

# The Impact of Knowledge-Based Economy on Growth Performance: Evidence from South Africa

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**Abstract:** This article seeks to measure and evaluate the impact of knowledge-based economy on growth performance in South Africa. The study focuses in identifying specific economic pillars that enhance growth performance in South Africa. Although transition from traditional to knowledge-based economy appears structural, the course to digital innovation guides adaptation to the global change. Following the World Bank KAM (knowledge assessment methodology), this article uses data analysis from the 2007 to 2016 to highlighted economic transition in the recent decade. This article uses quantitative methods to analyse secondary data collected from various websites such as SA Statistics, organisation for the Economic Cooperation and Development (OECD) as well as the World bank that publish South African economic data. Data analysis is done using SPSS software version 26 as a major statistical tool for advance data interpretation. However, the study is limited to yearly data frequency compared to quarterly or monthly frequency since statistical data are mostly published per year. The empirical results showed that 67% of GDP (Gross Domestic Product) is explained by the dependent variables namely FDI (Foreign Direct Investment), R&D (Research and Development), trade ICT (Information, Communication and Technology) and Computer balance as well as literacy. Innovation system, economic regime, information infrastructure as well as human resources' elements are statistically significant in improving economic growth in South Africa with a correlation matrix of 81%. Data interpretation showed that transition from traditional to knowledge-based economy is a key driver of national economic prosperity that guarantees long-term survival. Suggestions from the study stipulates that decision-makers should ensure efficiency of knowledge-based economy structure through definition and application of knowledge-related policies tailored to the country's specifications. The proposed conceptual framework will guide the implementation of successful knowledge-based economy that will enrich growth performance in South Africa.

**Keywords:** Growth, performance, knowledge-based economy, South Africa.

## 1. INTRODUCTION AND BACKGROUND

Considering the importance of digital transformation, any country should consider the impact of technological innovation as well as knowledge usage on the overall economic indicators. This suggests implementation of an economy based on continuous knowledge acquisition, creation and execution for national growth. Knowledge-based economy is an economy that makes prominence use of knowledge to enhance economy and business development through continuous innovations (David and Foray, 2002). Nowadays, it is generally accepted that economic activities based on knowledge boost not only the overall economy of the country but also business opportunities internally and globally. There are several organisations in South Africa that manage increase on development and knowledge expression. The south African science and technology company has a mission of defining policies that will drive national transformation to a knowledge-based economy. The national Advisory Council on innovation (NACI) has undertaken a foresight exercise to control and execute application of science, technology and innovation in South Africa. They also defined indicators that are

critical in formulating and implementing economic policies and strategies (NACI, 2019): See Table 1 below.

The NACI highlighted the positive impact of National Research and Development Strategy (NRDS) on the South African knowledge generation capacity in positioning science-based technology to increase quality of life and economic growth in the country. From knowledge-based to technology-based economy, South African has defined a benchmark of well-organised innovation systems in the BRICS (Brazil, Russia, India, China and South Africa) countries that enhanced economic growth by increasing GDP per capita. The NACI strategy also enhance the importance of ICT in improving economic growth in South Africa in transforming approaches and implementation from a resource-based economy to a knowledge-based economy. From 1995 to 2012, knowledge-based economy index of South Africa appeared as displayed on the Table 2 below. With a continuous improvement, South Africa will improve skills development through innovation and the use of smart technologies to enhance knowledge thinking.

Macro-economic issues as well as economic growth in South Africa have been a serious topic on the timely debate. Seeking for the equilibrium of the balance of payments contributes and adds value to the economic

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**Table 1: Key Indicators of the Performance of the S&T System at Macro Level**

Level	Area	Indicator
Primary	Future R & D capacity	Set proportion of higher education (HE) enrolments Matriculants with mathematics
	Current R & D capacity	Publications Global share publications R & D intensity
	Imported know-how	Technology payments High-technology manufacturing imports
Intermediate	Science, engineering and technology human capital	SET graduations Researchers per thousand workforce
	Technical progress (improvement and innovation)	Patents, high-technology start-ups Business innovation investment Key technology missions
	Business performance	Technology trade mix Proportion of high-technology firms Sectoral performance
High	Quality of life	Real growth in GDP per capital Human Development index
	Wealth creation	Technology-based growth

Source: (NACI, 2019).

**Table 2: Knowledge-Based Economy Index**

Year	1995	2007	2008	2009	2012
<b>KBE Index</b>	48	50	55	65	67

Source: World bank (2019).

performance in South Africa. Considering the low rate employment, poverty and economic recession happening in South Africa, the government is now devoted to bringing correctives measures. certain authors argued that job creation in south Africa depends on the capacity of the country to enhance gross domestic product (GPD) and attract more foreign investors (Tsepo, 2018). Many knowledge economic indicators such as innovation, technology and research and development are used by institutions such as World bank, SARB and statistics South Arica to evaluate the country's penetration level towards knowledge-based economy. Knowing that human is the critical resource in implementing the knowledge policies and achieving knowledge capacity, South Africa therefore increase investment in education and learning in every industry.

One of the South African government's vision towards the industrialisation trajectory followed by the NIPF/DTI is to build long-term intensification of industrialisation process following 4IR requirements in order to keep track of continuous knowledge economy improvement (OECD, 2019). In so doing, several

programmes have been established to define new directions to the industrial innovation and global adjustments namely the Organisation for the economic corporation and development (OECD), the Accelerated and shared growth initiative for South Africa (ASGI-SA) as well as The Support Programme for Industrial Innovation (SPII) and The Technology and Human Resources for Industry Programme (THRIP). It is up to the government to put in place relevant and accurate growth strategy based on a combination of knowledge and economic requirements (OECD, 2019). Since many years. South Arica experienced low rate of unemployment that also tells about average of education and training especially at the higher education level. Lack of education and training consequently undermine knowledge acquisition and development. Knowing that human resource capacity is the critical elements of the knowledge-based economy, low rate of education and literacy in South Africa is a concern. Adaptation to modern economies requires monitoring and guidance compared to traditional economic system. In this regard, local government should set a benchmark economic from a developed

country as a standard to follow (UNECE, 2002). Just like the SARB created business systems and technology department specifically for the exploitation of opportunities arising from current, new and emerging technologies (SARB, 2019), South Africa government needs to redefine road to a fully knowledge-based economy.

Assessing the impact of knowledge on the economic growth of a country remains a major concern for every economy that want to remain sustainable over time. Leading by the volume of change coming with the fourth industrial revolution (4IR), the importance of knowledge-based economy (KBE) is evident. But the question is, what are the characteristics of an efficient knowledge-based economies approach? And how to keep the expression of knowledge-based economies sustainable in South Africa? South Africa still has a low level of innovation capacity due to the lack of infrastructures and openness strategies (OECD, 2019). Besides individuals' limitations, South African governments define unrealistic policies and undermine the negative effect of foreign economies on local performance. Despite the existence of innovation programs, execution and alignment of these programmes to economic requirements have not been meeting expecting results considering the level of imports and dependence to foreign countries with high technological level.

The aim of this articles is to determine the impact of knowledge-based economy approach on growth performance in South Africa for the period from 2007 to 2016. As an open economy, the South African government should be aware of the degree of engagement with other countries to protect local interests. Local as well as global indicators will be used to evaluate the level of knowledge engagement of the South African economy in areas like research and development as well as foreign direct investment. This article equally contributes in achieving restructuration

of economy system to continuously use knowledge thinking to improve economic performance.

2. LITERATURE REVIEW

Digital change comes with knowledge revolution and increase of global competition. Adoption of knowledge-based economy and increase in knowledge management in general are the bottom line of creativity, social welfare and economic growth as highlighted by David and Foray (2002). Acquisition and creation of knowledge as well as dissemination and usage of knowledge are the criteria groups of knowledge expression (Daugélienė, 2005). Building a knowledge economy in South Africa has been a topic of many debates among researchers and economists. At a time, confusion is made between moving to a knowledge-based economy or technology-based economy. Observations showed that investing in technology is part of the knowledge requirement landscape in addition to the learning concept (Archibugi and Lundavall, 2001).

2.1. South African Economy

South Africa economy is characterised by a stable macro-economic environment. General economic situation in South Africa highlights the following:

Table 3: Macroeconomic Picture in South Africa

Macroeconomic picture	Status
The economy	Open
Exchange rate	Flexible
Monetary policy and foreign reserves	Stable
The share of short-term debt	Low
Political rights and civil liberties	Reasonable
Economic freedom	Slightly increased
Corruption	Slightly declining

Source: Tsepo (2007).



Figure 1: Educational attainment in South Africa.

Source: SA Statistics (2019).

In South Africa, education is governed by the department of basic education (DBE) and the department of higher education and training (DHET). The percentage of educational attainment by population groups as presented in Figure 1 and Table 5 tells about trajectory to the knowledge acquisition and development.

**Table 4: Educational Attainment Percentage**

Country	Description	Percentage
South Africa	Post-Secondary	12.1%
	Secondary	68,2%
	Primary	13,6%
	Pre-school	0,1%
	No Schooling	6%

Source: SA Statistics (2019).

In South Africa, 6% of the population are not attending school and only 12.1% reach the post-Secondary level.

**2.2. Knowledge-Based Economy**

The mechanism of functioning of knowledge-based economy goes in hand with the phenomenon of environmental adaptation. According to the World Bank (2019), the concept of knowledge-based economy is built of the four dimensions as follow:

- “An economic incentive and institutional regime that offer an efficient platform to implement knowledge economy

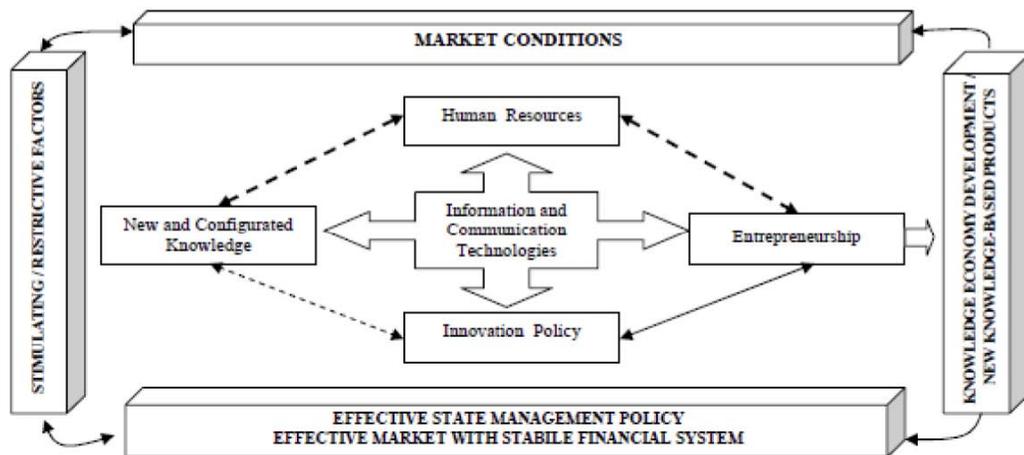
- Educated and skilled workers that constitute the human resources to execute the knowledge on the traditional economy
- An effective innovation system that will keep the whole economic ecosystem in the run of knowledge research and revolution
- A modern and adequate information infrastructure to improve effective communications that drive knowledge acquisition and sharing” (World Bank, 2019)

According to Daugėlienė (2006), knowledge-based economy expression is characterised by ICT, human resources, innovative business and innovation policy as depicted on Figure 2 below.

Understanding and assessing the impact of knowledge change on economy growth allow to optimise results. Daugėlienė (2005) defined an assessment model of knowledge-based economy penetration considering globalisation and internal constraints. He grouped list of elements as displayed on Figure 3 below that can be considered while assessing a comprehensive knowledge expression.

In other words, authors are rather indicating what knowledge indicators can be used while drawing an economic model. He designed many interactive models such as the World bank, Harvard and the OECD among others that can guide knowledge assessment.

Al-Maadeed and Weerakkody (2016) in contrary developed a conceptual model based on the KBE theoretical paradox and advance practices. They classified determinants of knowledge-based economy



**Figure 2:** The structure of Knowledge-based Economy Expression.

Source: Daugėlienė (2006).

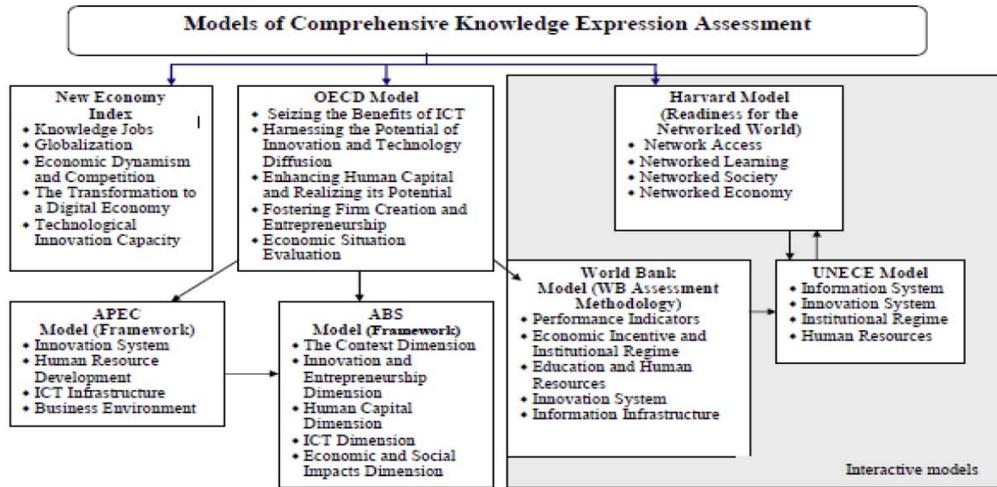


Figure 3: Model of Comprehensive Knowledge Expression Assessment.

Source: Daugėlienė (2005).

at the national level in four groups namely main pillars, drivers, process and functions as depicted on the Figure 4 below.

Somehow, it is not relevant to only define determinants of an economic variable at national level because external or foreign variables also affect results of internal economic aggregates. Additionally, cognitive leadership aspects by means of the beliefs and intentions cannot be the only enabler of all determinants of KBE economy. Following the same approach, Jafari and Akhavan's (2007) argued that there is a strong relationship between public belief, culture, social awareness and government policies in improving knowledge management. Barkhordar,

Fattahi and Azimi (2018) argued that knowledge economic development in sub-Saharan Africa depends on the development of education and skilled force in addition to the investment on scientific research and technological development. The world bank established a program called knowledge for development program (K4D) to deeply measure and compare economic index between countries (World Bank, 2019). The program highlights the four pillars framework to be used as the basis for their transition from the traditional to the knowledge economy. The following knowledge assessment methodology (KAM) defined by the World Bank helps countries to determine their strengths and weaknesses to be able to compete globally (World Bank, 2019).

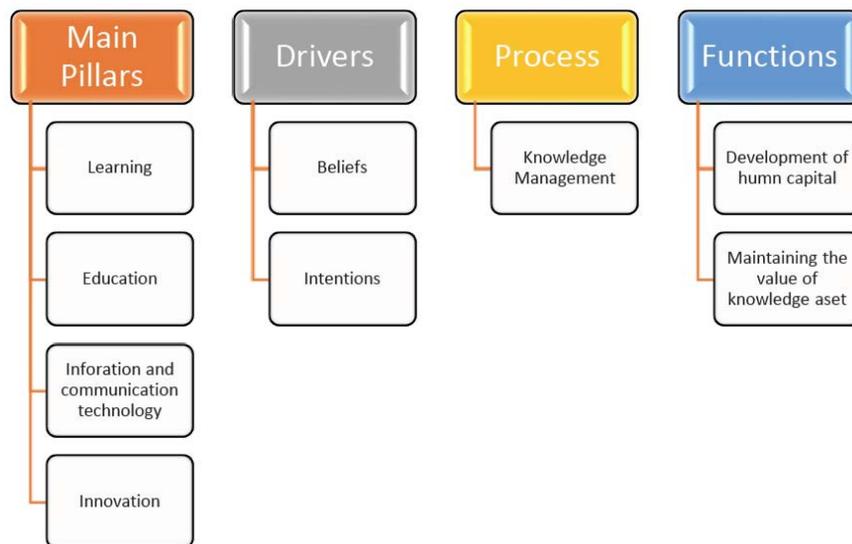


Figure 4: Determinants of the KBE Development at a National level.

Source: Al-Maadeed and Weerakkody (2016).

PILLAR 1 Economic and institutional regime	PILLAR 2 Education and skills	PILLAR 3 Information and communication infrastructure	PILLAR 4 Innovation system
The country's economic and institutional regime must provide incentives for the efficient use of existing and new knowledge and the flourishing of entrepreneurship.	The country's people need education and skills that enable them to create and share, and to use it well.	A dynamic information infrastructure is needed to facilitate the effective communication, dissemination, and processing of information..	The country's innovation system—firms, research centers, universities, think tanks, consultants, and other organizations—must be capable of tapping the growing stock of global knowledge, assimilating and adapting it to local needs, and creating new technology.

Figure 5: The four pillars of the knowledge economy.

Source: World Bank (2019).

The knowledge economy index measures performance of the four pillars. The World bank defined basic scorecard of the KAM as follow:

Furthermore, the World Bank provided details of variables available in the KAM as follow:

**2.3. Growth Performance**

Many researches focused on understanding the relationship between knowledge-based economy and growth performance in specific countries or region. Although economic conditions and variables are not the same in many countries, evidence showed that economic pillars lead to the same results. Evidence from MENA (Middle East and North America) countries showed that human capital, capital and research in addition to infrastructure, institutions and business growth are the dimensions of knowledge-based economy that improve growth performance (Barkhordar, Fattahi and Azimi, 2018). In sub-Saharan

Africa East and Central Africa, West Africa and Southern Africa), research findings revealed that investing in technological development and innovation systems leads to the increase of GDP per capita (Gyekye and Oseifuah, 2015). Knowledge and its application such as pillars, policies and practices play a critical role in growth and productivity process as highlighted by the World Bank (2019). Growth performance enhancement also depends on policies defined by the government and other decision makers. Implementation and execution of change start with the respect of related policies. As highlighted by Al-Maadeed and Weerakkody (2016), country position that includes political, legal, institutional, infrastructural and social settings is an enabler of knowledge economy achievement. Successful transition to the knowledge-based economy required decision makers at the country or region level to define and ensure complete implementation of knowledge-related policies (Barkhordar, Fattahi and Azimi, 2018). Knowledge

<b>Performance</b> Average annual GDP growth (%) Human Development Index
<b>Economic Incentive and Institutional Regime</b> Tariff and non-tariff barriers Regulatory Quality Rule of Law
<b>Education and Human Resources</b> Adult literacy rate (% age 15 and above) Secondary enrolment Tertiary enrolment
<b>Innovation System</b> Researchers in R&D, per million population Patent applications granted by the USPTO, per million population Scientific and technical journal articles, per million population
<b>Information Infrastructure</b> Telephones per 1,000 persons, (telephone mainlines + mobile phones) Computers per 1,000 persons Internet users per 10,000 persons

Figure 6: KAM basic Scorecard.

Source: World Bank (2019).

<p><b>Performance Indicators</b>                  Average Annual GDP growth (%)                  GDP per capita (International Current PPP)                  Human Development Index                  Poverty Index                  Composite ICRG risk rating                  Average unemployment rate, % of total labor force                  Employment in industry (% of total employment)                  Employment in services (% of total employment)                  GDP (current US\$ bil)</p> <p><b>Economic Regime</b>                  Average Gross capital formation as % of GDP                  General government budget balance as % of GDP                  Trade as % of GDP                  Tariff &amp; nontariff barriers                  Intellectual Property is well protected                  Soundness of banks                  Exports of goods and services as % of GDP                  Interest rate spread (lending minus deposit rate)                  Intensity of local competition                  Domestic credit to the private sector (% of GDP)</p> <p><b>Institutions</b>                  Regulatory quality                  Rule of law                  Government Effectiveness                  Voice and accountability                  Political stability                  Control of corruption                  Press freedom</p> <p><b>Education and Human Resources</b>                  Adult literacy rate (% age 15 and above)                  Average years of schooling                  Secondary enrolment                  Tertiary enrolment                  Life expectancy at birth, years                  Internet access in schools                  Public spending on education as % of GDP                  Professional and technical workers as % of the labor force                  8th grade achievement in mathematics                  8th grade achievement in science                  Quality of science and math education                  Extent of staff training                  Management education is locally available in first class business schools                  Well educated people do not emigrate abroad</p>	<p><b>Innovation System</b>                  FDI as percentage of GDP                  Royalty and license fees payments (\$ millions)                  Royalty and license fees payments in US\$ millions / million population                  Royalty and license fees receipts in US\$ millions                  Royalty and license fees receipts in US\$ millions / million population                  Science &amp; engineering enrolment ratio (% of tertiary level students)                  Researchers in R&amp;D                  Researchers in R&amp;D / million                  Total expenditure for R&amp;D as percentage of GDP                  Manufacturing Trade as % of GDP                  Research collaboration between companies and universities                  Cost to register a business (% of GNI per capita)                  Cost to enforce a contract (% of GNI per capita)                  Scientific and technical journal articles                  Scientific and technical journal articles per million people                  Administrative burden for start-ups                  Availability of venture capital                  Patent Applications granted by the USPTO                  Patent Applications granted by the USPTO (per million pop.)                  State of cluster development                  High-technology exports as percentage of manufactured exports                  Private sector spending on R&amp;D</p> <p><b>Information Infrastructure</b>                  Telephones per 1,000 people (telephone mainlines + mobile phones)                  Main Telephone lines per 1,000 people                  65. Mobile phones per 1,000 people                  Computers per 1,000 persons                  TV Sets per 1,000 people                  Radios per 1,000 people                  Daily newspapers per 1,000 people                  Internet hosts per 10,000 people                  Internet users per 10,000 people                  International telecommunications: cost of call to US in \$ per 3 minutes                  E-government                  ICT Expenditures as a % of GDP</p> <p><b>Gender Equality</b>                  Gender development Index                  Females in labor force (% of total labor force)                  Seats in Parliament held by women (as % of total)                  Females Literacy Rate (% of females ages 15 and above)                  School enrolment, secondary, female (% gross)                  School enrolment, tertiary, female (% gross)</p>
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Figure 7: Knowledge Based Methodology.

Source: World Bank (2019).

development is also a goal for financial institutions in South Africa. The department of economic research and statistics at the SARB has a purpose to conduct and coordinate research while collecting information at domestic and international level in order to counter relevant economic issues (SARB, 2019).

**2.4. Contribution of the Study**

This paper highlights the importance of the knowledge-based economy in improving growth performance in South Africa. Adoption and adaptation of knowledge development contribute to the long-term economic growth. Compared to previous studies that randomly investigate on the determinants of economic growth, the present study focuses determining relevant economic factors following knowledge assessment methodology as prescribed by the World Bank (World Bank, 2019). The current article also considers the key role playing by digital change in defining new trajectory to the knowledge economy. According to the authors, the level of research and development as well as the ICT trade balance are the component of the knowledge economy. Additionally, trade of communications and computer and the volume of foreign direct investment confirm knowledge capacity of the country.

**3. MODEL SPECIFICATION AND DATA**

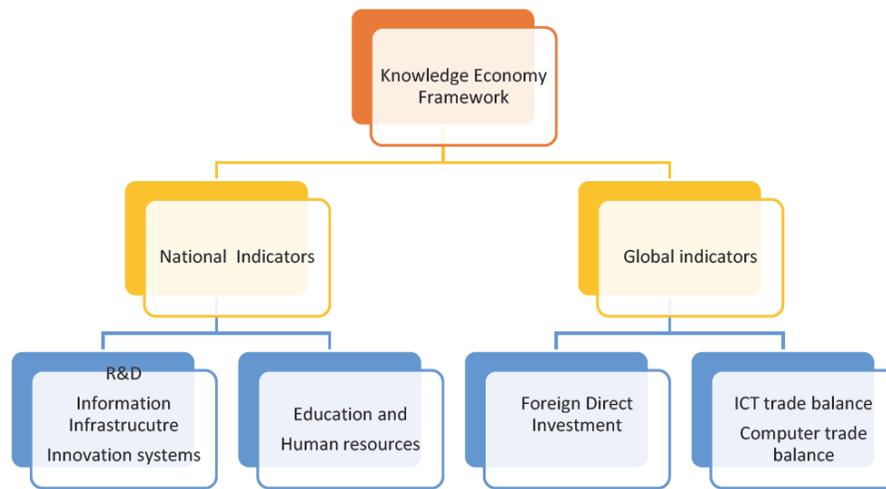
This model specification focuses on the knowledge and adoption of smart technologies at the local level to improve domestic and the overall economy growth. Knowledge economic indicators are the variables that help to measure a relative state of knowledge economic in the country as asserted by World Bank (2019). The current study uses the knowledge assessment methodology to assess relationship between KBE and growth in South Africa. The chosen model specification uses knowledge-based economy framework in alignment with the following knowledge assessment methodology established by the world bank (World bank, 2019).

The above knowledge economic indicators influence knowledge creation, adaptation and development both at national and global level. Figure 8 below shows that R&D, innovations systems and information infrastructure as well as human resources by means of education and training are the relevant indicators at national level. Foreign direct investment and trade balance of ICT and communications and computer reveal knowledge acquisition at global level. However, internal situation somehow impacts external indicators and vice versa.

**Table 5: Knowledge Assessment Methodology in South Africa**

Dimensions	Variables	Symbols
Performance indicators	Average annual GDP growth (%)	GDP
Innovation systems	FDI as percentage of GDP	FDI
	Total expenditure for R&D as percentage of GDP	RD
Economic regime	ICT goods exports % of total exports	ICT_EXP
	ICT goods imports % of total imports	ICT_IMP
Information and Communication infrastructure	Communications, computer, etc. (% of service exports, BoP)	COM_EXP
	Communications, computer, etc. (% of service imports, BoP)	COM_IMP
Education and Human Resources	Literacy rate, adult total (% of people ages 15 and above)	LIT

Source: World bank (2019).



**Figure 8:** Knowledge Economy factors in South Africa.

Source: Authors' Compilation.

**3.1. National Indicators**

Research and development (R&D) is a key point in measuring knowledge-based economy. It encompasses creation and development whether at product, business or policy level. In south Africa, prominence of gross domestic expenditure allocated to research and development is one of the most critical indicators of the race toward knowledge-based economy. As a percentage of GDP, it reflects the level of R&D productivity in the country. An economic system driven by innovative systems and rapid productivity attract foreigners to create business locally. In this regard, foreign direct investment (FDI) in South Africa informs about how developed the knowledge and the technology in the country is that attract investors. FDI is calculated as a percentage of GDP. Considering the pace towards digital change, information infrastructure is pivotal for the knowledge development. In South Africa, ICT expenditure reveals how

committed is the country in learning. ICT expenditure as a percentage of GDP. Adoption and implementation of knowledge economy is aligned with Education and Human resources management. Above all, there is a need on human resource skills to apply knowledge capacity on economy. So far, Literacy rate, adult total (% of people ages 15 and above) is the relevant indicator for the country's workforce associated with the 4IR knowledge development. This indicator is relevant in the sense that population between 15 and above constitute the foundation of tomorrow's learning through knowledge transfer.

**3.2. Global Indicators**

Considering the global market tendency, countries should develop positioning at international level to remain competitive. In so doing, one of the variables of development if the level of foreign direct investment (FDI) done by South Africa in foreign countries. FDI is

**Table 6: Knowledge-Based Economy Variables**

Independent Variable		Dependent Variables	
GDP	Gross Domestic Product	FDI	Foreign Direct Investment
		R&D	Research and development
		ICT_TB	ICT trade balance
		COM_TB	Computer Trade balance
		LIT	Literacy rate

Source: Author's Compilation.

calculated as a percentage of GDP. ICT\_EXP is calculated as the percentage of total exports done in South Africa. ICT\_IMP is calculated as the percentage of total exports done in South Africa. ICT trade balance represents the level of ICT exports (ICT\_EXP) versus imports (ICT\_IMP) in South Africa compared to COM trade balance that highlights the balance between exports (COM\_EXP) and imports (COM\_IMP) of communications and computer services in South Africa. ICT trade balance as well as computer trade balance reflects technological level of South Africa worldwide. The following table summarises independent and dependent variables.

The linear equation form is stated as follow

$$GDP = \beta_0 + \beta_1 FDI + \beta_2 R\&D + \beta_3 ICT\_TB + \beta_4 COM\_TB + \beta_5 LIT + \epsilon$$

Where:

GDP = Gross Domestic Product

FDI = Foreign Direct Investment

R&D = Research and development

ICT\_TB = ICT trade balance

COM\_TB = Computer Trade balance

LIT = Literacy rate, with  $\epsilon$  as the error term and  $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$  the estimation parameters, and  $\beta_0$  the constant term

Data used in this research where collected from secondary sources such as the World Bank, the OECD, the South African reserve bank (SARB) and statistics South Africa. The study considered yearly frequency of the recent decade period from 2006 to 2017 to investigate on up-to-date data that tells about current knowledge development. Theoretical analysis is

done using descriptive statistics and correlation analysis to determine relationship between growth performance in South Arica and the knowledge-based economic indicators.

#### 4. RESEARCH ANALYSIS AND RESULTS

##### 4.1. Results Analysis

##### 4.1.1. Descriptive Statistics

##### 4.1.1.1. Correlation Matrix

This correlation matrix shows that there is a strong relationship between GDP and FDI, R&D, trade ICT and Computer and literacy. Although the coefficient of dependent variables are relatively low and negative sometimes, they still affect the GDP in the same pattern. This also explains sustainability of the current account deficit in South Africa since years.

##### 4.1.2. Summary Outputs

The multiple R coefficient equals to 0.8195. it shows a positive and significant correlation between growth performance and the dependent variables. The coefficient of determination R Square equals to 67.16% and thus indicates goodness of fit between variables. This means that 67% of GDP is explained by the dependent variables namely FDI, R&D, trade ICT and Computer as well as literacy. The significance F value which is 0.0326796 is less than .05 (5%). This means that the regression model is reliable. This result shows that there is significant relationship between growth performance and the dependent variables. The Regression model outputs are as follow:

Based on statistical data from the regression model, economic growth performance equation can be written as follow:

$$GDP = \beta_0 + \beta_1 FDI + \beta_2 R\&D + \beta_3 ICT\_TB + \beta_4 COM\_TB + \beta_5 LIT + \epsilon \tag{1}$$

**Table 7: Descriptive Statistics**

	<i>GDP</i>	<i>FDI</i>	<i>R&amp;D</i>	<i>ICT_TB</i>	<i>COM_TB</i>	<i>LIT</i>
Mean	2.1728	2.7736	72.4000	-3.9710	-12.7836	92.7720
Median	2.3493	3.0000	73.5000	-7.0675	-13.2404	93.4158
Standard Deviation	1.8422	1.1395	10.2545	6.5983	2.3467	1.9857
Kurtosis	1.4101	0.1839	1.6368	1.3886	0.3955	1.0650
Skewness	-0.4554	-0.3279	-1.3406	1.7560	0.7247	-1.4909
Range	6.8986	3.8600	34.0000	17.0501	7.8638	5.6928
Count	10	10	10	10	10	10

Source: Authors' compilation.

**Table 8: Correlation Matrix**

	<i>GDP</i>	<i>FDI</i>	<i>R&amp;D</i>	<i>ICT_TB</i>	<i>COM_TB</i>	<i>LIT</i>
<i>GDP</i>	1	0.51238223	-0.7384016	0.61425526	0.6517033	-0.61473596
<i>FDI</i>	0.51238223	1	-0.71761351	0.46629714	0.72086896	-0.58301782
<i>R&amp;D</i>	-0.7384016	-0.71761351	1	-0.88966815	-0.87915755	0.8442962
<i>ICT_TB</i>	0.61425526	0.46629714	-0.88966815	1	0.8779435	-0.94243652
<i>COM_TB</i>	0.6517033	0.72086896	-0.87915755	0.8779435	1	-0.86721623
<i>LIT</i>	-0.61473596	-0.58301782	0.8442962	-0.94243652	-0.86721623	1

Source: Authors' Compilation.

**Table 9: Summary Outputs**

Regression Statistics	
Multiple R	0.8195479
R Square	0.67165876
Adjusted R Square	0.26123221
Standard Error	1.58338493
Observations	10
F	16.3649
Significance F	0.0326796

Source: Author's Compilation.

**Table 10: Regression Model**

	Coefficients	Standard Error	t Stat	P-value
Intercept	153.30043	127.111893	1.20602744	0.02942626
<i>FDI</i>	-1.78404431	1.55156071	-1.14983855	0.00314281
<i>R&amp;D</i>	-0.37283108	0.22556407	-1.65288327	0.01736983
<i>ICT_TB</i>	-0.76117878	0.6173089	-1.23305979	0.02850642
<i>COM_TB</i>	0.68541656	0.77236086	0.88743047	0.04249857
<i>LIT</i>	-1.22285731	1.19238437	-1.02555631	0.03630687

Source: Regression Model Outputs.



Figure 9: GDP growth (Annual %) 2006-2017.

Source: SA Statistics (2019).

The regression model becomes

$$GDP = 153.30 - 1.78 FDI - 0.37 R\&D - 0.76 ICT\_TB - 0.68 COM\_TB - 1.22 LIT + \epsilon$$

## 4.2. Research Results

### 4.2.1. Performance Indicators

Following the ASGI-SA programme, South African’s government aims to achieve six percent gross domestic product (GDP) (DTI, 2019). This suggests that the GDP per capita is the appropriate economic indicator to evaluate economic performance of a country.

Since recent years, the economy of South Africa has experienced a decline on Growth trend as depicted on Figure 9 above. Domestic as well as global impact have been at the origin of such decrease. Continuous deficit of the current account has negatively affected the percentage of GDP.

### 4.2.2. Innovation Systems

Innovation systems help to build an economic ecosystem based on the continuous search for knowledge development and global fit. Innovation

systems also includes upgrade of trading policies, industrial financing advanced strategies, competition strategies and sector regulation that constitute the main engine of knowledge economy. As a middle-income developing country, South Africa continuously needs to invest in its innovation and technology capacities in every sector to meet global requirements. The department of trade and industry (Dti) funds The Support Programme for Industrial Innovation (SPII) that promote technology development in South Africa industry. The Technology and Human Resources for Industry Programme (THRIP) also stimulates industry and government to increase their investment in research, technology development, diffusion and the promotion of innovation.

In South Africa, there is an increase of innovation on good and services at commercial and manufacturing level. Innovation systems cover areas such as technological innovation, innovative business, product innovation and innovation policies. Using internet of things, South Africa is capable to perform higher knowledge activity by means of developing applications and software tailored to every economic sector to improve productivity and efficiency. Research centres at universities as well as at the organisation level are



Figure 10: Foreign Direct Investment (FDI).

Source: SA Statistics (2019).

growing in South Africa to create new technology that underpin development of development of new digital product and processes.

**4.2.2.1. Foreign Direct Investment**

FDI has a significant but negative relationship with a coefficient of -1.78404 towards GDP. A higher-level percentage of FDI also highlights inclusion of the foreign investment in the new industrial area in South Africa. Example of the new advanced manufacturing process that required medium to high-tech products to compete in the global trade.

**4.2.2.2. Research and Development**

Regarding the speed of digital change around the world, focus of research and development is mostly on the technological intervention capacity in every sector. As a pluralistic system of governance, each government department receives an effective amount to spend on R&D. This entails a higher level of government expenditure for technology financing. Advanced technology requirements in sectors such as automotive, aerospace, electrics and electronics are now explored in South Africa compared to foreign direct investors. South Africa increasingly invests on research and development to promote innovation and

technologic capacities to deliver quality goods and services tailored to the customer’s expectations. Although it is risky and costly to get aligned with such investment and economical tendency, South Africa needs to cope with the digital disruption in order to survive economically.

The national research foundation (NRF) in South Africa funds the Technology and Human Resources for Industry Programme (THRIP) that promotes partnerships in pre-commercial research between business and the public-funded research base including universities and research institutions. The Automotive Investment Scheme (AIS) is an incentive that aims to grow and develop the automotive sector through investment in new and/or replacement models and components to be able to compete internationally.

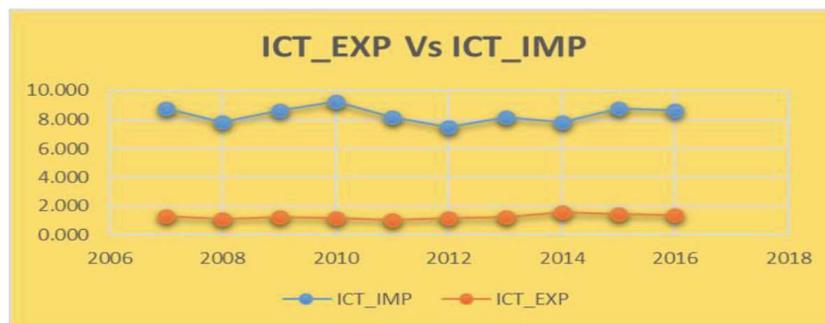
**4.2.3. Economic Regime**

The increase of telecommunications and technological penetration have considerably improved digital change in South Africa. The real picture is to align technology adoption, adaptation and transfer. The level of technology transfer via import and export tells about technology adoption and adaptation. Figure 12 shows that south Africa imports more than they exports especially in ICT whereby percentage of ICT goods



**Figure 11:** Research & Development (R&D) (% of GDP).

**Source:** SA Statistics (2019).



**Figure 12:** ICT Exports Vs Imports.

**Source:** World Bank (2019).



Figure 13: ICT Trade Balance.

Source: World Bank (2019).

imports on the total imports is higher than the ICT goods exports % of total exports.

Such difference leads to negative percentage of ICT trade balance which is not efficiency for the South African economy as depicted on the Figure 13 above.

4.2.3.1. ICT Trade Balance

ICT adoption in every sector in South Africa leads to ICT transfer and tells about how far the country towards the pace of technological advancement is. Benchmark of advanced technologies around the world include adoption of the following smart technologies such as artificial intelligence, nanotechnology, robotics, photonics and biotechnology among others. Despite the increase of cyber-attacks coming with the increase of ICT, necessary measures can be taken at the country level to restrict systems' penetration.

4.2.4. Information and Communications Infrastructure

Data transmissions are done using telecommunications and internet of thing through communication and computers. From industrial age to the current digital age, economic atmosphere is dominated by uncertainty and highly dynamic systems requiring IoT skills. Specific technology platforms

whether hardware or software need to be put in place to support continuous digital change and economic adaptation. In South Africa, sophisticated and smart devices are used to improve effective communication, dissemination and information processing. Figure 14 shows that south Africa imports more than they exports especially in ICT whereby Communications, computer, etc. (% of service imports, BoP) is higher than the Communications, computer, etc. (% of service exports, BoP).

4.2.4.1. Computer Trade Balance

Figure 15 once more depicts sustainability of negative trade balance from the communication, computer and others. Hence, technology dependence from the foreign countries.

Convergence of technologies improves information and communication infrastructure for emerging technologies such as South Africa. The use of advanced materials and systems is the building blocks of smart infrastructure and devices to host innovative systems and techniques. In South Africa, the Council for Scientific and Industrial Research (CSIR) has a national laser centre for nanostructured materials that focuses on research specifically into energy and materials. Such initiatives will improve local technology



Figure 14: Communications, Computer Exports Vs Imports.

Source: World Bank (2019).



**Figure 15:** Communications, Computer Trade Balance.

**Source:** World Bank (2019).

development to adverse rate of computer and communication devices imports.

**4.2.5. Education and Human Resources**

Admittedly, knowledge work force actively contributes to the company growth and long-term sustainability. However, development of e-learning and thinking ability are the key drivers of the new dynamic world that need to be considered by any organisation. In South Africa, knowledge development of human resource is now considered as an asset for a company to meet global challenge and develop competitive edge. At the country level, protection of intellectual property and patents increases innovation tendencies. Education and skills development are the building blocks of knowledge development. Several South African institutions such as CSIR, SARB and NACI have created research centre and academies to enhance organisational efficiency and effectiveness through people development (SARB, 2019). Literacy rate, adult total (% of people ages 15 and above) governs the aptitude of people to learn and adjust to the continuous change. Educational attainment is a prerequisite to knowledge and critical thinking that lead to innovation.

**5. ECONOMIC ENVIRONMENT IN SOUTH AFRICA**

The following domestic challenges have been undermining properness of the South African economy:

- Low rate of infrastructure development
- Low technological innovation in the manufacturing and mining sectors
- Partial execution of policy trade in certain key sectors
- Decrease on foreign investment return and economic recession
- High rate of unemployment
- Unstable exchange rate

Despite the above challenges, South Africa continues to focus on the implementation of relevant trade policies to recover better economic situation. Increase of customer knowledge boosts adoption of technological change in South Africa at individual and business levels.



**Figure 16:** Literacy rate in South Africa per adult total.

**Source:** Data. World Bank (2019).

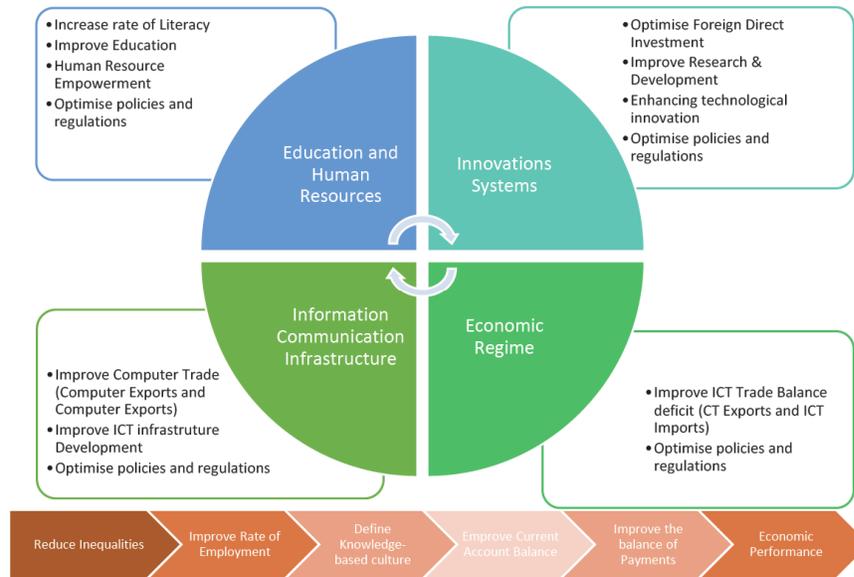


Figure 17: The proposed Conceptual framework.

Source: Authors' Compilation.

## 6. CONCEPTUAL FRAMEWORK

Based on the above results, the following conceptual framework will help to improve knowledge-based economy in South Africa. Successful implementation of this proposed conceptual framework depends on the South African government in optimising policies and regulations related to the four pillars namely innovation systems, economic regime, ICT infrastructure and education and human resources. Sustainable economic performance equally depends on favourable economic environment to become a solid foundation for long-term survival. It is all about:

- Reducing inequalities
- Improving rate of employment
- Define knowledge-based culture countrywide
- Improve the current account deficit
- Improve the balance of payments

## 7. CONCLUSION

Knowledge economic development together with the process of industrialisation require efficient and sustainable policies and regulation to drive South Africa to the trajectory of the fourth industrial revolution. As a middle-income developing country, South Africa is gradually combining knowledge and technology-intensive approach to achieve economic performance through increase of GDP per capita.

Following the knowledge economy framework, the current study uses research and development, foreign direct exchange, ICT trade balance and information infrastructure as determinant of the knowledge-based economy. Research findings showed that growth economic performance by means of gross domestic product (GDP) in South Africa is linked to the adoption of knowledge-based indicators with a correlation coefficient of 81%. A negative correlation between GDP and the trade balance is due to the higher rate of imports compared to exports. Hence, sustainability of the current account deficit that lower the balance of payments in South Africa. Regarding the increasingly percentage of GDP against research and development, it is evident that knowledge and innovation enhance economic growth as well as the overall development in South Africa. The knowledge economy framework shows that investment on R&D as well as education and training enhance innovation and technological adoption that consequently boost economic situation in the current dynamic world. However, creation, adoption and adaptation to the knowledge economy relies on a conducive economic condition defined at the governmental and institutional level.

In order to continuously ensure improvement of knowledge-based economy, South African policy makers should gradually innovate on strategic policy instruments for better results. Although knowledge-based economy is a better option to improve sustainability of economy growth in South Africa, internal differences are still compromising attainment of

this global goal. It is important for government to focus in solving national issues such as inequalities, low rate of employment, health and well-being among others. The proposed conceptual framework will help the government to easily implement knowledge-based economy in every sector of the economic system. National economic prosperity thus relies on both knowledge-based economy and diminution of internal challenges.

## RECOMMENDATIONS

Future studies should use quarterly or monthly data frequency if already published to optimise research results for period of 10 years from 2007 to 2016. Additionally, other researchers should emphasise on a comparative analysis between South African as an emerging economy using knowledge-based approach and other developed economies. The use of upgraded statistical method to assess relationship between economic growth performance and knowledge variables will be relevant. Other authors can see how to apply the current conceptual framework to foreign economies in the sub-region and globally.

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Received on 05-05-2020

Accepted on 11-06-2020

Published on 09-11-2020

DOI: <https://doi.org/10.6000/1929-7092.2020.09.37>

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