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Knowledge-Based Economy Capacity Building for Developing Countries: A Panel Analysis in Southern African Development Community

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Abstract: The Southern African Development Community is lagging behind in terms of knowledge economy relative to other regions worldwide. This dramatically reduces the chances of keeping up with their economically established counterparts in terms of sustainable development. This paper therefore, applies multivariate panel data analysis which is predicted on the Cobb–Douglas production function to analyze the affiliation flanked by knowledge-based economy pillars and economic growth from 1998–2018. The World Bank knowledge-based economy framework is employed. To achieve the study goal, the long-run effect regarding proxies of each pillar in the knowledge-based economy on economic growth is first estimated. Afterwards, the average impact of each pillar is examined using the average impact index (AII). Employment of both conventional unit root and co-integration tests showed all observed series are stationary and co-integrated. Further estimation of the long-run relationship using both static and dynamic models (fixed effect and generalized method of moment) portrayed that government effectiveness, adjusted savings on education expenditure, tertiary enrollment, scientific and technical journals, and mobile cellular subscriptions have significant positive impact on economic growth. Finally, the AII estimation unveiled that the innovation pillar is the most impactful aspect on economic growth followed by education and skills with the least being information and communication technology infrastructure. Feasible policy recommendations are further suggested.

Keywords: knowledge-based economy; economic growth; panel analysis; capacity building; Southern African Development Community



Citation: Phale, K.; Li, F.; Adjei Mensah, I.; Omari-Sasu, A.Y.; Musah, M. Knowledge-Based Economy Capacity Building for Developing Countries: A Panel Analysis in Southern African Development Community. *Sustainability* **2021**, *13*, 2890. <https://doi.org/10.3390/su13052890>

Academic Editors: Marc A. Rosen and Jungho Baek

Received: 6 January 2021

Accepted: 3 March 2021

Published: 7 March 2021

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1. Introduction

If monetary policies continue to run out of steam, the World Economic Forum reports that it would be important for economies to depend on fiscal policy, structural changes, and public incentives to devote more capital to the full spectrum of growth factors. This would allow countries to take full advantage of the new prospects presented by the Fourth Industrial Revolution, driven by the transition to knowledge-based economies (KBE) [1]. According to [2], a knowledge-based economy is one that uses knowledge as the primary motor of economic growth. Basically, it is an economy, in which the main drivers of growth, wealth creation, and employment across all industries are production, distribution, and use of knowledge. In particular, countries need knowledge-based economies, not only to build more effective domestic economies but also to take advantage of economic opportunities beyond their borders. The usage of knowledge, as expressed in areas such as research and development, entrepreneurship and innovation, and at the level of education and

skills of individuals, is now recognized as one of the core drivers of growth, productivity, and competition in the global economy [2]. The knowledge concept for this analysis is adapted from the World Bank Institute knowledge-economy framework, which categorizes knowledge into four pillars: economic and institutional regime, education and skills, and an efficient innovation system, as well as the information and communication technology infrastructure, which all constitute a knowledge economy of a country.

In today's increasingly competitive global economy, science, technology, entrepreneurship, human resource development, and innovation capacity building can no longer be seen as a luxury suitable primarily for wealthier and more economically dynamic countries. Rather, if any nation hopes to prosper and survive the challenges of the global economy, and if world leaders expect globalization to foster sustainable development and sustainable poverty reduction, KBE capacity building is an absolute necessity. This can be backed up by the fact that different researchers, including but not limited to [3–8], have all studied the relationship between the role of knowledge-based economy and economic growth of selected countries and regions, and they all respectively found out that there exists a significant and positive impact of knowledge toward economic growth. It is therefore widely acknowledged that knowledge is essential for economic growth and development. When a country has more investment in knowledge, the more economically advanced it will be. Thus, the critical economic development and growth issue is no longer whether countries should build KBE capacity but what type of capacity to build, where to start, and how to build it, given each country's economic constraints and starting point. KBEs have been at the center of key policy reports from the Organization for Economic Cooperation and Development (OECD) and the World Bank in recent years [6,9–11]. It is within this policy framework that the relevance of KBE has been mastered by North America, Europe, and East Asia, which have inevitably been determining the pattern of economic development in the international arena [12].

The Southern African Development Community (SADC) is an international intergovernmental organization comprised of 15 countries in Southern Africa. It was established with the signing of the Declaration and Treaty of the SADC on August 17, 1992, in Namibia during the Heads of State and Government of the Southern African Development Coordination Conference. The underlying motivation for member states joining this community stems from the fact that the SADC aims to achieve development, peace and security, and economic growth; to enhance the standard and quality of life of the people of Southern Africa; and to increase regional integration amongst its member states. While other developing countries in Latin America and Asia have been catching up with KBE frontiers in pursuit of their regional and national goals [6,13,14], the overall index of the knowledge economy in SADC is worsening, though it has been recognized as Africa's leading regional economic community [15–18]. SADC is lagging behind in regards to its knowledge economy compared to other regions of the world, particularly in terms of education, innovation, institutions, information, and communication technology (ICT) and economic incentives [18–20]. This represents a challenge in attaining global competitiveness, sustainable developments, poverty reduction, and considerably diminishes prospects of SADC countries catching up with their more economically developed counterparts. As the contemporary development literature highlights, twenty-first century economic prosperity is largely centered on KBEs [6,21–24]. In order for SADC countries, and regions alike, to brace the challenge of globalization, poverty reduction, and sustainable developments, appropriate KBE capacity building strategies and policy initiatives are needed for the successful catch-up process with frontier countries and regions [25]. With this context in mind, this themed issue is timely for informing scholars and policy makers on the development of SADC's KBE with backed-up findings acquired from examining the knowledge-economy specificities of which dimension of the knowledge economy to highlight and at what point.

A pattern that emerged from past studies revealed that much more on KBE is known when it comes to frontier, advanced high-income countries than it is for latecomer, struggling middle- or low-income countries. Recent studies on African knowledge economy

usually advise that African nations who are seeking to successfully transition and catch up with KBE frontiers should use the advanced economies (from North America, Europe, and East Asia) as role models in their quest to successfully attain the KBE status [12,25,26]. They advise on adoption of the generic global discourse of strategies and policies that those KBE frontier countries have used to reach the point of being regarded as KBEs which African countries should mimic and benchmark from in order for them to also catch up and become KBEs. They however, have not devised an approach from a latecomer economy's perspective that may assist African nations and countries alike, to know which KBE dimension to highlight and what capacity to build in order for them to successfully transition and catch up. We reckon that African nations are basing their KBE developmental strategies and policy initiatives on the mainstream criteria inspired by the beauty of the KBE-transition success stories of the advanced frontier countries they want to catch up with.

This study thus cautions that knowledge and policies from developed countries should not be applied in developing countries without incorporating specificities of the developing countries. From this standpoint, we propose that the focus of debate in policy making and defining policy objectives should move beyond setting objectives exclusively adopted from global discourse to also considering local strengths and capabilities. In such conditions, there will be less resistance to the government plans and fewer social challenges. In fact, devoting too much attention to building the wrong type of KBE capacity may be just as detrimental as not building any or focusing too little on building the one that could actually accelerate the catch-up process. This may as well be the reason behind the gradual depreciation of SADC countries and Africa as a whole in their level of development in the knowledge-economy international rankings, given that they are focusing on the wrong dimensions and capacity. This study therefore in its provision of practical policy initiatives drawn from assessing SADC's KBE specificities intend to fill the abovementioned gap. It will help latecomer economies, especially those low- and middle-income, undeveloped, and developing countries, get perspective and foster their transition into and catch-up process with KBE frontiers since they homogeneously share common traditions, colonial history, economically comparable natural resources, post-independence growth patterns, regional proximity, political stability, and an overall level of developments with the region of interest (SADC) in this study. To resolve the aforementioned review limitations, with the World Bank knowledge-based-economy framework having been employed, the present study attempts to contribute to the literature in the following ways:

- Comparatively, this current study performs the investigation on nexus between knowledge-based economy and economic growth in SADC, a region with countries that have in recent years undoubtedly receded in terms of international rankings when it comes to transition into knowledge-based economies. Thus, this study provides a concrete breakdown with respect to assessing the effect of various proxies measuring the pillars of knowledge-based economy on economic growth, rather than only focusing on a composite index.
- Contributively, this is the first study to the best of our familiarity in SADC region and African KBE studies to examine the effect of various dimensions (pillars) of KBE in hierarchical form from the most impactful KBE pillar to the least impactful affecting the economic growth with the aim of determining which KBE dimension should be afforded more attention as it may be the missing link to fill the gap between latecomer and frontier countries in the knowledge economy.
- This study will help low- and middle-income, undeveloped, and developing countries like those in the SADC region lessen chances of misplaced KBE policy initiatives, which are not incorporating the specificities of the latecomer status but rather are just inspired by the beauty of the KBE-transition success stories of the advanced frontier countries they want to catch up with.
- From the theory perspective, most empirical research focusing on the connection amid knowledge-based economy and economic growth in a panel setting only investigates the nexus amid the aforesaid variables by ignoring the standard econometric

procedure of testing for the existence or absence of cross-sectional residual dependency. According to the report from [27], the existence or non-existence of residual cross-sectional connectedness present in a panel data system is vital with regard to selecting the appropriate econometric approach. Thus, this current research proves that the panel data possess no issues of cross-sectional dependencies through the cross-sectional reliance test of [28] together with slope homogeneity checks of [29]. In view of this, efficient, econometric approaches are employed to provide reliable outcomes.

This study then continues like this: the second section outlines some theoretical and scientific analysis that explores the role of the individual pillars of knowledge-based economy in economic growth. The analytical model, data, and techniques used to approximate the empirical model are discussed in the third section, while the empirical findings are discussed in the fourth section and fifth sections respectively. Furthermore, the conclusions and policy recommendations are given in the sixth section where the last section elaborates on the limitation of the study.

2. Review of Literature

There is a substantial amount of empirical literature on the relationship between knowledge-based economy pillars and economic growth. Therefore, in this chapter, we briefly review the empirical literature on the liaison amid economic growth and each pillar of the knowledge-based economy as defined by the World Bank Institute, thus providing empirical support to the knowledge-based-economy framework proposed in our methodology.

2.1. Economic and Institutional Regime and Economic Growth

The ability of government to provide effective regulatory framework can be a benchmark of how an economy and market transaction perform. Thus, the effect of economic and institutional regime on economic development depends on the quality of governance process, regulatory policies adopted, and incentives applied. Specifically, the authors of [30] has proven that government incentives and institutional regimes give unique and statistically significant contributions to economic growth. This is because economic growth depends on whether the state has well-established transparent macroeconomic and competitive policies, as well as a legal framework that provides a way for different individuals to generate and use knowledge freely, efficiently, and effectively. Reference [31] has shown that institutional quality positively and significantly impacts economic growth in Islamic countries. Report [32] finds that economic and institutional regimes, among other factors of production, have a significant effect on economic growth. In addition, it has been argued that institutional regime of a country should be planned efficiently to encourage businesses to utilize knowledge, given that the favorable environment and condition for economic activity are delivered.

In view of the country-level research focused on emerging and developed countries, good governance has been stated to be very critical for economic growth by [33], because better governance ultimately translates to higher per capita GDP. Furthermore, the authors of both [34,35] argued that good governance facilitates the “helping hand” of power in some provinces of China while inhibiting the “taking hold” of power, resulting in a positive effect on economic growth across three potential routes or channels: marketing, government capability, and the rule of law. Reference [36] concluded that economic and institutional quality facilitates the reconstruction of the industrial system in the provincial areas of China, with a “governance capacity + governance output” two-dimensional governance perspective and a robust governance quality index incomparable across the years 1985–2005.

2.2. Education and Skills and Economic Growth

For efficient development, acquisition, distribution, and use of applicable information, a well-educated and trained population is important. This tends to increase the overall

productivity factor and thereby economic growth. A more educated populace appears to be comparatively more mature technologically as well. This increases local demand for innovative products of the best quality, which helps to inspire local industries to innovate and create technologically advanced goods and manufacturing techniques.

Reference [37] examined the long-term link amongst higher education and the fiscal advancement in the South Asian states with the implementation of the econometric co-integration panel. The study identified a detailed affirmative correlation between the fiscal development of the South Asian nations and the total percentage of high-school enrollment. Therefore, the study concluded that if South Asian nations paid more careful attention to higher education, the quality human capital necessary for economic growth may improve.

In addition, the authors of [38] considered what transpires if universities use community raw data of 15,000 universities in 78 countries to exert control on fiscal advancement. The presence of a positive association between imminent improvement in GDP per capita and population growth at different universities was identified based on panel data from 1950 to 2010. Furthermore, the study identified positive spillover impacts on adjacent states from universities from other metropolitan regions. Upon education being regarded as a poverty alleviation tool, a study undertaken by [39] indicated that government spending on education and other primary economic sectors has not had a significant impact on Nigeria's poverty reduction agenda. From the perspective of [40], in India, the relationship between education and economic growth was investigated using Granger causality and co-integration approaches from 1975 to 2016. The research focused on basic, secondary, and tertiary education levels and concluded that there was a strong correlation between various levels of education and economic growth. Using a panel data of 14 Asian economies [41] also established the presence of long-run equilibrium association between expenditure on education and economic growth from 1973 to 2012. According to their findings, it revealed that 0.84 percent of economic growth is stimulated by one percent increase on education investment.

Considering the research by [42], the causal relation between education and economic growth in India was investigated during the period 1951–2001. The results showed the unidirectional causality of economic growth from education. In particular, higher education leads directly to economic growth by making workforces more productive, contributing indirectly to the production of expertise, ideas, and technical advances. The causal association between education and economic growth was investigated in Pakistan by [43] using panel data spanning the period from 1970 to 2009. The findings demonstrated a feedback causal relationship between said variables. The comparative growth effects of disaggregated gender and level-specific enrollment ratios for Asian economies were investigated using extreme bounds analysis (EBA). The findings revealed that for both genders, the effects of education are positively significant at education levels. They contribute to quality human capital, which in turn has a positive effect on the overall economic growth.

2.3. Efficient Innovation System and Economic Growth

A well-documented literature among development economists suggests that innovation is the seed of productivity growth [44,45]. A multiple autoregressive model analysis showed that innovation, expressed through the number of patents, and the level of research and development (R&D) expenditures in Central and Eastern European countries (CEECs) exert a strong influence on economic growth [44]. Furthermore, to inspect the effect of innovation on economic growth in CEECs, the authors of [46] utilized an unbalanced panel dataset from 1993 to 2014. The findings, based on the autoregressive distributed lag (ARDL) panel model, show that innovation in terms of R&D investment has so little effect on economic growth, while patents have a positive long-term impact on economic growth. On the other hand, the development level of a country is a generator of innovation, which enables funds to be allocated to R&D and represents the main origin of support to the innovation process in CEECs [47]. The article also points out that CEECs have increased

economic development, but growth is not dependent on the process of innovation, as innovation is a process of catch-up relative to the rate of growth.

Reference [48] analyzed the relationship between R&D investment, innovation, and economic growth in 13 high-income OECD economies. They evaluated causal relationships between the variables, estimating a trivariate panel vector autoregressive (VAR) model, using panel fixed effects, and generalized method of moments (GMM) methods with annual data from 1991 to 2007. Specifically, they reported that the relationship between innovation and economic growth is positively significant. Furthermore, [49], the dynamic OLS and fully modified OLS estimation approaches were used to analyze the long-term relationship between innovation and economic growth in 21 OECD countries over the period 1990 to 2010. The research found out that the long-term association between innovation and economic growth is solid and tangible. In the same area of study, the authors of [50] predicated on the impact of innovation on high-technology exports, ICT exports, overall exports, and economic growth in 11 developing Asian countries, using data from the 1996–2012 with panel data analysis, which considers cross-sectional dependence. Relying on the Eberhardt–Bond panel AMG method of estimation, R&D investment (quantifying innovation) was seen to boost technology exports by 6.5 percent, ICT exports by 0.6 percent, and economic growth by 0.43 percent.

2.4. Information and Communication Technology (ICT) Infrastructure and Economic Growth

The fast global advancement of ICT in the last thirty years has drawn a lot of interest among several economists and scholars who have concentrated on researching the effects of ICT diffusion on the economic growth of developed and emerging economies. It is therefore undeniable that breakthroughs regarding information and communication technology play an important role in affecting our living standards in many different ways. Sectors, which involve ICT producing, have been through major technological progressions, which have contributed to huge expansions in economic progression globally. The development of ICT technology leads to economic growth by (a) meeting the demand for digital goods, such as communication devices, computers, and applications, and (b) increasing competitiveness and investments in the ICT sector [51].

Using a panel of 17 MENA economies, the authors of [52] identified a positively significant effect of ICT diffusion (assessed by three metrics: namely, mobile phone usage, fixed line telephones, and internet usage) on economic growth over the period 1960–2009. Furthermore, the existence of causal ties between ICT infrastructure, financial development, and economic growth has been investigated in 21 Asian countries over the period 2001–2012 by [30], and it has been acquired that ICT infrastructure and financial development are significant in deciding Asian countries' long-term economic growth. In addition, the authors of [53] observed that ICT investments only fuel economic growth in developed countries over the period 1993–2001, using generalized method of moments and a fixed effect model for 42 developing and developed countries. From the side of [54], the impact of mobile telephony as an indicator of ICT on economic growth in India by means of yearly data from 2001–2012 unveiled that mobile telephony is significantly and positively related to economic growth. Similarly, using static and dynamic panel data collected over the period from 1990 to 2014, the authors of [55] examined the effect of information and communication technology investment on economic growth in Organization of the Islamic Cooperation (OIC) countries. The findings showed that investments in ICT had a substantial influence on economic growth in the selected countries.

To assess the extent and trajectory of causal interactions between ICT (both broadband and internet users) and economic growth, the authors of [56] employed the panel co-integration method and the Granger-causality test on annual data from 2001 to 2012 from G-20 countries. A positive and significant connection between ICT infrastructure and economic growth was discovered with the use of the consumer price index, labor force participation, and gross fixed-capital investment as control variables. By employing the GMM estimation technique over the period of 2007–2016, the authors of [57] in MENA

region reported that ICT in terms of mobile phone usage, internet usage, and broadband adoption was the major driver of economic growth. Specifically, mobile phone was evidenced to have the highest positive impact followed by internet usage and then broadband adoption. In a comparative study between 41 SSA economies and 33 OECD countries from 2006 to 2016, the authors of [58] examined the contribution of digitalization as a form of ICT to economic growth also using the GMM estimator. The findings showed that digitalization leads favorably to economic growth in both nations. However, relative to the OECD countries, the influence of broadband internet was small for SSA countries, while the influence of mobile telecommunications is higher for SSA than for OECD countries. Furthermore, the authors of [56] did a study on the liaison amid economic growth and internet usage in South Africa from the period 1991 to 2013. The outcome demonstrated a strong and positive long-term correlation between economic growth and the use of the internet. This thus gave the indication that internet usage has future potential significant effect through creation of knowledge spillover in shaping the South African economy.

3. Methods

3.1. Theoretical Model Design

We used the Cobb–Douglas production function as a vehicle and guide to research the relationship between knowledge-based economy and economic growth in order to show how economic growth can be influenced. The reason for the employment of this function is simply because the effect of diminishing marginal return of factor of production is taken into account, which makes the model relatively reliable as it is close to actual production. The Cobb–Douglas production function is theoretically expressed as

$$Y_{it} = A_{it}K_{it}^{\theta}L_{it}^{\theta_1}, \text{ where } \theta + \theta_1 = 1 \quad (1)$$

where L represents labor force, K denotes capital stock, and A is the total-factor productivity.

It is undeniable that labor and capital have long been regarded as primary development factors in which more attention was being paid only to them and less emphasis on other factors when it comes to the economic growth theory [59]. The Solow residual, which is unexplained by increased labor and capital accumulation, is due to the development of total-factor productivity in the growth theory. Investment in knowledge, innovation, and human capital play a very important role in economic growth based on the endogenous growth model. This theory focuses primarily on a knowledge-based economy's spillover effects and positive externalities that further promote economic growth.

Based on the endogenous growth model, investment in knowledge, innovation, and human capital play a very important role in economic growth. This theory mainly focusses on the spillover effect and positive externalities of knowledge-based economy, which further enhance economic development. In particular, the endogenous growth model stated by [60] is the best theoretical basis for measuring the change in the knowledge-based economy. Moreover, knowledge has been pinpointed as part of growth that is not accounted for by other production factors such as labor and capital [61]. As per [62], persistent investments in the four knowledge-based economy pillars (indicated by KEP) would help to increase the overall productivity factor growth rate and ultimately foster economic growth. Thus, relying on the aforementioned assertions, this study contributively substitutes total-factor productivity in Cobb–Douglas neoclassical growth function in Equation (1) by the knowledge-based economy pillars to obtain Equation (2) as

$$Y_{it} = KEP_{it}K_{it}^{\theta}L_{it}^{\theta_1} \quad (2)$$

where Y_{it} represents production output of i th cross-section at time t , KEP_{it} on the other hand represents knowledge-based economy pillars (the knowledge-based economy pillars are developed by World Bank which is being used to analyze impact of four knowledge-based economy pillars), K denotes the capital stock, and L is the labor force, whereas θ and θ_1 capture the elasticities of capital stock and labor, respectively.

In order to standardize the data measurements and as well improve upon results accuracy [63], a natural logarithm is applied to linearize Equation (2). Thus, the log-linear transformation of the Cobb–Douglas function in knowledge-based economy pillars is expressed as

$$\ln Y_{it} = \ln \text{KEP}_{it} + \theta \ln K_{it} + \theta_1 L_{it} + \varepsilon_{it} \quad (3)$$

Notably, the knowledge-based economy framework developed by the World Bank comprises of four pillars or principles that turn knowledge into an efficient engine of growth. These pillars as previously mentioned are an economic and institutional regime, education and skills, efficient innovation system, and information and communication technology infrastructure. The knowledge-based economy measure can therefore be expressed as a function of the four primary pillars as

$$\text{KEP} = f(\text{EIR}, \text{ES}, \text{EIS}, \text{ICT}) \quad (4)$$

Thus, by substituting the relation in Equation (4) into Equation (3), we obtain the extended Cobb–Douglas production function as;

$$\ln Y_{it} = \phi_0 + \phi_1 \ln \text{EIR}_{it} + \phi_2 \ln \text{ES}_{it} + \phi_3 \ln \text{EIS}_{it} + \phi_4 \ln \text{ICT}_{it} + \sum_{j=1}^2 \Omega'_j Z_{it} + \varepsilon_{it} \quad (5)$$

where EIR represents economic and institutional regime, ES denotes education and skills, EIS is efficient innovation system, ICT stands for information and communication technology infrastructure, ϕ_0 is the constant term, ϕ_1, \dots, ϕ_4 represents the average impact of the corresponding pillars of knowledge-based economy, Z is a vector containing the variables labor and capital stock, and Ω defines a vector of parameter estimates pertaining to labor and capital stock, which are constant variables in the Cobb–Douglas function.

To identify the most impactful pillar towards economic growth, the study takes into account the variables measuring each pillar. Thus, following the research of [8], the average impact index (AII) model is employed and expressed as

$$\phi_p = \frac{\sum |\Omega_v \mu_v|}{\eta_v} \quad (6)$$

where ϕ_p denotes the AII of each pillar, Ω_v is the parameter estimate of each proxy pertaining to the respective pillars which can be obtained from estimation outcomes from Equation (6), μ_v is the mean for each proxy pertaining to a specific pillar, and η_v represents the number of proxies used for particular pillar.

Several proxies have been adopted for each pillar shown in knowledge-based-economy framework. Thus, with the aim of further assessing the various proxies of knowledge based economy on growth output, we adopted trade (TRA), government effectiveness (GOE), and regulatory quality (REGQ) as measurements variables of EIR pillar; adjusted saving on education expenditure (ADJS) and tertiary enrollment (TEREN) as items measuring ES pillar; scientific and technical journal articles (ST) as the proxy of EIS pillar; and internet users (INT) and mobile cellular subscriptions (MCS) as the proxies of ICT pillar. Hence, by incorporating the mentioned proxies pertaining to the various pillars of knowledge-economy, Equation (5) is extended as;

$$\begin{aligned} \ln Y_{it} = & \Omega_0 + \Omega_1 \ln \text{TRA}_{it} + \Omega_2 \ln \text{GOE}_{it} + \Omega_3 \ln \text{REGQ}_{it} + \Omega_4 \ln \text{ADJS}_{it} \\ & + \Omega_5 \ln \text{TEREN}_{it} + \Omega_6 \ln \text{ST}_{it} + \Omega_7 \ln \text{INT}_{it} + \Omega_8 \ln \text{MCS}_{it} \\ & + \sum_{j=1}^2 \Omega'_j Z_{it} + \lambda_{it} + \mu_{it} \end{aligned} \quad (7)$$

where Ω_0 represents the constant term, whereas $\Omega_1, \dots, \Omega_8$ capture the effects of the already defined proxies for the various pillars on economic growth and $\lambda_{it} + \mu_{it} = \varepsilon_{it}$. Noticeably, λ_{it} is part of the residual term.

Furthermore, the full model is subdivided hierarchically into four regression models to examine individual effects of observed variables measuring the respective pillars as

$$\ln Y_{it} = \alpha_0 + \alpha_1 \ln \text{TRA}_{it} + \alpha_2 \ln \text{GOE}_{it} + \alpha_3 \ln \text{REGQ}_{it} + \sum_{j=1}^2 \Omega'_j Z_{it} + \lambda_{it} + \mu_{it} \quad (8)$$

$$\ln Y_{it} = \gamma_0 + \gamma_1 \ln \text{ADJS}_{it} + \gamma_2 \ln \text{TEREN}_{it} + \sum_{j=1}^2 \Omega'_j Z_{it} + \lambda_{it} + \mu_{it} \quad (9)$$

$$\ln Y_{it} = \delta_0 + \delta_1 \ln \text{ST}_{it} + \sum_{j=1}^2 \Omega'_j Z_{it} + \mu_{it} \quad (10)$$

$$\ln Y_{it} = \Theta_0 + \Theta_1 \ln \text{INT}_{it} + \Theta_2 \ln \text{MCS}_{it} + \sum_{j=1}^2 \Omega'_j Z_{it} + \mu_{it} + \lambda_{it} + \mu_{it} \quad (11)$$

where $\alpha_0, \gamma_0, \delta_0$, and Θ_0 stand for the constant terms, $\alpha_1, \dots, \alpha_3$ represent the respective parameter estimates for proxies (TRA, GOE, and REGQ) of EIR (first pillar), $\gamma_1, \dots, \gamma_2$ captures the elasticity estimates for proxies (ADJS and TEREN) of ES (second pillar), δ_1 measure the impact of ST as a proxy for EIS (third pillar), $\Theta_1, \dots, \Theta_2$ are the long-term estimates for proxies (INT and MCS) of ICT (fourth pillar), while Z and Ω have already been defined in Equation (5).

3.2. Analytical Approach

Overlooking matters of cross-sectional dependency would lead to inconsistencies in a panel data context. The presence of cross-sectional dependency specifies the econometric procedure to be used. Therefore, it is of particular interest to investigate whether or not there is any question of cross-sectional dependencies prior to performing further empirical analysis. The [28,29] cross-sectional dependency tests (BP-LM and PCD-LM tests) are therefore used in this analysis to detect the existence or lack of cross-sectional dependencies.

In the second phase of the panel econometric analytical procedure, the study assesses the stationarity properties of employed variables (proxies pertaining to the four knowledge-based economy pillars) using first generation panel unit root tests which includes the Im, Pesaran, and Shin (IPS) test, augmented Dickey–Fuller (ADF) test, and Philip–Perron–Fisher (PP) test. These conventional tests of unit roots are utilized due to the absence of cross-sectional dependency (Ref; Table 4). Notably, if the unit root findings suggest that the sequence of data is stationary, then the process of regression analysis can be used to evaluate the sequence characteristics. If, on the other hand, the dataset is nonstationary, the differenced test can then be used to determine the order of the stationary series. For this function, if the series in some order is nonstationary, then the analysis stops. Therefore, in the multivariate case, as our analysis demonstrates, the co-integration test is used to analyze the existence of long-run relationships between the observed series.

Subsequently confirming the integration order for observed series of variables employed, a co-integration test as already mentioned is carried out as the third step of the analytical procedure. Thus, this study on the bases that there exists residual cross-sectional independency used the Pedroni panel co-integration test. Specifically, if the co-integration analysis used indicates the lack of a long-term relationship, then the series of variables used cannot be evaluated.

Conversely, if the co-integration relationship is verified, then the research will continue with the determination of the model type. Most importantly, the full model as specified in Equation (7) can either be a fixed effect or a random-effect model depending on λ_i . Notably, the model is likely to become a fixed effect (FE) model if the distinct non-observation provided by λ_i can be measured and does not change with time. On the other hand, if the individual non-observation effect presented in λ_i is a random variable and conforms to a particular distribution then the full model (Equation (7)) is a random-effect (RE) model.

Thus, to confirm as to whether the study's full model is fixed or random-effect model, the Hausman test together with the likelihood ratio (LR) test are employed. Specifically, if the LR test of cross-section F-statistic is greater than the critical value at specific significant level, the null conjuncture that the FE is laid off may be rejected (meaning the FE model is accepted). On the other hand, if the Hausman test statistic is also higher than critical value, then the null hypothesis that the RE is not linked to the explanatory variables can be rejected indicating the FE model is appropriate. Hence, as confirmed by the aforementioned tests (Hausman test and LR test) (see Table 7), the FE model was preferred in this current study compared to the RE model. Specifically, the FE approach compared to other conventional econometric approaches such as the vector error-correction model (VECM) address potential issues for a panel data case regarding heterogeneity of individual cross-sectional variations due to the distinctive intercepts. In addition, a major benefit of the FE estimation is that the potential sources of biases in the estimations are limited in comparison to the VECM together with other traditional methods of estimation. In the case of VECM estimation method, a correlation between any unobserved variable and the treatment variable of interest results in a biased estimate of the treatment effect. By contrast, the FE model limits the sources of bias to time-varying variables that correlate with the treatment as well as with the outcome overtime. These conditions therefore justify the employment the FE estimation method instead of other traditional approaches.

Aside from estimating the long-run affiliation amid the study variables, the generalized method of moments (GMM) as a dynamic estimation technique through the [64] estimator is further executed. Notably, the GMM additionally is employed as robust estimator to validate the estimation outcomes from the FE method through a dynamic panel data model which allows for the lagged response variable (economic growth). This method of estimation (GMM approach) uses a set of instrumental variables that account for the issues of endogeneity arising from the potential correlation between independent variables and error terms in a dynamic panel data model according to [65]. Advantageously, it also permits one to deal with omitted dynamics in static panel models (for instance FE model), owing to ignorance of the impacts of lagged values of the response variable and also accounts for the issues pertaining to autocorrelation (serial correlation).

3.3. Data

This recent paper employs annual panel time-series data over the period 1998–2018 for 15 countries sampled from the Southern African Development Community (SADC) comprising Botswana, Eswathini, Lesotho, South Africa, Madagascar, Comoros, Seychelles, Mauritius, Angola, Zimbabwe, Malawi, Democratic Republic of Congo, Tanzania, Mozambique, and Namibia. With the purpose of examining the nexus amid a knowledge-based economy and economic growth, four pillars (economic and institutional regime, education and skills, and an efficient innovation system, as well as information and communication technology infrastructure) relying on the knowledge-based-economy framework are utilized. The impact of each of the aforementioned pillars on economic growth was examined using their respective proxies of measurement. Hence, trade, government effectiveness, and regulatory quality are employed as proxies for economic and institutional regime (first pillar); adjusted saving on education expenditure and tertiary enrollment as measures of education and skills (second pillar); scientific and technical journal articles as a proxy for efficient innovation system (third pillar); and internet users and mobile cellular subscriptions as measurement items in the case of information and communication technology infrastructure (fourth pillar). Specifically, gross domestic product measures economic growth which in this study is the response variable. Considering the proxies used in measuring the various pillars, data on trade, adjusted savings on education expenditure, tertiary enrollment, and scientific and technical journal articles, as well as internet use and mobile cellular subscriptions are sourced from the World Bank development indicators [66]. On other hand, data on government effectiveness and regulatory quality are extracted from the Worldwide Governance Indicators [67]. Notably, due to implementation

of the Cobb–Douglas production function, labor (sourced from WDI), and capital stock (obtained from Penn World Table) are also used as additional variables. In particular, the selected measurement variables pertaining to the various pillars of knowledge-based economy along with sampled countries are dictated by the availability of data. Summarily, description of variables together with their respective sources are illustrated in Table 1.

Table 1. Summary of data description.

Pillars and Their Respective Proxies				
Pillar	Measurement Var.	Abbreviation	Definition	Data Source
Economic and institutional regime	Trade	TRA	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	World Bank [66]
	Government effectiveness	GOE	Reflects perceptions of the quality of public services, civil service, policy formulation, and implementation, as well as the credibility of the government's commitment to such policies.	Worldwide Governance Indicators [67]
	Regulatory quality	REGQ	Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development.	Worldwide Governance Indicators [67]
Education and skills	Adjusted saving on education expenditure	ADJS	Education expenditure refers to the current operating expenditures in education, including wages and salaries.	World Bank [66]
	Tertiary enrollment	TEREN	The percentage of total enrollment, regardless of age, in postsecondary institutions to the population of people within five years of the age at which students normally graduate high school.	World Bank [66]
Efficient innovation system	Scientific and technical journal articles	ST	Refers to the number of scientific and engineering articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.	World Bank [66]
Information and communication technology infrastructure	Internet users	INT	Internet users are individuals who have used the Internet in the last 12 months.	World Bank [66]
	Mobile cellular subscription	MCS	Mobile cellular telephone subscriptions are subscriptions to a public mobile telephone service that provide access to the PSTN using cellular technology. The indicator includes the number of postpaid subscriptions and the number of active prepaid accounts.	World Bank [66]
Constant variables in Cobb–Douglas function				
Variable	Measurement var.	Abbreviation	Definition	Data source
Economic growth	Gross domestic product per capita	Y	This variable is being used as an indicator of economic growth. GDP per capita is GDP divided by midyear population in the economy.	World Bank [66]

Table 1. Cont.

Pillars and Their Respective Proxies				
Pillar	Measurement Var.	Abbreviation	Definition	Data Source
Labor	Labor force total	L	Total labor force comprises people ages 15 and older who meet the International Labour Organization definition of an economically active population, which includes both the employed and the unemployed.	World Bank [66]
Capital stock	Capital stock at constant national price (in mil. \$US)	K	Capital stock includes the common stocks and preferred stock, which issue by the issuing companies. It is measured by the equity capital in the countries' businesses.	Penn World Table

3.4. Descriptive Statistics

With respect to a sample of 15 SADC countries from 1998 to 2018, Table 2 shows the descriptive statistics for the study variables. All variables are converted into natural logarithms as is already understood. Descriptively, statistics in Table 1 indicate that economic growth (GDP), being the response variable, averages 23.1279 with a standard deviation of 1.3723. Adjusted savings: education expenditure (ADJS) registered the highest mean score of 19.5704 with a standard deviation of 1.5302, followed by labor (L) ($M = 14.8901$, $SD = 1.5971$) and then capital (K) ($M = 11.3694$, $SD = 1.3381$) with mobile cellular subscriptions (MCS) and internet users (INT) having the lowest averages of ($M = 1.8734$, $SD = 3.3778$) and ($M = 0.3183$, $SD = 2.5135$), respectively. Generally, the usual value of skewness and kurtosis should be “zero” and “three”, respectively, for an observed series to be symmetric. The results for skewness and kurtosis suggest that a normal distribution is not preceded by any of the series observed. In particular, skewness values suggest that the variables (TRA, GOE, REGQ, TEREN, INT, MCS, and $\ln L$) are negatively skewed, indicating that these variables are flatter to the left relative to a normal distribution, whereas GDP, ADJS, ST, and K are positively skewed, flatter to the right. This suggests, thus, that most of the observations per the dataset are allocated to the negative side of a normal curve. In addition, according to the effects of kurtosis, the distributions of TEREN and K are roughly mesokurtic (approximately 3 kurtosis values), while the distributions of GDP, GOE, REGQ, ADJS, ST, INT, and MCS are leptokurtic (values of kurtosis greater than 3). Of all the variables, only TRA and L had their kurtosis values lower than the usual value, meaning that platykurtic is their respective kurtosis distribution. After verifying that none of the kurtosis and skewness values meet the conditions of normality for the above variables, we conclude that the series is not normally distributed. This is in line with the Jarque–Bera normality test, which gives clear evidence to reject the null hypothesis that a normal distribution is followed by the observed series.

Considering the visualization properties, a scatter plot is employed to examine the relationship between proxies pertaining to the implemented KBE pillars and economic growth. Figure 1 therefore displays the relationship between the various proxies and economic growth (being the response variable) during the period 1998–2018. Evidence from the plot indicates that with the exception of trade (a proxy of economic and institutional regime pillar), all other proxies, which includes regulatory quality and government effectiveness (for economic and institutional regime pillar), adjusted savings on education expenditure and tertiary enrollment (for education and skills pillar), and science and technical journal articles (for efficient innovation system pillar), as well as internet users and mobile money cellular subscriptions (for information and communication technology pillar), are positively related with economic growth. Specifically, adjusted savings on education expenditure (being a proxy of the economic and institutional regime pillar) along with science and technical journal articles (also as proxy of an efficient innovation system pillar) showed the strongest positive relationship with economic growth. The determinant of this pattern may have been due to the reason that, over the period of 1998–2018,

getting formal education became popular within the SADC region, which may have led to a boom in increased quality human capital thus having a spillover effect on innovation leading to increased GDP yield.

Table 2. Descriptive statistics (in natural logarithm).

Variable	Obs	Mean	Std. Dev.	Skewness	Kurtosis	Jarque–Bera
GDP	315	23.1279	1.3723	0.5427	3.8927	25.9241 ***
TRA	315	4.3035	0.4533	−0.1409	2.3916	51.8996 ***
GOE	315	3.1809	1.1138	−1.2075	3.6177	81.5547 ***
REGQ	315	3.2420	1.0210	−1.3546	4.3304	119.5735 ***
ADJS	315	19.5704	1.5302	0.5238	3.9660	26.6523 ***
TEREN	315	1.4507	1.0990	−0.3314	2.6757	27.1477 ***
ST	315	3.9465	1.9540	0.1713	4.3417	25.1659 ***
INT	315	0.3183	2.5135	−1.0916	4.0303	76.4863 ***
MCS	315	1.8734	3.3778	−2.6149	13.3257	1758.362 ***
L	315	14.8901	1.5971	−0.3914	1.7423	28.8041 ***
K	315	11.3694	1.3381	0.6489	3.0917	22.2184 ***

Note: All variables have been transformed into natural logarithms. *** represents 1% level of significance.

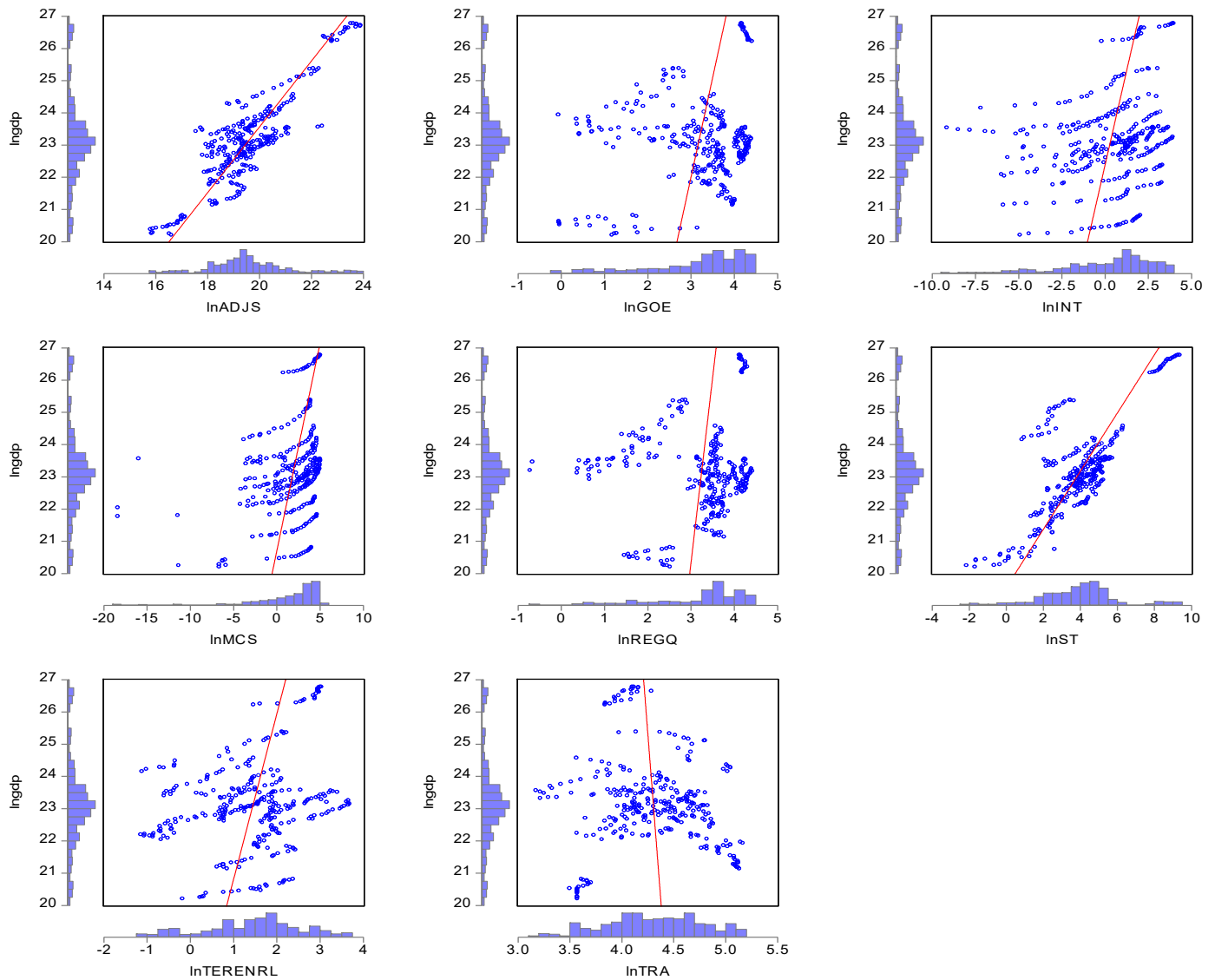


Figure 1. Scatter plot depicting the relationship between economic growth and proxies of knowledge-based economies (KBE) pillars.

3.5. Correlation and Multi-Collinearity Analysis

Table 3 shows the correlation analysis among variables used in this study. The outcome outlines that our response variable (GDP) has positive relationships with all the independent variables. Furthermore, as an important issue, this study implemented multiple observed explanatory variables (Ref; Equation (5)) which are likely to result in unembroidered multi-collinearity. Thus, to discourse this concern, a correlation matrix among the regressors is conducted. A preview from the cross-correlational matrix unveils frail associations for all possible pairs of independent variables, where the respective correlation coefficients are far less than 0.50. This outcome of weak correlation structure amid independent variables therefore infers that multi-collinearity is not likely to be an issue in the analysis. This outcome pertaining to the absence of multi-collinearity as shown by the correlation matrix is supported by the tolerance and variance inflation factor (VIF) test values as illustrated in the last two columns of Table 3. Specifically, values regarding VIF are far less than 0.5, whereas those of the tolerance are greater than 0.2.

Table 3. Correlation analysis and collinearity test.

Var.	GDP	L	K	TRA	GOE	REGQ	ADJS	GEDU	ST	INT	MCS	VIF	Tol.
GDP	1.000											-	-
L	0.708 ***	1.000										4.366	0.229
K	0.954 **	0.622 ***	1.000									3.964	0.252
TRA	-0.073	-0.355 ***	-0.04	1.000								1.807	0.553
GOE	0.199 **	-0.091	0.151 **	0.343 **	1.000							4.122	0.243
REGQ	0.117 **	-0.176 **	0.101 **	0.235 **	0.437 ***	1.000						3.836	0.261
ADJS	0.877 ***	0.490 ***	0.102 **	0.112 *	0.438 ***	0.353 ***	1.000					2.120	0.472
TEREN	0.243 ***	-0.294 **	0.238 ***	0.342 ***	0.215 ***	0.240 ***	0.424 ***	1.000				3.715	0.269
ST	0.777 ***	0.177 *	0.393 ***	-0.116 ***	0.461 **	0.338 ***	0.093	0.316 ***	1.000			3.910	0.256
INT	0.232 ***	-0.152 *	0.227 **	0.222 ***	0.236 ***	0.268 ***	0.450 ***	0.138 **	0.391 ***	1.000		4.292	0.232
MCS	0.315 ***	0.089	0.281 ***	0.181 **	0.082	0.128 *	0.438 **	0.285 ***	0.409 **	0.180 **	1.000	3.252	0.233

Note: *, ** and *** indicate 10%, 5% and 1% levels of significance, respectively. In addition, Tol. represents tolerance, and VIF means variance inflation factor. The tolerance test value is computed using the relations $\frac{1}{VIF}$.

4. Results

4.1. Cross-Sectional Dependence Test

A cross-sectional dependency evaluation on the panel data model should be conducted before proceeding with our empirical analysis. Table 4 displays the findings of the Breusch and Pagan LM, along with the Pesaran CD-LM test. Findings of both tests fail to reject the null hypothesis of no cross-sectional dependency at a 10% significance level. Therefore, this means the cross-sectional dependency in the panel data model does not need to be considered in the empirical analysis procedure. Since we have failed to reject the null hypothesis, it is now possible to use the first-generation unit root tests, including the Im, Pesaran, and Shin W-stat (IPS) test, the augmented Dickey–Fuller–Fisher (ADF–Fisher) test and the Phillips–Perron–Fisher (PP–Fisher) test, to analyze the stationarity of the variables.

Table 4. Results from cross-sectional dependence tests.

Test	Statistic	p-Value
Breusch and Pagan LM	0.929	0.353
Pesaran CD-LM	1.247	0.213

4.2. Panel Unit Root Examination

By undertaking unit root tests, stationarity of the data could be identified. Table 5 therefore reports the results of multiple unit root tests at level and first difference. By assuming there is a common unit-root process in our panel data, we looked into the IPS, ADF–Fisher, and the PP–Fisher tests as they process the smallest size distortion and perform best against homogeneous alternatives, where autoregressive coefficients are the same for all panel unit. Centering on the IPS test of integration order, it is strongly evident that

all observed series of variables have a unit root at their respective levels but significantly become stationary when differenced in their first order (I(1)). Furthermore, the ADF and PP–Fisher test considered also prove the results’ consistency. Thus, we have sufficient evidence to conclude that all variables from the panel data are integrated by order one; in other words, all variables are nonstationary in levels.

Table 5. Results of panel unit root test.

Variables	IPS Test		ADF Fisher Test		PP Fisher	
	Level	First Difference	Level	First Difference	Level	First Difference
lnGDP	0.594	−2.851 ***	34.122	77.128 ***	39.816	145.995 ***
lnL	1.707	−2.166 ***	24.474	50.467 **	23.679	51.327 ***
lnK	1.282	−2.856 **	29.389	106.823 ***	21.472	61.771 ***
lnTRA	1.012	−5.373 ***	37.476	102.493 ***	33.338	33.338 ***
lnGOE	0.075	−4.958 ***	48.993	113.464 ***	42.664 *	186.634 ***
lnREGQ	0.160	−4.589 ***	34.151	96.595 ***	27.211	178.054 ***
lnADJS	2.878	−5.950 ***	87.044	132.716 ***	46.971	211.549 ***
lnTEREN	0.094	−4.571 ***	51.864	94.215 ***	33.573	240.588 ***
lnST	3.266	−8.023 ***	73.566	167.374 ***	37.802	429.180 ***
lnINT	11.123	−5.370 ***	55.695 *	141.607 ***	54.335	129.415 ***
lnMCS	3.187	−23.084 ***	39.211	201.347 ***	26.110	310.312 ***

Notes: *, **, and *** imply that the rejection of the null hypothesis of nonstationary at 10%, 5%, and 1% significance level, respectively.

4.3. Panel Co-Integration Test

Considering that, the variables are acknowledged to be stationary at the same order, we continue by using Pedroni panel co-integration tests to evaluate the existence or absence of long-term relationships (co-integration) among the observed series defined in the full model. This co-integration test consists of seven test statistics (four panel and three group statistics) based on the mean values of the individual autoregressive parameters corresponding to the unit-root test of the residuals. Theoretically, these test statistics asymptotically follow a normal distribution. Hence, relying on the Pedroni co-integration test outcomes from Table 6, the null conjuncture of non-existence of long-run liaison is significantly rejected among all the group and panel statistics at 5% significance levels. This therefore infers that there exists co-integration amid employed variables, which needs to be further estimated.

Table 6. Results of panel co-integration test.

Test Statistic	Test Value	Probability Value
Panel statistics		
v-statistics	−1.724 **	0.047
Rho-statistic	−1.729 **	0.039
PP-statistic	−1.690 **	0.055
ADF-statistic	−1.769 **	0.038
Group statistics		
Rho-statistic	−1.883 **	0.041
PP-statistic	−2.125 **	0.031
ADF-statistic	−1.723 **	0.042

Note: ** represents significance level at 5%.

4.4. Model Determination

There are two approaches used in this study to test the fixed effect and the random-effect. The first is the likelihood-ratio (LR) test method used for fixed-effect testing, and the second is the Hausman test method used for random-effect testing. These two approaches

are used to assess if the model is the fixed effect or the random effect prior to estimating the contributions of labor, capital stock, and our selected knowledge-based economy proxies on GDP. The outcomes of the effect test can be seen in Table 7. Because the LR test's cross-section F statistic is greater than the critical value at 1% significance level, the null hypothesis that the fixed effect is redundant may be rejected, i.e., the inclusion of the fixed effect is acceptable. Likewise, the null hypothesis that the random effect is not linked to the independent variable can be rejected at 1% significance level, with the cross-section random figure of the Hausman test being greater than the critical value. Therefore, the fixed effect is preferred over the random-effect model as per the outcomes of the obtained random effect and the fixed-effect parameters as well as the variance values after the discrepancy shown.

Table 7. Panel model determination results.

LR Test Results			
	Statistic	Prob. Value	
Cross-section F	178.663	0.0000	
Hausman Test Results			
	Chi-Square Statistic	Prob. Value	
Cross-section random	49.600 ***	0.000	
Variable	Fixed	Random	Var. (Diff)
lnL	0.100	0.234	−0.134 ***
lnK	0.335	0.354	−0.019 ***
lnTRA	−0.006	−0.017	0.010 ***
lnGOE	0.112	0.111	0.001 ***
lnREGQ	−0.024	−0.023	−0.001 ***
lnADJS	0.131	0.126	0.004 ***
lnTEREN	0.069	0.055	0.013 ***
lnST	0.075	0.073	0.002 ***
lnINT	0.006	0.002	0.004 ***
lnMCS	0.0070	0.006	0.0004 ***

Note: *** means 1% level of significance.

4.5. Long-Run Estimation

After identifying that the fixed-effect model (FEM) is more appropriate, we proceeded to the stage of estimating the long-run elastic effect regarding the proxies of each pillar on economy growth through the conventional Cobb–Dougllass Function. Table 8 therefore reports economic growth (GDP) as the dependent variable and also summarizes all the regressions that have been estimated separately using the different knowledge-based-economy pillars. Postestimation tests which includes R^2 , adjusted R^2 , F-statistics together with its probability values and the Durbin–Watson test values for model (8), model (9), model (10), model (11), and model (7) (full fixed-effect model) are very substantial indicating clearly that the various regression models specified in the study are significant and a good fit.

In the framework of Cobb–Douglas production function, it is clearly shown that both labor and capital as constant variables have significant positive relationships towards GDP, with the exception of model (9) and model (7), where labor is evidenced to have an insignificant negative effect on GDP. Emphatically, the results indicate clear evidence of the positive effect on economic growth by government effectiveness in both model (8) and the full model (7). Therefore, an increase in government effectiveness causes an increase in economic growth in countries within the SADC region. Further, regulatory quality shows a statistically insignificant negative relationship with economic growth in the full model (7) but shows a statistically significant positive relationship with growth output in model (8). In addition, adjusted savings on education expenditure and tertiary enrollment as expected appeared with positive signs and statistically significant both in

the full model (7) and in model (9). Moreover, scientific and technical journals publications measuring the innovation system pillar also showed an expected positively significant relationship with economic growth in both the full model (7) and model (10). The results finally show evidence of a positively significant influence of internet users on economic growth in model (11), while the positive relationship is not significant in the full model (7). On the other hand, considering mobile cellular subscriptions, a significant positive effect is witnessed from the side of the full model (7), while in the case of the model (11) an insignificant positive impact is unveiled.

Table 8. Economic growth regression using fixed-effect model (FEM).

Pillar	Variable	Model				
		(8)	(9)	(10)	(11)	(7) (Full Model)
	c	3.3604 *** (1.3958)	16.5328 *** (1.260)	13.2772 *** (1.6456)	11.6397 *** (1.6668)	16.9623 *** (1.0868)
	L	0.3503 *** (0.0985)	−0.0160 (0.0891)	0.3563 *** (0.1170)	0.5042 *** (0.1174)	−0.0357 (0.0789)
	K	0.3445 *** (0.03422)	0.2749 *** (0.0284)	0.3594 *** (0.0380)	0.3487 *** (0.0393)	0.2926 *** (0.0273)
Economic and institutional regime	TRA	−0.0060 (0.0293)	-	-	-	0.0203 (0.0227)
	GOE	0.1283 *** (0.0158)	-	-	-	0.1121 *** (0.0126)
	REGQ	0.0778 *** (0.0170)	-	-	-	−0.0198 (0.0146)
Education and skills	ADJS	-	0.1850 *** (0.0111)	-	-	0.1361 *** (0.0128)
	TEREN	-	0.0606 *** (0.0155)	-	-	0.0913 *** (0.0140)
Efficient innovation system	ST	-	-	0.1164 *** (0.0189)	-	0.0565 *** (0.0130)
Information and communication technology infrastructure	INT	-	-	-	0.0471 *** (0.0104)	0.0033 (0.0070)
	MCS	-	-	-	0.0003 (0.0041)	0.0080 *** (0.0026)
	R ²	0.9959	0.9969	0.9942	0.9938	0.9977
	Adjusted R ²	0.9953	0.9964	0.9934	0.9930	0.9974
	Prob. (F. Statistic)	0.0000	0.0000	0.0000	0.0000	0.0000
	D-W test stat	0.3217	0.4856	0.2628	0.1363	0.6074

Notes: *** imply that the rejection of the null hypothesis of insignificant relationship at 1% significance level, respectively. Robust standard errors are in parentheses (), D–W represents Durbin–Watson.

Furthermore, it is necessary that this recent study investigates the robustness or in other words validates outcomes from the FE estimation results using generalized method of moments (GMM) via Arellano–Bond estimator. Table 9 therefore highlights the findings of the long-run GMM estimation method based on the various models specified in the study. Outcomes from the GMM method evidently show that, given variations among parameter estimates, the respective effects on economic growth from the corresponding proxies pertaining to the employed knowledge-based-economy pillars are in tandem with the findings obtained from the estimation of the FE model. Aside from GMM estimation being consistent with that of the FE estimation, the GMM Arellano–Bond method indicates that the estimated coefficient of the lagged variable (adjustment coefficient) is positive and statistically significant across all specified models. Thus, this implies that a period lagged value of economic growth has a positive and palpable effect on its current value at 1% level of significance. The outcome is in consonant with the report given by [68]. Regarding postestimation examinations, Table 9 in addition investigates issues of autocorrelation

together with instrumental validity using the AR [2] autocorrelation test along with Sargan test of over identification (OIR). Specifically, results from the AR [2] infer no sign of autocorrelation at standard significant level for each specified model. In the same manner, the Sargan post estimation test also shows no evidence of miss-specification at standard level. These results from the aforementioned postestimation tests suggest a reasonable specification on the GMM estimation.

Table 9. Economic growth regression using generalized methods of moments (GMM) (Arelano–Bond estimator).

Pillar	Variable	Model				
		(8)	(9)	(10)	(11)	(7) (full Model)
	c	−0.766 *** (0.283)	1.084 ** (0.554)	0.462 (0.400)	1.864 *** (0.554)	3.078 *** (0.706)
	GDP (−1)	0.902 *** (0.029)	0.796 *** (0.030)	0.862 *** (0.027)	0.869 *** (0.027)	0.779 *** (0.034)
	L	0.201 *** (0.043)	−0.025 (0.017)	0.173 *** (0.041)	0.264 *** (0.050)	0.040 (0.048)
	K	0.038 *** (0.012)	0.177 *** (0.041)	0.285 *** (0.017)	0.179 *** (0.018)	0.043 ** (0.019)
Economic and institutional regime	TRA	−0.013 (0.019)	-	-	-	0.003 (0.007)
	GOE	0.478 *** (0.024)	-	-	-	0.031 *** (0.108)
	REGQ	0.399 *** (0.028)	-	-	-	−0.006 (0.009)
Education and skills	ADJS	-	0.038 *** (0.006)	-	-	0.036 *** (0.006)
	TEREN	-	0.045 *** (0.008)	-	-	0.018 ** (0.008)
Efficient innovation system	ST	-	-	0.022 *** (0.006)	-	0.013 ** (0.006)
Information and communication technology infrastructure	INT	-	-	-	0.077 ** (0.003)	0.003 (0.002)
	MCS	-	-	-	0.004 (0.002)	0.007 ** (0.003)
Post-estimation examination						
	Sargan test	10.779	10.103	11.485	12.837	2.049
	<i>p</i> -value	0.682	0.583	0.343	0.354	0.995
	AR [2] test	−0.739	−1.355	−1.151	−1.145	−1.166
	<i>p</i> -value	0.460	0.176	0.249	0.252	0.244

Note: ** and *** represent the significance at 5% and 1% levels, respectively. The Sargan test indicates the overidentification test for the restriction of the GMM estimation, whereas the AR [2] test is the Arellano–Bond test for the existence of the second-order autocorrelation in the first differences. Values in parenthesis () are standard error estimates.

4.6. Average Impact Estimation

With the purpose of investigating the impact of each KBE pillar on economic growth, we estimated the mean value of every single proxy in each pillar and multiplied it with its coefficient to calculate the average impact index (AII) following the study of [8]. In order to have a better estimation of the impacts, the impact index has been normalized by using absolute value. Furthermore, we have divided the number of proxies in each pillar from the impact index to obtain the AII. From our estimations, efficient innovation system pillar proved to be the most impactful pillar with an average impact index of 0.2229 followed by education and skills at 0.1704. Furthermore, the economic and institutional regime pillar is the third most impactful pillar in the SADC region with an AII value of 0.1586. On a final note, ICT pillar is evidenced to be the weakest of all the KBE pillars with an AII value of 0.0160. Results regarding the AII estimation outcomes for the respective KBE pillars

are therefore outlined in Table 10. Notably, the AII estimates were based on the coefficient estimates from the estimated fixed effect full model.

Table 10. Average impact index of knowledge-economy pillar.

Pillar	Variable	Mean (μ_v)	Coefficient (Ω_v)	$ \Omega_v \mu_v $	Average Impact Index ($\phi_p = \frac{\sum \Omega_v \mu_v }{\eta_v}$)
First pillar: economic and institutional regime	TRA	4.3035	0.0203	0.0989	0.1586
	GOE	3.1809	0.1121	0.3566	
	REGQ	1.0210	−0.0198	0.0202	
Second pillar: education and skills	ADJS	1.5302	0.1361	0.2083	0.1704
	TEREN	1.4507	0.0913	0.1324	
Third pillar: innovation system	ST	3.9465	0.0565	0.2229	0.2229
Fourth pillar: information and communication technology infrastructure	INST	0.3183	0.0033	0.0011	0.0160
	MCS	1.8734	0.0080	0.0149	

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5. Discussion

If every economy wishes that the pressures of the modern economy thrive and endure and also expects globalization to promote sustainable growth and mitigate poverty, KBE capacity building is an absolute necessity. Nonetheless, relative to other regions of the world, SADC is lagging behind in terms of its knowledge economy, especially in terms of education, innovation, organizations, information and communication, and economic incentives. This poses a challenge to achieving global competitiveness, sustainable growth, poverty reduction and greatly diminishes the chances of SADC countries keeping up with their more economically developed counterparts. Based on the aforementioned statement, this current study attempts to assess the effect of different pillars (dimensions) of KBE on SADC's economic development for better KBE capacity building approach.

To achieve this goal of the study, estimates of proxies measuring the various employed pillars of KBE (as indicted by the World Bank) were derived through the FE model using the Cobb–Douglas production function framework. Specifically, results pertaining to the FE model firstly revealed that there exists a positive effect of government effectiveness on growth of the economy in SADC. This therefore infers that a surge in government effectiveness will trigger economic growth in SADC to increase. The positive affiliation amid government effectiveness and economic growth in our case may suggest that governments in this region enhance their market efficiency by enforcing property rights to help private sector to drive economic growth. As suggested by [6], the private sector of countries within the SADC region need to be complemented through accelerating capital accumulation and stimulating the integration together with awareness of evolving technologies (ensuring efficiency in productivity). This finding is as well in tandem with a few

studies including [36,69] who also reported a significant positive influence on economic growth by government effectiveness. Reference [69] went on to say that because of the importance of good governance in economic growth, nations should take the initiative to incorporate it as one of the goals of millennium development goals (MDGs). Moreover, governance is a large determining factor in the allocation of foreign aid and investments by many multilateral development banks such as World Bank and Asian Development Bank, and many developed countries such as USA. Therefore, our finding has policy relevance for many economic and development issues such as foreign direct investment (FDI) conditionality. Conversely, the link between regulatory quality and growth output was evidenced to be negative and statistically insignificant. Although this outcome does not appear to be consistent with some of the earlier studies [32,33] which revealed significant positive association between regulatory quality and economic growth, it may be related to the fact that regulations are often forced onto people and institutions with too little thought or assessment of what is gained relative to the damage suffered in time, resources, uncertainty, and productivity. In addition, the growth of state interference in the market system often restricts the capacity of public and corporations to achieve fundamental economic and social goals, resulting in decreased economic growth, primarily in emerging economies such as those in SADC nations. Theoretically, according to the evolution trend of governance [70–73], there are seven main single perspectives of governance evaluation in the world: horizontal allocation of power (e.g., marketization), vertical allocation of power (e.g., decentralization), supervising power (e.g., rule of law), bureaucracy, bureaucratic autonomy, governance capacity, and governance output. In line with the study of [71], if SADC countries are to benefit from improved government effectiveness and regulatory quality, policy makers must focus on the multidimensional governance perspective. For instance, “horizontal allocation power + governance capacity + supervising power”. This will present diminishing marginal returns which could be interpreted as a shift from high-speed economic growth effect to high-quality economic development effect. More attention should be paid to the allocation of power among governments at different administrative levels. The effect of marketization and rule of law on economic growth should also be thoroughly analyzed. In case of education expenditure and tertiary enrollment, a positive statistically significant effect on economic growth as expected was established. This is consistent with the findings of [74–76]. The positive effect on economic growth from education expenditure and tertiary enrollment in our study could be associated with the improved level of infrastructures required for quality education delivery within the SADC region, which occurs due to an increase in total government expenditure on education and the advanced knowledge gained in tertiary schools, which boosts the quality of human capital. Emphatically, as the quality of education increases, human capital is developed; performance at workplace is improved leading to economic advancement in SADC region. Reference [41] also evidenced a similar relationship in their study. As higher quality of human capital is created through education spending on the aspect of skills training in operating advanced technology tools, resources can be fully utilized while simultaneously minimizing operation costs throughout the production process. Moreover, scientific and technical journal publications as a measurement item of innovation system pillar also showed an expected positive significant effect on economic growth. Reference [77] unveiled that, research and development support (which can be estimated by the number of publications in science and technological journals) leads to the development of innovation, as well as updated skills for sustainable economic success and progress. Thus, being innovative tends to work synonymously with being trained and qualified to produce and utilize knowledge. In recent years, SADC countries have been extensively engaged in the creation of efficient innovation networks consisting of research institutes, higher education institutions, think tanks, and other organizations capable of producing knowledge for development [15]. This has therefore motivated member states of the SADC community to draw on the increasing stock of global expertise and make efforts to assimilate and adapt them to local needs and as well as develop unique innovations

that will in turn contribute to rise in economic growth. Finally, the FE estimation approach showed evidence of internet users being characterized by an insignificant positive effect, whereas mobile cellular subscriptions was identified to have a significant positive effect on economic growth. According to [15,78], since 1994, SADC nations started to invest in ICT infrastructure due to the globalization of communication technology policies. As such, internet usage and mobile cellular subscriptions gained fame in the region which may have facilitated economic development and growth. Access to the internet and mobile phones have therefore expanded the supply of information, allowing markets to operate more efficiently. The use of cell phones in mobile and internet banking has recently also been extraordinary, allowing greater access to resources, which encourages investment and efficiency. The positive insignificant effect of internet users on economic growth may be because of the assertion that internet usage is yet to translate into productivity in SADC. In another recent study, the authors of [79] investigated the long-run and short-run relationship between economic growth and internet usage in South Africa which is a country in SADC. Their results showed a positive and significant long-run relationship between internet usage and economic growth but not in the short run. This information reveals that internet usage has a future potential significant effect; therefore, results of investment in internet usage would not immediately show in its infancy. They may take time to materialize meaning that governments in SADC should keep on building this ICT aspect. This will in the long run help them overcome inefficiencies in things like trade promotion as well as customs services and logistics so as to become more competitive and integrated in the international trading system. At the end of the day, economic growth, financial development, poverty reduction, and catching up with KBE frontiers will be achieved.

Of paramount interest to us, the respective impacts of the various KBE pillars on economic growth were further scrutinized, relying on the average impact index (AII) computed using means and parameter estimates of the corresponding proxies pertaining to employed dimensions of KBE. From the AII outcomes, efficient innovation system pillar came out to be the most impactful pillar followed by education and skills. This stems from the fact that, from past experiences of KBE frontiers, innovation has been a principal indicator of the knowledge economy given that KBEs are primarily innovation driven [80]. This was also confirmed by [81] when he studied market-driven knowledge creation as an engine of productivity growth and how it affects economies of scale and market power. The study agreed with theoretical expectations that increase in knowledge is mainly directly proportional to innovation (which was measured by R&D spending). It is worth noting that, the vast majority of technologies required to reduce poverty, add value to natural resources, and upgrade the technological proficiency of local industry have already been invented. They are typically in widespread use in many advanced countries. The problem is that these technologies are not widely used in many developing countries. SADC countries should therefore focus on building the capacity to use these technologies rather than conducting frontier-level R&D. However, this does not mean that there is no role for innovation as a whole in developing countries or that these countries should not devote any resources to building their R&D capacity. It simply means that building R&D capacity, by itself, does not solve many of the most pressing development challenges facing these countries. It is also expected that human-capital development through strengthening of the education sector enhances the rate of innovation, given that it is a relevant factor in the knowledge production process [82,83]. Thus, it is not out of place that SADC countries may have paid more attention to developing activities associated with these two knowledge dimensions making them the two most impactful pillars. They are after all the mainstream generic global knowledge dimensions of interest when knowledge economy is mentioned.

Finally, economic and institutional regime together with ICT pillars were reported to have the least impact on economic growth from the AII outcome. The weak impact from the side of economic and institutional regime pillar may be due to the fact that the stagnant economic prosperity which has been substantially documented in African

development literature is due to poor institutions and capital flight repugnant to investment of which SADC community is not exceptional [84,85]. Furthermore, in the “South Korea as Knowledge Economy and Learning from Success Stories” report, it has been deduced that African countries as whole are substantially lacking in this pillar (economic and institutional regime pillar) [86]. The issues as reported by [87] include inter alia, poor institutions especially corruption, surplus banking liquidity, or absence of credit to finance investment needs [88,89]. From the context of ICT pillar, although there is a huge potential on the socioeconomic rewards of ICT in SADC community and Africa as whole, there seems to be some existing fundamental setbacks to access [25]. This according to [26] is especially the case of SADC, where internet penetration rates remain relatively low, while the need for effective development strategies continues to be pressing. Reference [90] in the study of linking ICT to the development of KBE pillars concluded that ICT provide a major support for the development of KBE and the other three pillars (the economic and institutional regime, education and skills, and the innovation systems) over time. In addition, in the study, the ICT pillar was the only pillar that was being the consistently significant and positive factor on both knowledge economy and each of the knowledge-economy pillars. Finally, he concluded that ICT was the most critical pillar-boosting innovation (which on our study has the highest AII). The ICT pillar therefore carries the potential to be the glue that holds together the efforts of transforming into KBEs and catching up with KBE frontiers.

6. Conclusions and Policy Suggestions

6.1. Conclusions

Knowledge has evolved into a fundamental engine of economic growth and sustainability through the enhancement of productivity and efficacy of economic initiatives. This as a result leads to improving mechanisms for discovering new ways to counter development policy syndromes. Recent evidence indicates that countries in Africa, especially the SADC region, can be on the verge of rapid and sustained economic growth if they can leverage the various dimensions of knowledge by employing appropriate policy initiatives. The World Bank’s Knowledge Economy Framework aims to explore and support the extent to which current policies in SADC nations affect the knowledge development process on the region and the African continent as a whole. Thus, in the case of economies within the SADC community, a multivariate model through the employment of panel data analytical approach in a Cobb–Douglas production function framework investigated the nexus between knowledge-based economy and economic growth during the period 1998–2018. The paper presented the World Bank’s knowledge-based-economy framework, which posits that economic and institutional regimes, education and skills, an efficient innovation system, and information and communication technology infrastructure would contribute to increased knowledge generation for economic development and, ultimately, to sustainable economic growth. Nonetheless, to achieve the study objective, we first estimated the long-run effect regarding the proxies of each pillar on economic growth using the fixed-effect model. Afterwards, impacts pertaining to each of the employed pillars of knowledge-based economy were examined by computing the average impact index for the SADC region.

Relying on the estimation of the fixed-effect model rather than the random-effect model (with evidence from the LR and Hausman tests) we discovered that in the presence of capital stock and labor as constant variables in the Cobb–Douglas production function five (5) out of the eight knowledge-based economy variables (proxies) we used in our study, showed palpable and statistically significant impact on economic growth at 1% level of significance. These proxies are as follows: government effectiveness, adjusted savings education expenditure, tertiary enrollment, scientific and technical journals, and mobile cellular subscriptions. Among the remaining three (3) proxies which showed an insignificant relationship, regulatory quality showed an inverse(negative) relationship with economic growth, while the other two (2), which are trade and internet users showed

positive relationships. The aforementioned outcomes were therefore confirmed by the GMM Arellano–Bond estimation approach. With the help of the average impact index, we computed the most impactful to the least impactful knowledge-based economy pillar on economic growth in the SADC region. Undoubtedly, the efficient innovation system pillar proved to be the most impactful pillar followed by education and skills. Economic and institutional regime pillar proved to be the third most impactful pillar and lastly information and communication technology infrastructure pillar became the least impactful of the four knowledge-based economy pillars.

6.2. Policy Suggestions

There is no single correct recipe for building KBE capacity. The four dimensions of KBE capacity building should not be seen as mutually exclusive or as either/or options. Policy makers do not have to necessarily “choose” one KBE capacity building objective to the exclusion of the others. The point of our study is that in a world of scarce financial resources and human capabilities, where it is impossible to do everything at once, policy makers will have to set priorities and determine sequences of KBE capacity-building initiatives, which are based on each country’s most pressing needs, objectives, and initial endowments. The AII reveals the fact that SADC underscores in information and communication technologies followed by economic and institutional regimes, while having the best score for efficient innovation system followed by education and skills. This therefore directs our recommendations towards the direction that the debate of experts should revolve around finding strategies to better improve information and communication technologies, followed by economic and institutional regimes, then education and skills, and lastly efficient innovation system to finally ensure the development of KBEs in SADC and ultimately Africa.

Information and communication technology infrastructure remains the least impactful pillar in economic growth in SADC, yet there are a multitude of benefits from ICT penetration in economic growth and sustainable development. The logical implication is that policy can leverage on the corresponding penetration potential to tackle development concerns. These broadly include concerns about affordability and absence of infrastructure. A relevant policy direction should be the implementation of measures which contribute toward improving the much-required infrastructures (physical capital) for enhanced ICT penetration and/or universal access mechanisms. Governments in SADC can put more emphasis on to the improvement and usage of ICT among businesses and the public. The widespread usage of ICT among businesses and the public increases the chances of a leap in economic development since they would now have access to the global digital economy.

Well set-up economic and institutional regimes are essential for the development of KBEs, but this pillar was found to be the second least impactful pillar on economic growth in the knowledge economy of SADC. If SADC wants to catch up to its economically prosperous counterparts, the economic and institutional regime that offers resources for the productive use of existing knowledge, the development of new knowledge, and the prosperity of entrepreneurship must be reinforced. Countries in the area should boost general governance and lessen regulatory impediments, including regulation that hampers investment in technology for innovation and ICT and encourages international capital in-flows in the knowledge sector. They should make a clear and strict stance on the regulations on property rights and entrepreneurship so that investors and trade moguls have confidence to run businesses, notably the high-end technology and knowledge operations. These strengthened protection policies therefore encourage people and enterprises to innovate and generate more intellectual properties.

As evidenced by our study, an efficient innovation system has the highest average impact factor on economic prosperity. The promotion of regional research and innovation remains important in order to enable lagging nations to catch up to their frontier counterparts in terms of innovation. Such a promotional venture could focus on, among others, validating and encouraging activities that place emphasis on local/regional initiatives in the promotion of new businesses. The ventures could also entail the cross-country construc-

tion of appealing environments for collaboration in R&D. The corresponding networks may border around the following ideas: (i) cooperation from a transitional setting with the purpose of facilitating catchup in science and R&D; (ii) orientation of R&D programs to involve regional policy makers and local actors, and (iii) integration and emphasis on nations in the SADC region that have achieved more development (e.g., poverty and income-inequality reductions) by enhancing R&D.

Promoting innovation automatically spills over to promoting education and skills development, which is the second most impactful pillar on economic growth. With this, it is crucial that continuity is maintained on investment in human-capital development. Strengthening partnerships for investment in skills training (formal, informal, vocational, lifelong learning, etc.) and the growth of human capital are important in creating communities that are increasingly knowledge-based for the success of the KBE in the SADC region. Strengthened university–industry collaborations need to be forged through the addition of private sector/industry members to national education and training councils, as well as to academic advisory boards at universities for curriculum improvement.

7. Limitations of the Study

This recent study encountered some limitations that cannot be overlooked. In the first place, the study estimated the affiliation between proxies of the pillars of KBE on economies without considering issues pertaining to asymmetries among the exogenous variables. Thus, to account for the eventual asymmetries along with an estimation of the long relationship, we suggest future research in a similar field to employ the augmented autoregressive distributed lag (ARDL) known as the co-integrating nonlinear ARDL (NARDL) and often referred to as the asymmetric effect ARDL method. In relation to the research of [91,92], the asymmetric ARDL addresses issues on nonstationary and nonlinearity in the framework of an unrestricted error correction model. The NARDL as well comes with its own positive and negative partial sum decompositions of the explanatory variables as indicated by [93,94].

Further, the study dealt with a panel of economies within the Southern Africa community without considering country specifics. However, if country specifics are considered in addition to grouped levels, such research in the future would be very novel and more scientific since more diverse findings can be obtained to make the story very interesting.

In addition, the study considered different proxies in relation to the World Bank proposed framework for each knowledge-based economy pillar with the aim to identify which pillar is most impactful to the least impactful on economic growth using the average impact estimation approach. Nonetheless, the number of proxies employed pertaining to each pillar was not balanced since some pillars had three proxies while others had two or one proxy. This resulted from the unavailability of data regarding some proxies found in some pillars. This may have potential unfair effect when the impact hierarchy of the knowledge-based economy pillars are assessed. Thus, as suggestion for future research in Southern Africa, proxies for the respective pillars with both several years and few years of data availability should be scrutinized and also treated distinctly to attain more interesting results.

Author Contributions: Conceptualization, K.P., F.L., and I.A.M.; methodology, K.P. and I.A.M.; software, K.P., I.A.M., and M.M.; validation, K.P., I.A.M., and A.Y.O.-S.; formal analysis, K.P., I.A.M., and A.Y.O.-S.; investigation, K.P., I.A.M., and A.Y.O.-S.; data curation, K.P. and I.A.M.; writing—original draft preparation, K.P. and I.A.M.; writing—review and editing, F.L., K.P., I.A.M., A.Y.O.-S., and M.M.; visualization, F.L. and K.P.; supervision, F.L.; funding acquisition, F.L. All authors have read and agreed to the published version of the manuscript.

Funding: National Natural Science Fund, 71503105, 71974081 funded this research.

Institutional Review Board Statement: Not Applicable.

Informed Consent Statement: Not Applicable.

Data Availability Statement: Data pertaining to the study variables can be obtained from <https://databank.worldbank.org/source/world-developmentindicators> (accessed on 25 December 2020).

Conflicts of Interest: The authors declare no conflict of interest.

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