 2018; Loukil, 2020). The researchers have exploited panel data from 54 countries between 1980 and 2009 to further broaden current financial growth literature by evaluating the non-linear effect of monetary policy on technological innovation. Moreover, the company-level data was used for 7 years by incorporating the factors conditional on the relationship between financial development and innovation and by expanding existing technical innovation literature. Tee et al. (2014), using panel data over 11 years for seven countries and incorporating additional variables other than the normal variables in charge of high-tech development, in the form of financial industry as well as stocks, have been researching variables such as corporate scale, sectoral type, and economy size. Once again, Sharma (2007) argues that R&D investments by big corporations are more likely in nations with an advanced banking scheme. To conclude, bank finance is considered to be a key element in the explanation of the technological advancement of current literature. In recent years, researchers have been constantly exploring the correlation between organizational quality and novelty (Acemoglu & Johnson, 2005, Kocak, 2017, Lee & Law, 2017, Rodrik et al., 2004, Sattar & Mahmood, 2011, Varsakelis, 2006). The reasoning behind the relationship regarding organizational quality and novelty focuses on the fact of organizations that are set up with a robust supervisory context, impacting on inducements for investors to expand in R&D, which would ultimately generate novelty (Carlin & Soskice, 2008). Tebaldi et al. (2013) have utilized panel information and broadened the latest information, applying the structural and technological developments on corruption, the government's efficiency, land ownership protection, and the rule of law on institutional development and innovation literature. Kocat (2017) found that the innovation process can be speeded up in countries with strong institutions. Lee and Law (2017) also analyze innovation and technical indicators by using panel statistics for 62

countries in the study to take social capital into account in determining the causes of technology innovation. In contrast to structural effectiveness, they find that social capital's impact is much more in the degree of innovation. Furthermore, the influence of operating effectiveness on upper quartile innovation seems to be positive. Similarly, Varsakelis (2006) argued that creative definition requires consideration of corruption, accountability, and political stability. The productivity of the company is one of the most critical variables to determine corruption. In addition to this context, the effect of dishonesty on the degree of novelty was considered negative by Mahagaonkar (2008). Kafouros et al. (2015) further submitted that a variation of the subnational organizational structure has a major effect on novelty. Administrative effectiveness increases the confidence of companies in the government's ability to enact laws that foster innovation. In short, banking finance offers more strength, investments, and inventions for companies on the one side. The positive impact of innovation financing from the bank is therefore well known in the literature (Easterly & Levine, 2003, Law et al., 2018). Wang et al. (2020) examined the impact of bank loans and institutional efficiency on technical advancement in the BRICS nations controlling for other relevant factors such as advanced technology exports as well as GDP. The findings of Westerlund's (2007) cointegration process indicate that the factors have a robust long connection. The ARDL approach is used in this analysis to determine the long-run coefficients of the response factor. The findings indicate that bank lending, institutional efficiency, advanced technology exports, and GDP all correlate positively with technical advancement. The existing studies have, however, revealed that technological progress is necessary for institutional growth (Lee & Law, 2017) (Table 1).

Proposed Framework and Technique for Analysis

Proposed Framework

Technological advancement relies significantly on social and systemic organization of a country. Rosenburg's pioneering work laid a strong framework for successful work and effectively promoted technological progress. Rosenberg (1963) proposed that institutional changes will have to go through a development stage in the next few decades, and this stage will depend on a century of knowledge building. Perhaps more specifically, Schumpeter (1911) stressed a role for financial advancement in technical progress. Schumpeter's hypothesis is founded on the notion that a mature banking sector promotes investment in innovation. Thus, therefore, bank loans further contribute to the development of inventions. Romer (1990) proposed that monopoly benefits interfere with the development of innovation by investigators. The theory suggests that as humanity's wealth expands, the expense of acquiring fresh

Table 1. Financing and Technological Innovation Studies.

Author	Purpose
Ryszawska (2016)	Sustainable finance in the sustainability transition process
Miao et al. (2017)	Relationship between green technology innovation and natural resource utilization efficiency
Owen et al. (2018)	The role of innovative low carbon early-stage businesses and finance
Ryszawska (2018)	The role of finance (financial agents and markets) from dominant view of finance on environment quality
Sun et al. (2019)	Relationship between green technology and funding of institutions
Yong et al. (2019)	Local innovation and technology development economic viability, social inclusiveness, and environmental sustainability in Malaysia
Khan et al. (2021)	The role of blockchain technology in circular CE practices and their impact on eco-environmental performance
Kirikkaleli & Adebayo (2021)	Effect of financial development and renewable energy consumption on environmental sustainability while controlling technological innovation and economic growth
Sun et al. (2021)	Effects of technological innovation within certain countries on the energy efficiency performance of neighboring countries
Anser et al. (2021)	Reduce air pollution and improve environmental production through low carbon energy financing
Sinha et al. (2022)	Analyze the socio-ecological policy trade-off caused by technological innovations

concepts continues to decrease. Besides, the analysis extends the theory of technological transformation, integrating the status of bank financing, institutional quality, and foreign direct investment. The modern development hypothesis shows that a professional and well-trained workforce creates resourcefulness (Aghion & Howitt, 2005). These professionals want to exchange ideas and solve problems that lead to the creation of creative proposals (Lucas, 2008). Nevertheless, these current principles of growth stress the participation in stimulating technical advancement of institutional structures. Moreover, by following the recent work of Wang et al. (2020), this study accesses the variables utilized by adding FDI to the model used as

$$TI_t = \beta_1 BF_t, + \beta_2 Y_t + \beta_3 HTE_t, + \beta_4 INSQ_t + \beta_5 FDI_t + \varepsilon_t \quad (1)$$

While TI is technological innovation, BF is bank funding (evaluated by funding given by financial institutions), Y reflects income, HTE indicates high-technology exports, INSQ is institutional quality, and FDI is foreign direct investment. The analysis also examined the impact of bank financing on

technological innovation and commented on how bank financing works with institutional quality, especially technological innovation

$$TI_t = \beta_1 BF_t, + \beta_2 Y_t + \beta_3 HTE_t, + \beta_4 INSQ_t + \beta_5 FDI_t + \beta_6 BF{*}INSQ + \varepsilon_t \tag{2}$$

The usual concept in terms of engagement is that institutional efficiency strengthens bank finance and technical advancement associations. Our research forecasts that banks, GDP, HTE, INSQ, and FDI will benefit from technology. We strive to have a positive effect on bank finance and technological innovation collaborations through structural efficiencies. The National Statistical Bureau is responsible for information on technological development, bank funding, gross domestic product, high technology exports, and institutional efficiency (World Bank, 2020).

Technique for Analysis

The cross-section ARDL model developed by Pesaran and Shin (1998) was used to examine the impact of independent coefficients on the dependent coefficient. This strategy has been chosen since a smaller sample size is a reasonable option for our research situation. Another advantage is that it may give both long as well as short balance relationship while also rectifying the associated forecast mistakes. It is reasonable to employ this technique for this investigation since the outcomes of this cross-sectional assessment are appropriate for evaluating long-term connections on panels that are complicated in character and contain heterogeneity. Furthermore, when compared to the ARDL method, the CS-ARDL technique includes a systematic type of approximations that allows not only for the recognition of models that have not been established but also for the recognition of faults and components that are sequentially related. Chudik et al. (2016) report that this strategy can be employed effectively in situations once T is not too great. Due to the low T for this investigation, CS-ARDL can be utilized in order to attain the desired results in this case. This approach is most beneficial for cointegration examination when the variables exhibit mixed order of integration features at I(0) or [I(1)]. Projections were established in general form utilizing a variety of methodologies. We utilized Pesaran (2007) as well as IPS (Im et al., 2003) produced CIPS to evaluate a unit root in order to ensure that coefficients hypotheses were not unreliable. Secondly, a likelihood for long run stabilizing relationships was confirmed by Westerlund (2007) cointegration test that included the possibility of cross-dependence. The ARDL (CS-ARDL) technique was used to estimate the long-term relationship among the coefficients because the coefficients were found to be co-incorporated in the

analysis. The Augmented Mean Group (AMG) as well as the Common Correlated Effects Mean Group Estimates (CCEMG) recommended by Eberhardt (2012) and Pesaran (2006), respectively, were utilized to appraise the robustness of the long-lasting stability connection. Endogeneity, heterogeneity, cross-sectional dependency, and various measurement periods are some of the issues that the approach has to contend with. It is advantageous to utilize these approaches since their cross-sectional measurements and their stated explanatory variables are enhanced by the use of a less-quadratic methodology for supplementary projects, which is less complex. It exhibits the logarithmically stochastic nature of the model's characteristics using this way (Pesaran, 2006). The major benefit of this study is that the sample sizes of the dataset are small and complex, yet the dataset as a whole is large and simple.

Empirical Results

Descriptive Statistics

The results in Table 2 show the descriptive statistics of the factors studied in E7 economies. The mean of technology innovation is found to be 23.6% annually, a median of 23%, and a maximum of 27.3% annually. Moreover, bank financing has a mean of 3.941 million US$ per year, a median of 3.852 941 million US$ per year, and a maximum of 4.73 941 million US$ per year. Furthermore, the average growth per year for E7 economies stands at 8.6%, a median of 9.1%, and a maximum of 9.6% per year. On the other hand, high-technology export has a mean of 5.3% per year, a median of 3% per year, and a maximum of 24% per year. Furthermore, institutional quality has a mean of 3.1% per year, a median of 3% per year, and a maximum of 3.76% per year. Lastly, foreign direct investment has a mean of 0.7 million US$ per year, a median of 0.8 million US$ per year, and a maximum of 1.62 million US$ per year. Table 3 reports the correlation matrix of the variables over the period. Specifically, there is a positive and significant association regarding technique innovation, institute quality, and FDI but a negative and significant association regarding technological innovation and economic growth. Furthermore, there is a positive and significant connection with bank financing and economic growth but negative and significant with high-technology exports. Economic growth on the other hand has a negative and significant connection with high-technology exports, institution quality, and FDI. High-tech exports have a positive and important relationship with institutional quality.

Table 2. Descriptive Statistics.

Variable	TI	BF	Y	THE	INSQ	FDI
Mean	23.563	3.941	8.632	5.344	3.069	0.696
Median	23.055	3.852	9.082	2.944	3.033	0.793
Maximum	27.318	4.730	9.590	23.885	3.759	1.6162
Minimum	21.182	3.305	6.747	0.619	2.230	−2.601
Std. Dev.	1.691	0.397	0.799	7.319	0.376	0.636
Skewness	0.959	0.197	−0.814	2.065	−0.320	−1.600
Kurtosis	2.943	1.751	2.321	5.373	2.768	7.568
Jarque–Bera	20.289***	9.428***	17.107***	124.810***	2.560***	171.151***
Probability	0.000	0.008	0.000	0.000	0.000	0.000
Observations	132	132	132	132	132	132

Table 3. Correlation Matrix.

Variable	TI	BF	Y	THE	INSQ	FDI
TI	1.000					
p-value	-					
BF	0.111	1.000				
p-value	0.2038	-				
Y	−0.1901**	0.208***	1.000			
p-value	0.0289	0.0162	-			
THE	−0.024	−0.400***	−0.184**	1.000		
p-value	0.7811	0.0000	0.0340	-		
INSQ	0.303***	0.009	−0.299***	0.257***	1.000	
p-value	0.0004	0.9173	0.0005	0.0028	-	
FDI	0.435***	−0.042	−0.290***	0.058	0.087	1.000
p-value	0.0000	0.6307	0.0007	0.5026	0.3168	-

Note: ***, **, and * are 1%, 5%, and 10% significant level, respectively.

Stationary, Cross-Section Dependency (CD), and Slope Homogeneity Tests

When compared to the extensively employed conventional econometric technique, this review is based on analytical study that has been conducted before it. Before doing any unit root tests, cointegration assessments, or long-run prediction, it is vital to take into consideration all of the possible concerns. As a basis, our approach first created a regression equation that verified for homogeneity in cross-sectional results before proceeding. It is possible to obtain incorrect evaluation findings by ignoring the information contained in a long-term dataset (Khan et al., 2020, Su et al., 2020). This is the reason why we examined cross-sectional dependence using the Lagrangian multiplier (LM) assessment suggested by Pesaran (2015), the CD test suggested by Pesaran (2007), the LM techniques suggested by Breusch and Pagan (1980), and the slope homogeneity suggested by Pesaran and Yamagata (2008). Because of the increasing divergence of the global economy, the issues highlighted by cross-sectional reliance are a source of worry. Many countries are becoming lesser autonomous of one another and are becoming more vulnerable to linked shocks as a result (Hao et al., 2021; Su et al., 2020).

Several countries have distinct economies as well as policies, and the assumption of homogeneity might contribute to erroneous consequences is based on this assumption of an increase of global economy (Su, Cai, et al., 2021). The results of the inquiry determined that (1) the assumption of cross-sectional dependence was correct and (2) the assumption of slope

Table 4. Cross-Sectional Dependency and Slope Homogeneity Analysis.

Mode	Pesaran (2007) CD Test	Pesaran (2015) LM Test	Breusch-Pagan (1980) LM Test	Slope Homogeneity Test		*p*-Value
TI= f (BF, Y, HTE, INQ, FDI)	2.516**	−1.746*	809.45***	Delta_tilde	7.584***	0.000
p-value	0.0119	0.081	0.0000	Adj. Delta_tilde	−7.368***	0.000

Note: ***, **, and * are 1%, 5%, and 10% significant level, respectively.

heterogeneity was correct. The outcomes of Table 4 demonstrate that the Pesaran (2015) LM, the Pesaran (2007) CDs, and the Breusch-Pagan (1980) LM have all been made dependence evaluated, and that the insignificant hypothesis supports the freedom of the randomly selected sample. As a result, all of the variables are interdependent on one another over time. Additionally, the models demonstrate the delta and revised delta variables of slope homogeneity check for the slope heterogeneity issue. The study result from CD and slope research serves as the foundation for the novel ways to regression assessment that have been developed.

Stationarity Test

The second-generation unit root test was not to refute the null hypothesis as the results showed that the panel figures were cross-based. As a result, in order to fix the cross-sectional dependence issue, it became important to combine a unit root test. The IPS and CIPS approaches were then utilized to assist in determining whether or not a model contains a unit root. It was much easier to assess the inclusion of all factors while using this strategy, as well. While this is a strategy that is particularly useful or necessary for analyzing second-order generation in panel study, these techniques are acceptable since they can identify heterogeneity inside and among panels. The fundamental CIPS configuration is as follows

$$\Delta CA_{i,t} = \Phi_i + \Phi_i Z_{i,t-1} + \Phi_i CA_{\dot{i}t} - 1 + \sum_{1=0}^{P} \Phi il \Delta CA_{t-1} + \sum_{1=0}^{P} \Phi il \Delta CA_{i,t1} + \mu_{it} \tag{3}$$

where $CA_{\dot{i}t} - 1$ and $\Delta CA_{i,t1}$ represent cross-section average. The CIPS statistic is also given below as

$$\mathrm{CIPS}_{2007} = \mathrm{N}^{-1} \sum_{\mathrm{i}=0}^{\mathrm{n}} \mathrm{CDFi} \tag{4}$$

where CDF is cross-sectional augmented Dickey–Fuller (CADF) given in equation 4. These methods are preferable for us to address the problem of a weakness in the pseudo-stationary data collection and to take advantage of the additional information provided in the inspection results by a joint cross-sectional time series. Table 4 shows that the parameters combine series one so the results are identical. The results are similar. It is also an indication of non-stationarity of the distribution variables at the level, but at first time, the differential stationary implies, for example, TI, that the variation at the level under the heterogeneity variance system is stationary at position I[1]. As shown in Table 5, all parameters were not stationary at level but at first suggestion that, the variables were acceptable for analysis and the results could be used in decision evaluations.

Cointegration Analysis

The employment of the recommended technique by Westerlund (2007) was forced by the discovery that second-generation cointegration framework is more appropriate for this data. In spite of cross-dependence estimating challenges, second-generation time series approach is sufficient to identify cointegration and shows that there is no presence of linkage contrary to the null hypothesis. The findings from Table 6, which are numerically expressed, demonstrate that the null claim must be rejected. The outcomes observed are long run in the sense that they have the potential to influence the dependent component in the long run. Specifically, it asserts that the variables are significantly connected with portfolio production at both the 1% and 10% thresholds, and that the variables have a long-term impact on portfolio innovation.

Long-Run and Short-Run Relationship

The test results for ARDL (CS-ARDL) cross-sectional technique are given in Table 7. The CS-ARDL equation is provided as the following equation

$$\Delta \mathrm{TI}_{\mathrm{i,t}} = \pi_{\mathrm{i}} + \sum_{\mathrm{i}=0}^{\mathrm{P}} \pi_{\mathrm{il}} \Delta \mathrm{TI}_{\mathrm{i,t-1}} + \sum_{\mathrm{i}=0}^{\mathrm{P}} \pi_{\mathrm{il}} \mathrm{AEV}_{\mathrm{i,t-1}} + \sum_{\mathrm{i}=0}^{\mathrm{P}} \pi_{\mathrm{il}} \mathrm{z}_{\mathrm{i,t-1}} + \mu_{\mathrm{it}} \tag{5}$$

The cross-section averages are indicated by $\mathrm{Z_t} = (\Delta \mathrm{TI_t}, \mathrm{AEV_t})$ where $\mathrm{AEV_t}$ represent the independent variables as a bank funding, high-technology export, institutional quality, and foreign direct investment. All parameters

Table 5. Unit Root Analysis.

	CIPS				IPS			
	I(0)		I(1)		I(0)		I(1)	
Variable	C	C&T	C	C&T	C	C&T	C	C&T
TI	−3.569	−3.639	−4.688***	−4.612***	−1.952	−2.262	−4.649***	−5.638***
BF	−2.871	−3.794	−3.044***	−5.097***	0.766	−3.834	−3.444***	−4.725***
Y	−3.204	−2.655	−4.162***	−4.292***	−0.074	−1.003	−5.250***	−5.017***
THE	−2.155	−1.430	−2.291**	−2.382*	− 0.114	−1.476	−5.041***	−5.216***
INSQ	−1.847	−2.109	−3.864***	−3.850***	−1.578	−1.824	−4.262***	−4.555***
FDI	−2.701	−2.993	−4.635***	−4.615***	−2.825	−3.313	−6.261***	−6.260***

Note: ***, **, and * are 1%, 5%, and 10% significant level, respectively.

Table 6. Westerlund Cointegration Analysis.

Statistics	Value	*p*-value
Gτ	−2.120*	0.061
Gα	−1.651***	0.000
Pτ	−4.172*	0.095
Pα	−2.443*	0.085

Note: ***, **, and * are 1%, 5%, and 10% significant level, respectively.

Table 7. Cross-Sectional (ARDL) Analysis Long Run and Short Run.

Variables	Model 1 Long Run	Short Run	Model 2 Long Run	Short Run
BF	0.1067**	0.0741**	0.0893***	0.0641**
p-value	0.013	0.027	0.001	0.043
Y	0.4321***	0.1891**	0.3742***	0.235*
p-value	0.002	0.024	0.005	0.096
THE	0.1245**	0.0834	0.0982**	0.0756
p-value	0.024	0.235	0.041	0.345
INSQ	0.2301*	0.0131	0.1894*	0.1546
p-value	0.074	0.321	0.053	0.855
FDI	0.0745**	0.0542*	0.0528**	0.0356**
p-value	0.035	0.089	0.032	0.048
INSQ*BF	-	-	0.8945**	0.7892*
p-value	-	-	0.045	0.075
ECM	-	−0.452**	-	−3.892**
p-value	-	0.041	-	0.032

Note: ***, **, and * are 1%, 5%, and 10% significant level, respectively.

discussed in models 1 and 2 reliably contribute to a favorable long-term effect on technical progress.

Discussion of Findings

As seen in Table 6, as the extent of bank financing rises, technical advancement also grows. Besides, banking systems foster technical advancement, both for immediate benefits and long-term growth. These findings are backed by Hertwich et al., (2015b); Law et al., 2018; Onifade et al., 2021, who reported that bank finance, an investment source, is positively linked to technological transition. Funding can help companies introduce emerging

technologies and test revolutionary new products. The relevance of bank financing in influencing technical progress and the overall competitiveness of an economy is vital to every country. Furthermore, the systemic quality has no impact on creativity in the short term but may have a substantial effect in the long term. These findings are confirmed by the literature (Lee & Law, 2017, Wang, 2013). Institutional quality offers a framework for emerging economies to keep up with their more established peers. Governments with a strong and well-established policymaking apparatus are more effective in economic growth. Strong institutions help countries to defend IPR, which makes an imitation of that country's goods incredibly expensive. Hence, an institution's quality standard has an important effect on fostering creativity. The findings show that, while high technology exports are positively linked to technical progress in E7 countries in the long term, in the short run, it is negligible. This concept stems from the fact that high-tech exports to E7 countries typically come from foreign companies supplying the host countries with information and technology. Due to hi-tech growth and exports, worldwide technologies will spread to Japan, which in turn will spur technological innovation (Wang et al., 2020). In terms of technology transfer and spillover impact, domestic companies are advantaged. Accordingly, hi-tech exports are crucial for technical advancement in E7 countries. Nevertheless, the findings suggest that higher levels of gross domestic product are correlated with greater innovation in E7 economies which affirms the findings of Coban et al. (2020), Gyamfi et al. (2021), and Bekun et al. (2021). Because of the economic production efficiency, GDP coefficient is strong and significant in the short term and in the long term. Furthermore, FDI has a positive and significant effect on technological innovation in long run and short run. This shows that the relevant countries are using foreign investment to enhance the data of technological knowledge. High-income countries have a larger capacity to spend on research and development which has a direct impact on technical advancement. According to the results, rich countries are much better at acknowledging the innovative capabilities they provide. This study investigated the link between institutional efficiency and bank financing. The assessment of institutional quality and bank financing takes into account their joint impact on investment in R&D. The positive coefficients and important coefficients of the interaction words indicate that with the improvement of operating efficiency, the positive effect of bank finance has been promoted. Considering the clear interdependence between the structural consistency of the case and bank financing, there is abundant proof of illustrating technical advancement. We used the two approximate AMG and CCEM values in Table 8 for robustness, and the findings are consistent with CS-ARDL; thus, all the independent variables (banking finance, economic growth, high-technology exports, institution

Table 8. Robustness Check Using AMG and CCEMG.

Variables	AMG	CCEMG	AMG	CCEMG
BF	0.1939**	0.7707**	1.1440**	1.8184**
p-value	0.047	0.012	0.028	0.016
Y	0.0620***	0.2748***	0.0795***	0.6475***
p-value	0.007	0.000	0.008	0.009
HTE	0.0586***	0.1686***	0.0959***	0.1541***
p-value	0.009	0.004	0.003	0.007
INSQ	0.0136*	0.3422*	0.1820*	1.5103*
p-value	0.057	0.089	0.074	0.057
FDI	0.0328*	0.0126*	0.0246**	0.0203**
p-value	0.066	0.086	0.022	0.019
INSQ*BF	-	-	1.4468**	1.6103**
p-value	-	-	0.030	0.018
Wald test	13.47**	12.46*	11.48*	13.61**
p-value	0.0281	0.0524	0.0610	0.0288
No. regressors	5	5	6	6
No. observations	133	133	133	133
No. group	7	7	7	7

Note: ***, **, and * are 1%, 5%, and 10% significant level, respectively.

quality, and the interaction terms utilized) are positively significant with the dependent variable and thus technological innovation.

Conclusion and Policy Recommendations

Concluding Remarks

The adoption of advanced technology and "internalization" in the Fourth Industrial Revolution provides opportunities for increased global profits. This paper explored the rippling effect that the current Industrial Revolution (ID 4.0) has on the financial industry. Bank financing emergent is highlighted as a crucial consideration to remember when assessing technical innovation. This is because bank financing contributes to the efficiency of the organizations and also assists an entire economy to effectively follow the steps of leading economies. Much of the academic literature on financial growth and innovation has examined the relationship between financial systems and innovation. More differently from this dimension, this study sought to discern how the availability of bank financing and institutional quality high-tech exports, investments abroad, and GDP expansion drive technological innovation. It employs the IPS, and the modern unit root testing approaches to assess the order of integration. Specifically, the CIPS test indicates that all factors

combined were in a correct order. Subsequently, the results of CD test were used to reject the null hypothesis that there is no cross-sectional dependence. In other words, expected shocks are likely to spread through E7 member states in one intersection. However, this poses the problem of slope heterogeneity as evident in the important delta and adjusted slope homogeneity test parameters. This analysis utilized the Westerlund cointegration approach to analyze long-run connection between technical progress, as well as its predictors like bank financing, institutional efficiency, advanced technology exports, foreign direct investment, and gross domestic product. Regarding technical progress and its predictors, we identify a long-term link between them. This study used the CS-ARDL technique to approximate the long-term coefficient of independent variables. The findings indicate a positive correlation between bank funding and institutional efficiency and high-tech exports, foreign direct investment and GDP, and technological innovation which has also been verified by AMG and CCEMG as techniques for sensitivity. This study indicates that large-scale illiquid financial investment is a necessity to implement the revolutionary technologies. Access to finance will also allow economies and businesses to implement technological innovations and to track costly patterns. Thus, adequate bank finance is essential for enhancing industrial efficiency and innovation. Nonetheless, economies without quality institutions will be unable to stimulate an innovative and efficient industrial ecosystem, thus limiting effective innovation in such economies. For instance, we surmise that, nations with established institutions can safeguard the property rights of indigenous businesses which retrospectively drives a favorable atmosphere that promotes security and innovation. Thus, E7 member states should reinforce independent frameworks that create an environment that welcomes innovation and creativity.

Policy Recommendations

The E7 must create detailed and meaningful frameworks outlining the trajectory of the Fourth Industrial Revolution. For instance, they must insure that principles and ethics are ingrained in their individual and collective activities, particularly those involving economic and finance systems. Thus, they must progress above tolerance and reverence to sincere concern and empathy, with empowerment and openness being their central tenets. The E7's policymakers must take steps to reorganize their economies, social structures, and systems of government. It is clear that the existing leadership systems and predominant wealth-creation mechanisms seem incapable of meeting internal or, more importantly, specific expectations. What is required now are systematic and creative structural transformations, not small-scale changes, or incremental amendments.

According to the findings of this study, large-scale illiquid capital investment is required for enterprises to embrace new technologies on a wide scale for the E7 economies. In order to facilitate the implementation of new

technologies and the undertaking of costly endeavors of innovation, access to finance should be made more accessible. Bank funding would therefore play a significant role in increasing innovation and productivity in the economy. The course of the Fourth Industrial Revolution will be determined by people, society, and principles. Regardless of how impressive they appear, new innovations are essentially just resources designed by humans for humanity. They should take this into consideration and realize that creativity and technology continue to prioritize individuals, catapulting humanity into a more prosperous and equitable future. Though the study examine how banking finance, economic growth, FDI, institution quality and quality high-tech exports on innovational advancement in to the extant current, but there is still a vacuum left unexplored as a future guide for other researchers to advance the body of knowledge on this theme. However, there is still a vacuum left unexplored as a future guide for other researchers to advance the body of knowledge on this theme. Thus, the need to enhance other ICT structures helps in fast tracking banking activities and motivates our suggestion for further study in other emerging blocs like SSA, MENA, and G7 economies.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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