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Energy consumption and investments for economic growth in Southern Africa Development Community (SADC)

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Dedication

I dedicate this work to my parents for the support they have been giving to me.

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Firstly I would like to thank God, for all the blessings and lessons that lead to accomplish everything I did until this day.

Secondly I thank my parents for the motivation, emotional and financial support they gave me, as without it I would not have get this far. Also to my family for kindness, patience, time and attention that they dedicated to me.

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Resumo

Este estudo analisa a relação entre o consumo de energia de fontes renováveis e fósseis com o crescimento económico, bem como, a relação do investimento total com o crescimento económico em 10 países da Comunidade de Desenvolvimento da África Austral (SADC). O método autorregressivo (ARDL) foi utilizado para capturar os efeitos de curto e longo prazo e o estimador Driscoll Kraay foi utilizado para obter resultados robustos. Para os restantes testes complementares verifica-se a presença de heterocedasticidade, correlação contemporânea, autocorrelação de primeira ordem e a dependência da seção transversal. O resultado mostra que o consumo de energia de combustíveis fósseis a curto prazo, tem contribuído para o crescimento económico. Enquanto, que o consumo de energia renovável a longo prazo apresenta um resultado negativo no crescimento económico, este efeito pode ser causado pela aplicação de energia de fontes renováveis em atividades não produtivas. O investimento total mostra ser um grande impulsionador no crescimento económico dos países em estudo a curto e a longo prazo. A versão preliminar deste trabalho foi apresentada na 3ª Conferencia anual sobre *Energy Transition: European and Global Perspectives*, organizada pela *Hellenic Association for Energy Economics* (HAEE) na Grécia.

Palavras-chave

Investimento total, Crescimento económico, SADC, Consumo de energia renovável, Consumo de energia de combustível fóssil.

Resumo alargado

Com o objetivo de reduzir a pobreza e o desemprego em África, várias são as medidas que devem ser tomadas, sendo uma delas o aumento eficiente do consumo de energia, pois esta impulsiona o crescimento social e económico, melhorando os padrões de vida e a produtividade industrial. Mas o que se verifica é que a maior parte dos países africanos possuem uma grande escassez no acesso à energia e eletricidade comprometendo o crescimento económico. Para acabar com a escassez, seria necessário aumentar a geração de energia, mas para isso deve haver mais investimentos e apoio por parte das entidades públicas e privadas.

Este estudo aborda a relação entre o crescimento económico com o consumo de energia renovável e de combustível fóssil, bem como a relação do crescimento económico com o investimento total para os países membros da Comunidade de Desenvolvimento da África Austral que são: Angola, África do sul, Botswana, Comores, República Democrática do Congo, Lesotho, Maurícias, Madagáscar, Malawi, Moçambique, Namíbia, Swazilândia, Seychelles, Tanzânia, Zâmbia e Zimbabwe. A Comunidade de Desenvolvimento da África Austral foi criada em 1992, é uma organização intergovernamental, que tem como objetivo, promover a cooperação e a integração socioeconómica, bem como a cooperação política e de segurança entre os 16 países da África austral.

O estudo considera uma abordagem de dados em painel, devido a falta de dados, apenas 10 países serão estudados, sendo eles: Angola, Botswana, República Democrática do Congo, Maurícias, Moçambique, Namíbia, África do sul, Tanzânia, Zâmbia e Zimbabwe, num período temporal de 1991 a 2013. O método ARDL é consistente para amostras pequenas, e foi usado para captar os efeitos de curto e longo prazo. Por se tratar de um estudo que engloba um conjunto de países, foi importante testar a dependência da seção transversal para verificar a possibilidade dos países em estudo serem mais sensíveis ao choque. O teste Hausman foi usado para determinar se seria usado o teste de efeitos fixos ou efeitos aleatórios para estimar o modelo final adequado. Para determinar a heterocedasticidade aplicou-se o teste Wald. A seguir foram feitos os testes de especificação, para determinar a correlação contemporânea aplicou-se o teste de Pesaran e para a autocorrelação de primeira ordem o teste Wooldridge. Por fim o estimador Driscoll Kraay foi utilizado para obter resultados robustos devido à presença de heteroscedasticidade, correlação contemporânea, autocorrelação de primeira ordem e dependência transversal. A variável dependente usada, foi o Produto interno bruto per capita resultante da razão do produto interno bruto e o total da população. Para as variáveis independentes foram usadas: o acesso à eletricidade, o consumo de energia de combustível fóssil, consumo de energia renovável, índice de volume

de exportação e o investimento total resultante da adição de investimento privado e investimento geral do governo.

Os resultados mostram que existe uma relação positiva de curto prazo entre consumo de energia de combustíveis fósseis e o crescimento económico, juntamente com o índice de volume de exportação. E para o longo prazo, o consumo de energia renovável apresenta uma relação negativa, este resultado é contrário ao que se esperava, devido ao facto da maior parte do consumo de energia nesse estudo ser proveniente de fontes hidroelétricas, e essa região tem uma grande reserva de hidrelétricas de baixo custo. O acesso a eletricidade mostra-se eficiente no crescimento económico uma vez que apresenta uma relação positiva. Para o investimento total, há uma relação positiva no crescimento económico para curto e longo prazo.

Com a limitação em obter os dados, os resultados obtidos nesse estudo devem ser olhados com um certo cuidado. É importante que para futuros trabalhos com mais dados seja feita uma análise de forma a transmitir resultados com maior robustez. E que seja realizado outro estudo referente ao crescimento económico, onde possa ser englobado outros indicadores tendo em conta as políticas públicas em relação a produção, distribuição e o consumo de energia. Com base nos resultados recomenda-se que os países em estudo continuem a consumir energia proveniente de fontes de combustíveis fósseis, apesar de esta ter um grande impacto negativo ao ambiente. Para a fase inicial onde a preocupação é reduzir a escassez elétrica e as más condições de vida, esta fonte tem dado um grande contributo no crescimento económico, como foi observado nos resultados. A posterior pode-se optar por um processo gradual de substituição das fontes de combustíveis fósseis para fontes renováveis. Em relação ao consumo de energia renovável, nota-se uma diminuição no crescimento económico e várias razões podem estar por detrás desse resultado, podendo ser a má aplicação da energia renovável, ou seja, ela está sendo aplicada para atividades não produtivas, de igual modo recomenda-se o uso de energia desta fonte, tendo em conta que causa menos danos ao ambiente, e para um desenvolvimento sustentável esta pretende ser uma excelente aliada. Recomenda-se ainda que o governo invista mais no sector energético. Crie políticas flexíveis que incentive cada vez mais a entrada de investimentos privados e a entrada de novas pequenas empresas no mercado.

Abstract

This study analyses the relation between the renewable and fossil energy consume and the economic growth, as well as the relation that the total investment has with the economic growth in 10 countries from the Southern Africa Develop Community (SADC). The autoregressive method (ARDL) was used to capture the effects on a short and long run and the Driscoll Kraay estimator was used to obtain robust results. As for the remaining complementary tests it is verified the presence of heteroscedasticity, contemporaneous correlation, autocorrelation of first order and cross sectional dependence. The result shows that the fossil fuel energy consume on a short run, has been contribution to the economic growth. While the renewable energy consume in a long run presents a negative result in economic growth, this effect can be caused by the application of energy from renewable sources in non-productive activities. The total investment shows that it can be a big boost to economic growth of the countries under this study on a short and long run. The preliminary version of this work was presented in the 3th Annual Conference about Energy Transition: European and Global Perspectives, organized by Hellenic Association for Energy Economics (HAEE) in Greece.

Keywords

Total investment, Economic growth, SADC, Renewable energy consumption, Fossil fuel energy consumption.

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List of Abbreviation

ARDL	Auto Regressive Distributed Lag
CSD	Cross Section Dependence
CIPS	Cross Section Augmented
CIA	Central Intelligence Agency
DBSA	Development Bank of Southern Africa
DRC	Democratic Republic of the Congo
EDF	Companhia Électricité de France
GDP	Gross Domestic Product
IRENA	International Renewable Energy Agency
IMF	International Monetary Fund
MW	Megawatts
PPU	Project Preparation Unit
SADC	Southern Africa Development Community
SACU	Southern Africa Customs Union
SAPP	Southern Africa Power Pool
SEC	Swaziland Electric Company
TL	Transmission Line
UN	United Nations
USTDA	US Trade and Development Agency
VIF	Variance Inflation Factor
WB	World Bank

1. Introduction

The concern of investing in energy sector in Africa is not a new topic. According to Africa progress report of 2015, most part of African countries have major deficit in the access to energy and electricity. About 621 million of inhabitants have no access to electricity and 4/5 depends on solid biomass energy (firewood and charcoal), which ends up contaminating the air and causing 600 thousand deaths per year. To respond to these challenges, it will be require to increase 10 times more the energy generation in order to ensure access to electricity to all Africans by 2030 and due such lack of energy, the potential growth of Africa will reduce to around 2% to 4% per year, which causes more unemployment and poverty.

The Development Bank of the Southern Africa (DBSA) since 2013 has been promoting financial and non-financial investments in sectors of social and economic infra-structures to SADC member countries, where 60% of these investments went to energy (Dlamini, 2017). Due to weak access to electric energy that ends up compromising the sustainable development of the community, there is a major concern in reducing these effects through expansion, but they face other types of problems such as lack of funding in this sector and resistance to the entrance of new energy suppliers in the market.

What can be observed in these countries is that energy consumption is divided according to two sources: fossil fuel and renewable sources. In the consumption of energy from fossil fuel sources we have: coal, distillate, nuclear, gas, biomass and oil. And in the consumption of energy from renewable sources we have: hydroelectric, wind, solar and landfill. It is important to highlight that hydroelectric is the most used source in comparison with other energy sources inside the countries under this study.

The main purpose of this study is to understand how investments and energy consumption could influence the sustainable growth in that area. It is important to describe the benefits that energy could bring to the population and what would be its contribution to the community, and understand what other factors influence economic growth. This study contributes to the literature, because it reveals relationships between the total investment with economic growth and the consumption of energy with economic growth for a series of the African countries less explored. Furthermore, it provides a vision on the importance that total investments and the consumption of renewable and fossil fuel energy have in economic growth, in a short and long run.

In general run, this study aims to respond to the following questions: What other factors apart from investment and consumption of the fossil fuel and renewable energy might have influenced in some sort the economic growth? What are the major challenges for the energy sector? How the rush to end the lack of energy supply may condition clear energy? Is there a concern on environmental part in energy consumption?

Concerning data analysis, the study uses annual data from 1991 to 2013, applying an approach of limit test ARDL by Pesaran and Smith (2001), with other procedures to obtain the results. In general, results show positive effect in the investments over the growth. In relation to the consumption of the fossil fuel and renewable energy, this shows different results, where the fossil fuel energy consumption in a short run boost economic growth, and consumption of the renewable energy in a long run, has no effect on economic growth. To a better understanding, this work is structured as follows: Section 2 contains introductory aspects related to the literature review, followed by the literature review based on previous studies on the relationship of the investments and energy consumption for economic growth. Section 3 presents variables studied, and the methodology used to analyse the data. Section 4 provides the results and estimations obtained in data analysis for the purpose of this study. Then next, section 5 discusses the results and recommends policies. Lastly, section 6 presents general conclusions of the work.

2. Literature Review

In the preparation of this work, a desk study was conducted, what contributed to the topic of this study. There was lack of empirical studies that analysed the nexus of energy consumption and investments with economic growth in Southern African countries, creating more interest in the study of this area and for a better understanding of the review.

Having that said, this section is divided in 5 parts: the first part being about the relationship between the energy consumption and the economic growth; the second part give us an overview on SADC and its main goals; the third part is about the difficulties in the access to electricity and about the investments made on energy in SADC members; the forth part talks about the interaction of the energy consumption with the environment; lastly, the fifth part concerns the benefits of energy to the population.

2.1. Energy consumption nexus economic growth

It can be said that several studies were conducted on the relationship between consumption of the renewable and fossil fuel energy and economic growth. Starting on the year 1996, where Jones and Thompson, studied the importance of electricity in the sustainable development of population, defending that the lack of access to electricity, makes it difficult for the population to be out of terminal cycle of poverty, since energy services like: lighting, water supply, communication and cooling systems are directly linked to human development.

Recently authors like, Naseri et al., (2015), Marques et al., (2016) and Destek et al., (2017) analysed the relationship between energy consumption and economic growth, by testing the traditional 4 hypothesis, as follows: **Growth hypothesis** -The increase in energy consumption can lead to an increase in production and economic growth because the consumption encourages the growth. **Conservation hypothesis**: It explains that even though there is no reduction in energy consumption, it will not affect the production and economic growth. If there is an increase in GDP, there will be also an increase in the energy consumption. The economic growth doesn't depend fully on energy consumption. **Feedback hypothesis**: It means that there is the presence of bidirectional of causality between energy consumption and economic growth. Meaning that energy consumption and economic growth interact between each other and complement themselves. **Neutrality hypothesis**: The energy consumption has less or no effect in production, meaning that energy consumption and economic growth are neutral in relation to one another, where consumption may have minimum impact or any economic growth. There are several studies from the old ones to the more recent ones that address the issue of energy consumption with economic growth, what is observed is the differences in the results.

Looking at more recent literature by Saidi et al., (2017), that studied the relationship of energy consumption with economic growth, with the technique of co-integration in panel of the 53 countries, that covered 11 countries of Africa (Tanzania, South Africa, Mauritius, and Zimbabwe, countries under this study) where bidirectional causality was observed on the short and long run between energy consumption and economic growth, which implies that there is a positive relationship in a long run between economic growth and energy consumption.

In his study Marke et al., (2016), shows that the increase in energy consumption is related to economic growth. Where consumption of energy from renewable sources is important for an average development and consumption of non-renewable sources that managed to boost more growth. It was also concluded in this study that other main factors cause economic growth, them being: labour, trade openness, inflation, exploration of the natural resources, investment and energy. These are not the only ones that concluded on that, Schwerhoff and Sy (2017), also affirmed that renewable energy is still a strong ally for Africa's growth, reducing poverty, because it has more potential to make many sectors competitive, like the case of agriculture, education, health, and also make the countries more independent, not needing to import fuel, as it ensures reliable and sustainable energy. The opposite is verified in another study Marques et al., (2018), where it presents a negative result in economic growth for renewable energy consumption.

2.2. SADC Overview

The Southern Africa Development Community (SADC) is an intergovernmental organization created in 1992 with the aim of reaching the sustainable and equitable economic development, peace, security and growth, besides poverty relief, improvement of the standard and living standard of the southern African population, gives support to the unprivileged throughout regional integration based on democratic principles and equitable and sustainable development throughout productive and efficient systems, deep cooperation and integration (SADC, 2017). The Southern Africa Development Community is constituted by 16 countries, them being: Angola, Botswana, Comoros, Democratic Republic of the Congo, Malawi, Madagascar, Mauritius, Mozambique, Namibia, Lesotho, South Africa, Seychelles, Swaziland¹, Tanzania, Zambia and Zimbabwe.

¹ In 2018 Swaziland change its name to Eswatini. In order not to cause confusion and maintain the study harmony, its previous name will be the one mention through the study.

2.3. Difficulties in accessing electricity and Investments in energy

It is observed that there are some difficulties in Africa in the access to electricity: first is in public services which are the government's property, that they establish legal protection against any form of perceived competition (Jones and Thompson, 1994); Secondly, the IRENA indicates some challenges such as: Lack of transparency at institutional level, lack of funding, lack of experience in developing projects and lack of relevant information, markets and availability of resources leading to bankable projects; Thirdly, is the lack of funding in energy projects (Oji, Soumonni and Ojah, 2016), where they investigated the ways by which the funding of renewable energy projects could help African countries to develop.

Hence they believe that the lack of access to reliable energy presents a major challenge for economic development of the Southern Africa, excluding South Africa for having a high electrification rate of 85%, in turn. According to IRENA (2016), as a way of meeting some difficulties, apart from facilitating the development and funding of the projects, by offering adequate tools and platforms for all stakeholders (main players of the markets, including governments, developers of the projects and investors). They created strong relationship with the government and international community of the investors as a way of expanding rapidly the investment in renewable energy.

At a global level, there is an unprecedented growth of investment in the renewable energy sector, this growth is important to mobilize rapidly a transition of sustainable energy. IRENA (2016), has been mobilizing several actions of investment sources either private as, or as public capital. In August 1996, this issue has been given more importance at SADC, after signing a protocol that entered into force in April 1998, being the main legal document that tackles the issue of energy development in the region and it provides wide range of legal and political framework for co-operation in the energy sector. The protocol aims to harmonize the regional and national energy politics, strengthen the cooperation in energy development and energy pooling; and guarantee reliable, continuous and sustainable energy service provision efficiently and economically. It also aims to promote the joint human capital development, organizational capacity buildings and the strengthening of the regional cooperation under research, development, adaptation, dissemination and transfer of low-cost energy technologies (Yearbook SADC, 2016 pg21).

A study made by IRENA (2016), defends the importance of the public policy as a form of supporting the electrification programs, especially in rural areas, through well-structured policies that are possible to secure loans, IRENA (2016) complements this idea of the importance of the public policies, by saying that it is possible to mobilize private investment through financial institutions, as the public funds may help to introduce the seed fund in an

emerging sector or new technology. Taking the risks of investment which increases the trust of the private investors and reduces funding costs. It's important to keep in mind that Aguirre and Ibikunle (2014), in his study about factors influencing renewable energy growth, shows another idea saying that certain government-backed energy policies blocks renewable energy's investments. According to Cedrick and Long (2017), due to high initial investment needed for required manufacture technologies and installations while facing budget restrictions. They should be integrated into the private sector that is at a better financial position to fund and carry out such expensive projects through their available capital or innovative technology. Concerning SADC, the Development Bank of Southern Africa mentions that since 2013 the investments in infrastructures in Africa in each sector are distributed in the following way: 60% in energy; 21% to utilities; 11% to transport; 5% to telecoms; 2% to social areas; and 1% to others. The bigger part of the investments going to energy, dividing them in sources. It can be observed that the biggest bet is the renewable sources, as it is distributed in: 51% to solar power; 23% to wind power; 11% to hydropower; 8% to energy (exclude renewable); 5% to diversified renewable energy; 2% to biomass and biofuel facility. The DBSA's in partnership with the projects preparation unit (PPU) approve and committed that by the 2017, 2018 and 2019 the projects would be close financially. These project will reach an area of more than 800Km's of transmission and generation of 1200MW (Dlamini 2017 pg.7-8). For more details on this projects see table 1.

Table 1: DBSA and PPU Projects

Project Name	Country	DBSA Role	Financial close
MoZISA Regional Transmission Line	Mozambique, Zimbabwe and South Africa	Source e manage funds for advisory services to compile feasibility studies until financial close.	August 2018
BoSA Transmission Line	Botswana and South Africa	Fund management for the transaction advisory from IIPSA	April 2018
ANNA Interconnector	Angola and Namibia	Leverage PPDF with IIPSA funding and other co-funding to commence early stage development.	December 2019
2 nd Alaska-Sherwood	Zimbabwe	PPU secured gap funds for consultants to produce a bankable feasibility study.	June 2018
2 nd DRC - Zambia Transmission Line	DRC and Zambia	PPU managed the co-funding contribution for the TL construction, on behalf of DFID.	N/A
Luapula - Lelya Hydro Schemes	DRC and Zambia	PPU was instrumental in approving funds for the technical feasibility studies, and catalysing funds from the WB for the ESIA.	December 2019
Mulembo Hydro Power Schemes	Zambia	PPU sourced project preparation funding from PPDF and is currently managing the feasibility study. DBSA potential for MLA and debt financing.	December 2018
Muchinga Power Station	Zambia	PPFS approved a preparation facility for 300 MW Hydro Power Station on the Lunsemfwa river.	September 2018
Ngonye Falls Hydro Power Project	Zambia	PPFS approved a preparation facility for a 40-120 MW hydroelectric Power Project upstream on the Zambesi River	April 2018
Arandis HFO and Tank Farm	Namibia	PPU approved a project preparation facility for 120MW HFO power plant. The facility will go towards the completion of the projects bankable feasibility study.	December 2017

Source: Development Bank of Southern Africa (2016)

2.4. Energy consumption interactions with the environment

The work of Quaschnig (2010), says that the use of energy has always influenced significantly the environment, that is why it becomes difficult to talk about energy without talking about the component of environment, because all generated energy is a result of use and transformation forces that the nature provide. It does not matter the source of energy to be used, it will always harm the environment, either in a form of forestry destruction or through gas emission in atmosphere ending up with climate change.

There is a different idea concerning the relation between the energy sources and its impact to the environment, Destek and PhD (2017) states that the fossil fuel energy consume is the main cause to global warming and climatic changes while the renewable energy consume is essential to the sustainable growth. At the same time electricity has a bad impact on the environment, because of that Cedrick and Long (2017), came up with the conclusion that renewable energy is less polluting. More recent studies made by Oji et al., (2016), describe the access to clean and stable energy as a major challenge for many African developing countries, noticing that these countries, urging to reduce the lack of energy, tend to prefer non-renewable sources. Although some countries opt by non-renewable sources, according (Marques, Fuinhas and Gaspar, 2016) some African governments, regional organizations and donor community, acknowledge that the access to sustainable energy is a prerequisite for African economic development. The energy consumption is not enough to generate economic growth, this consume also has to be sustainable, what can only be possible with renewable sources.

The UN has been supporting through deployment of technologies and services of the renewable energy and energetic efficiency, in order to tackle challenges related to access and energy safety, as well as mitigation and adaptation on climate change, by contributing to global and sustainable social and economic development for the SADC region (Booklet SADC, 2016).

The SADC development agenda has as priority, the provision of reliable and sustainable energy, economic wellbeing and poverty eradication. For the issue of energy provision, this establishes as initiatives: sustainable energy for all, double the global rate of improvement in energy efficiency and double the share of renewable energy in the global mix by 2030, inspired by objectives of sustainable development that comprise 3 goals (clean energy and accessible price, climate action and sustainable communities) and in historical commitment

assumed in Paris at COP 21² in 2015, of reducing gas emission with greenhouse effect, to limit global warming to not more than 2 degree Celsius or 1.5 degree Celsius in comparison to pre-industrial levels.

2.5. Benefits of energy to the population

Without a doubt, energy consumption and its access brings major contribution to social and economic growth, as it allows improvements in living standards and industrial productivity. Based on (Booklet SADC, 2016), table 2 describes the benefits to different sectors such as: home, work and community.

Table 2: Benefits of energy

Home	Work	Community
Faster cooking	Reduced physical effort	Medical procedure at night
Less smoke saves lives	Faster processing	Evening education
More efficient, less wood	Cheaper price	Light streets: safe communities
Study after sunset	Greater range of service	Cool vaccines, less spoilage
Connection and Communication	Business after dark	Reliable and rapid testing
Increased Comfort	Trade without traveling	Clean, reliable water supply
Leisure and learning	Access market information	Less time spent, less distance travelled
Less food waste	Cool and frozen products	Sterilized equipment
Better nutrition	Fresher for longer	Fever infection
		Order and accessible records
		Digitized institutions

Source: Booklet SADC (2016)

The benefits of energy mentioned in the table above are a few of many other, the rural areas present more lack when compared to urban areas. A very important aspect mentioned by the (Booklet SADC, 2016), is that energy and food security are vital for a sustainable future in a limited resources context. One of the benefits that is relevant to mention is that energy allows, transport, water treatments and pumping to take place, which allows water to be supplied to the production and processing of agricultural goods. It is also used in tractors, irrigation machines and in transportation of agricultural goods.

² Was the 21st Conference Of the Parties - otherwise known as Paris 2015, an annual UN conference on the subject of the climate, and climate change where countries will meet to negotiate a new climate change agreement. The meeting is held in Paris.

3. Data and methodology framework

This section will be divided in two parts: the first one will be data presentation, classification and sources and the second one will be the methodology tests applied to get the results.

3.1. Data

There are 16 SADC member countries and due to the lack of data, only 10 countries will be analysed in a period of 23 years, from 1991 to 2013, and them being: Angola, Botswana, Democratic Republic of Congo, Mauritius, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe. The data analysis was performed using the Software STATA MP 14.0 where data will be transformed into the data panel format that will increase the number of observation by bringing more viability to the study.

There are several studies related to energy consumption with economic growth, but what can be observed is that most of them do not take into consideration the use of some variables that may better explain the relationship among them, according to the reality of countries under the study, apart from that, other variables help to explain the economic growth. For that reason and after several trials done with several variables, the following are the variables used in this study. The source of the variables was the World Bank, for: gross domestic products (constant 2010 U.S dollars); population (number of people); export volume index (index); renewable energy consumption (% of total final energy consumption); fossil fuel energy consumption (% of total) and access to electricity (% of population). The IMF was the data source for general government investment (billions of Constant Dollars 2011) and Private investment (billions of Constant Dollars 2011).

The variable used in the estimated model are as follows: (i) Gross domestic product per capita - the ratio between gross domestic product and total population that is the dependent variable. The GDP is a good index to measure economic growth of a country since it comprises in exposing the amount produced in a certain country in terms of goods and services (Fuinhas et al. 2013). The data of GDP will be analysed in values per capita because this way is possible to eliminate distortions produced by price variation and the distortion produced by population variation, taking into account countries under the study. In several literatures related to this study, the GDP variable per capita is used to create a relation between the economic growth and the energy consumption. And the remaining are independent variables: (ii) Total investment resulting from the sum of general government investment and private investment. For Coelho (2013), what feeds the process of economic production are: the savings and investment, which can be concluded that to encourage economic growth, there are several factors to take into account, and investment well combined is one of them.

For this study is relevant because is related to economic growth and is one of the focuses of this study. (iii) Export volume index, are comprised of sales of goods and services produced in a country to abroad. This variable is important because it analyses the progress of products in the external market and to what extent this will influence economic growth. (iv) Access to electricity. Due to weak access of countries under the study on what they present and according to the literature and to the observed data, that variable would help to understand if really the access to electricity implies in certain way the economic growth. This variable integrates the access to electricity of the urban and rural areas. (v) Renewable energy consumption, by the diversity found in several studies on the influence that the consumption of renewable energy may have, it intends to test in emerging economies in which effects this will have in the economic growth. This variable is represented by renewable sources, where for SADC member states most part comes from hydroelectric sources. (vi) Fossil fuel energy consumption is comprised of coal, oil petroleum and natural gas products. The purpose of using this variable is also to test separately its impact on growth. The separation of energy sources is important to test separately the impact of each one of them, as that in terms of consumed quantity they are not in the same level and also in terms of costs.

The following will be presented in a general way, all members of SADC, giving an overview that covers: the population, the geographic location, including the economic situation and its situation concerning energy.

3.1.1. Angola

With the population of more than 29 million inhabitants (2017), Angola is located at the coast of Atlantic ocean, south of West Africa. According to *Euronews Journal* (2017), 65% of population lives without electricity. The capacity of the installed generation in Angola is mostly from hydroelectric, thermal and gas sources, however, this capacity is not enough to meet the current demand in Angola although it has major potential to be self-sufficient in energy supply based on hydro resources, gas and available oil. To establish the security on demand of electric energy, Angola intends to bet on hydroelectric sources (even with threats of drought) and on gas, also the abandon of diesel. It is relevant to highlight that Angola it is on top 10 of world users of the renewable and lower emissions of CO₂. With the establishment of the general law of the electricity of 1996 and the Law 5/02 on delimited areas of the economic activities, the State will have more control in generation, transmission and distribution of the electric energy for public consumption, that means that these activities require concession of the State to be operated by the private entities, apart from its dimension. Although the Angolan legal Framework allows investment attraction from the private sector, the regulation framework will not sustain private investment due to low tariffs, caused by tariffs or concessions of the Government subsidies (Magombo, 2009).

Angola is currently interconnecting the internal transmission network from north to central and south and it is expanding to the south part of the country, mainly in cities of Xangongo, Cahama and Ondjiva. Apart from major hydroelectric undertakings with the potential of more than 6.000MW are being planned, with some constructions on their way. Angola currently has a repressed demand with deficit of 300MW that will change when new generation starts operating (SADC 2017 pg 8).

3.1.2. Botswana

Located in the Centre of the Southern Africa, with a small population, Botswana counts with population of 2 million inhabitants (2018), it has very limited explored energy resources and currently depends on all oil products and import of electricity from South Africa and Zambia. The available energy resources in Botswana are: coal, solar energy and bioenergy, having an adequate strong potential for installation of solar energy, with more than 3.200 hours of solar light per year, but unfortunately its contribution to the shortage of the national energy is not felt. The fact that Botswana has no resources for the hydroelectric energy, most part of electricity comes from thermal source and coal (generated from Morupule Power Station), with some small diesel generators in rural areas (BITC, 2018). This country has one of the highest tariffs of electric energy in the Southern Africa; the justification of high tariffs is because of relocation of some intensive energy industries in neighbour countries. The electric concessionaire that Botswana Power Corporation has chosen EDF (*Companhia Électricité de France*) to put its rural electrification program decentralized, being that EDF has opportunity to show its capacity in terms of installations that are ecologically responsible and long lasting (Vallon, 2014).

3.1.3. Comoros

For the One World Nation (2018) the archipelago of Comoros, is located in the east of Mozambique, off the east coast of the African continent and west of the northern tip of Madagascar. It is composed by 4 islands, Grande Comoros, Mohéli, Anjouan and Mayotte, with a small population of 808 thousand (2017). In 1975 Comoros gains independence from France, except for the Mayotte Island. In mid-2017, Comoros joined other 15 SADC member states and now is a full member. It is a poor country, but in comparison with some other Sub-Saharan African countries it can be said that Comoros is in a better position. According to the poverty evaluation report about Comoros published by the World Bank in 2018, there have been a 10 per cent reduction on the level of poverty since 2014, which it is more verified in the urban area. According to the Central Intelligence Agency (2018), most part of the installed electricity capacity comes from fossil sources, 96.2%, and the other part comes from hydroelectric sources, 3.8%. By 2015 about 200.000 of population had no access to electricity, in 2016 the elected government advanced with several commitments, one of them was to reduce expenditures and improve the access to electricity.

3.1.4. Democratic Republic of the Congo

The Democratic Republic of the Congo is the largest francophone African country and also the most populated Southern Africa country, with many natural resources. It occupies an area of 2, 3 million km², and it has about 77 million inhabitants, 80 million hectares of arable land and more than 1.100 minerals and precious metals. About 80% of the country's income comes from copper and cobalt exportation. In 2016 a currency depreciation took place and as well as a decrease in the global exportation, that caused damage in the external accounts and a loss of 31% in the exchange rate between the local currency and US dollar (The World Bank, 2017). According the OECD (2014), the CDR's electricity rate is 9%, in other words, about 60 millions of people do not have access to electricity, even though the country possesses a hydroelectric potential.

3.1.5. Lesotho

Lesotho is one of the smallest country and it is mountainous and landlocked, located in the Southern Africa, and geographically is surrounded by South Africa which shares linguistic and cultural traits. It is comprised of 2 million inhabitants (2018), this country faces major social and economic challenges, hence more than half of the population live under the poverty line and it has the second highest rate of HIV/AIDS prevalence. Due to little arable land, the population becomes vulnerable due to the lack of food, depending on deliveries, agriculture, regional customs revenues and still depending on narrow economy based on textile manufacturing. It imports about 85% of consumption goods from South Africa including most of the agricultural inputs. In terms of education, it is notorious to verify the progress, and it has one of the highest rates of adult education in Africa (CIA, 2018). The installed capacity of hydroelectric plants is in 100%, the government promotes the use of renewable energies, subsidizing 84% of the buying price and installation of USD 1864.37, and the remaining 16% is reimbursed in a period of 7 years (Jadhar et al., 2017). Even though, 1.700.000 of the population still continues without access to electricity.

3.1.6. Madagascar

According to One World Nation (2018), Madagascar is the largest African island, located in the Indian ocean, about 950km east of the coast of Mozambique with the general population of about 22 million (2017). Considered one of poorest country in the world, its economy is sustained by mining, fishing, clothing manufacture and agriculture. With environmental destruction, the agricultural activity has been compromised, (Wildmadagascar, 2017). According to euronews (2017) the equipment used on energy supply are outdated and the country has many illegal connections, causing many shutdowns and cuts in the energy supply. Aiming to respond to the increasing demand and to produce low-cost electricity, in 2017 a business plan was developed to solve this problem and make the quality network stable.

3.1.7. Malawi

According to the SADC website, Malawi is a landlocked country, located in the centre of Africa, on the north and northeast it is border by Tanzania, on the east, south, and southwest is border by Mozambique and on west by Zambia, it occupies an area of 118,484 km². It has about 14 million habitants. It also has the third largest lake in Africa with a 568km extension. The Malawian economy is supported by the agriculture (Tabaco, tea and sugar), contributing to more than a third of the GDP, generating more than 90% of the total exportation income. Another big bid is the tourism sector, which is seen as growing sector and economic diversification to increase foreign exchange earnings. Malawi has been through some restrictions in the energy supply. In the cooperation scope between SADC countries in a protocol implementation, Mozambique that has been sharing energy with South Africa, starts sharing energy with Malawi as well, as the Malawi no Shire hydroelectric station has outdated equipment, making the energy supply irregular (Ngozo, 2012).

3.1.8. Mauritius

Mauritius is an island in the Indian Ocean, located off the eastern coast of Africa. Mauritius lies about 500 miles (800 km) east of Madagascar in the Indian Ocean, it has about 1 million inhabitants (2017). The economy is based on manufacture exportation, agriculture, tourism and financial services. A few years ago the economy was completely dependent on the sugar production. Thanks to Government's effort the economy is now more diverse. With this diversification, the dependency on the agricultural sector decreases, although it still is quite important, as about a sixth of the income comes from the agricultural exportation (Bowman, 2018). The country's revision report number 13 issued on July 2010, states that most part of the energy consumed in this country is imported. Until 2016 about 100% of the population had access to electricity, where, 66.3% of the electricity comes from fossil fuel sources, 29, 4% comes from other renewable sources and 5.8% comes from hydroelectric (CIA, 2018).

3.1.9. Mozambique

Mozambique is located in the Southeast of Africa, surrounded by Indian Ocean, between South Africa and Tanzania, with about 30 million inhabitants (2018). Mozambique is a poor country and with high rate of poverty and is affected by natural disasters, diseases, high population growth, low agricultural productivity, unequal wealth distribution, emigration in large scale, economic dependence and political conflicts.

In the previous decade of 2015 Mozambique has grown considerably, to an annual average rate of 6 to 8%, but in 2016 some information, reveals that Mozambican Government was responsible for more than 2 billion US\$ in loans secured by the government, made by state companies of defence and security without parliament approval or inclusion in the national

budget, what led IMF and international donors to withdraw the budget support, creating high currency depreciation, slowing down the growth in the recent years.

Mozambique has a vast potential to energy production in the north of the country, producing more than the country itself could use. And this potential is more in hydroelectric sources of about 85.6% and 14% for fossil fuel and 0.5% for other renewable sources. The region as a whole, lacks adequate offer and estimations indicate that the high and growing demand, and it's about 15.700.000 people have no access to electricity. (CIA, 2018)

Despite, the current infrastructure of energy transmission, Mozambique is far to be sufficient to transport major quantities of energy that could be generated by projects in the north to the market of south and of the region. Alternatives routes to the market of the region are being explored, for example, through Zimbabwe. (SADC 2017 pg25).

3.1.10. Namibia

Namibia is located in the Southern Africa, border by Atlantic Ocean south, and located between Angola and South Africa, with about 2 million inhabitants (2018). The Namibian economy is fully connected to South Africa and is highly dependent on extraction and mineral processing for exportation. One of the major world producer of uranium, the Namibian economy still continues to be vulnerable to world price fluctuation of the commodities making it volatile to SACU annual quotas (Southern Africa Customs Union) in Namibia and global prices of minerals that complicate budget planning. Another issue that makes the economy of this country vulnerable is drought, so in drought years, they normally import about 50% of their cereal needs (CIA, 2018).

The installed capacity is divided in 64.6% for hydroelectric power, 30.1% for fossil and 5.9% for other renewable sources, where only 32% of the population have access to electricity. Namibia imports the rest of the energy from Southern African Power Pool (Jadhar 2017).

3.1.11. Seychelles

Seychelles is an archipelago in the Indian Ocean, situated at northeast of Madagascar, with a well reduced population of about 98 thousand inhabitants (2018).

The sustainable investment of this country comes from services of social welfare, such as free basic health care and education up to secondary level, what make the country reach high rate in human development index, being among the highest of Africa.

It has the highest income among other African countries, in spite that, it has very unequal income. The economic growth is estimated in 55% of the GDP from tourism sector and tuna fishing. In recent years the Government has encouraged foreign investment, in order to improve hotels and other services, to promote agriculture development, fishing and manufacturing in a small scale and make the country less dependent on tourism.

In recent years, Seychelles acquired the status of the developed country, due to strong touristic sector and to the low prices of the commodities. It is also noticed that the lack of access to electricity presents a high reduction rate, of about 2.795 people without access to electricity, meaning that 97% have access to electricity and the sources of the installed capacity are 92% for fossil and 9.2% for other renewable sources (CIA, 2018). Being aware of that they need to improve the energy security, the government has intensified efforts to reduce the dependency on fossil fuel and encourage the use of renewable energy through incentives, such as financial rebate scheme, subsidies (Seychelles News Agency, 2017).

3.1.12. South Africa

Officially the Republic of South Africa, it occupies the southern tip of Africa, stretching from north to south for about 1,600 km and from east to west for about 1,600 km. South Africa has a coastline with the Atlantic Ocean to the west and no the east with the Indian Ocean. It has common borders with the republics of Zimbabwe, Mozambique, Namibia, Botswana, and the kingdoms of Lesotho and Swaziland. (Geography of South Africa, 2005).

According to the *Focus Economics website* although South Africa had hopes of recover their economy with the ascension of Cyril Ramaphosa to the country's presidency in February of 2018, the weak performance of the mining and manufacturing sector in March of 2018 have frustrated the expectation of strong growth in the first quarter. Despite that, full-year prospects appear relatively bright as other sectors of the economy have shown initial of an upturn, since Ramaphosa took place, with the hopes of business-friendly policies and a crackdown on corruption. Upbeat PMI reading through April suggest that the private sector keeps on posting gains and hiring workers despite a VAT hike and ongoing labour strikes.

According to the energy advocacy issued on May 2015, the country's energy situation starts receiving the Government's highest priority and at an attempt to minimise the disruptions in the energy supply, the government has been doing everything possible.

Central Intelligence Agency (2018), says that, the supply of instable electricity is one of the factors that also delays the country's development. ESKOM, an energy state company is constructing three new plants and installing new programs of the energy demand management to improve reliability of the electricity network in order to meet the needs of the minority, estimated in 7.700.000 inhabitants that have no access to electricity, but this

company has been accused of mismanagement and corruption and it faces a debt that is becoming bigger. Another factor that limits the growth is the fact that the country faces structural restrictions such as lack of competencies, global competitiveness in declining and frequent shutdowns due to the strike. The government ends up facing major pressures of the urban groups to improve basic service provision, for low income areas, to increase employments and reduction of fees at universities. South Africa has a much diversified energy system; most part is comprised of fossil sources 86.7%, followed by other renewable sources 7.1%, nuclear with 3.9% and hydroelectric with 1.4%. All these factors of the economy instability; end up creating concern to international investors.

3.1.13. Swaziland

According to the Monthly Newsletter of SADC Secretariat issued on May 2018, the Kingdom of Swaziland changed the name to the Kingdom of Eswatini, during the double celebration of the 50th birthday of His Majesty, king Mswati III and 50th Independence Anniversary of the Kingdom, on the 19th of April 2018. The Kingdom of Swaziland is a small landlocked country, located in the southern part of Africa bordered by the Republic of Mozambique to the east and the rest by the Republic of South Africa. Covers a total area of 17,364 km² with 1 million inhabitants (2017). Currently, Swaziland Electricity Company (SEC) import 80% of its total energy consumption from SADC region through Southern Africa Power Pool (SAPP). Only 20% are internally generated in hydroelectric plants. The total installed capacity of the internal energy production is 60MW. The current maximum demand for the country is 230MW leaving 900.000 people without electricity. The main objective is the development of several solar photovoltaic plants located in the east and in the north east of the country to improve the quality of supply in those areas. This will increase the generation capacity installed in the country in 95%, reducing significantly on dependency of the imported energy from outside the country (SADC 2017 pg31).

3.1.14. Tanzania

Tanzania is located on the east of Africa. It has the Africa's tallest mountain, the Kilimanjaro Mountain, covered in snow. The total population is of about 58 million. The backbone of the Tanzanian economy is the agriculture that represents 46% of Gross Domestic Product, its main crops that bring income are: cotton lint, cashew nut, Tabaco, coffee and tea. Tanzania has many mineral deposits (gold, diamond, rubies, tin, copper, nickel, lead cobalt, limestone, titanium, vanadium, uranium, phosphate and gypsum), as well as coal and natural gas deposits (SADC, 2012). Concerning energy, according to CIA (2018) data, 24% of the population have access to electricity. Its main installed capacity are hydroelectric (47%) and fossil fuel (46%).

3.1.15. Zambia

Officially the Republic of Zambia is located in a landlocked country, is in centre of Southern Africa, with about 15, 9 million inhabitant (One World Nations Online, 2018). According to the World Bank (2017), in 2017 the Zambian economy keeps on recovering. It is predicted an increase of the economy of 4.5% for 2018 and 4.7% for 2019, the kwacha³ stability allowed the Central Bank to release the monetary policy. Improvements are being made in the agricultural sector, it can be verified an increase in the agricultural production, mainly in corn, what ends up reducing the vulnerability associated to the high dependency on dry farming. Concerning energy, Zambia has been evolving to a technology level in this field. The Trade and Development Agency (USTDA) approved a subsidy to support the viability study to the country's first Aeolic energy central. (Caterpillar, 2017).

3.1.16. Zimbabwe

Zimbabwe is located between South Africa and Zambia, it has about 16 million inhabitants (2018). The economy of Zimbabwe strongly depends on its mining sectors and agriculture. From 2010 to 2013 recorded a real growth of more than 10% per year, but it suffered a drop in 2014 to 2017 due to weak harvest, low revenue of the diamonds and reduction of investments.

The World Bank and African Development Bank (SADC 2017 pg.31), want Zimbabwe to implement fiscal and significant structural reforms before they can grant them new loans, not only the foreign and domestic investment continues to be hindered by the lack of land tenure and titling, but the inability to repatriated dividends to investors overseas, and the lack of clarity regarding the government's Indigenization and Economic Empowerment Act. (CIA, 2018). About 40% of population in Zimbabwe has access to electricity, being that, 30% of the consumed energy is imported from Mozambique, South Africa, DRC and other neighbouring counties of the region. Its installed capacity for fossil sources are 58%, for hydroelectric 37.1% and 5% for other renewable sources, in the rural area 80 to 90% of people depend on firewood.

3.1. Methodology

When we intend to analyse the data in panels, it is important to choose adequate technique namely attending to the characteristics of the data. For this study, it is intended to analyse the relationship of causality between energy consumption, investment and the Gross Domestic Product per capita relationship with other chosen variables.

³ Currency of Zambia

The ARDL (Autoregressive Distributed Lag) Approach was used to capture the short and long run effects, introduced by Pesaran and Smith (2001), in order to incorporate I (0) and I (1) variables in same estimation. This approach is consistent with small samples and they may deal with endogeneity potential between variables and structure breakdown that could have happened in series. But before that, it is important to test the possibility of having *cross section dependence* (CSD), in countries under this study, them belonging to the community, whether there is more possibility of having more financial integration, or a possibility of one country being more sensible to the shock of one another. The Hausman test was conducted to determine which model should be used. Afterwards the additional tests was applied, in which it was verified the existence of contemporaneous correlation, heteroscedasticity and first order autocorrelation. After gaining the results, the estimator Driscoll Kraay was used to obtain robust results.

4. Results

Table 3, shows the descriptive statistics and table 4 the CSD test. What is observed is Cross section dependence, which could be consequence of the similar characteristics of the countries under study. After observing the existence of CSD, second generation unit root test was done, (CIPS - Cross section augmented) by Pesaran (2007), to verify the order of variables integration. It is a test for panel with fixed effects that allow heterogeneity in the parameters and serial correlation of the cross-sectional units, besides correcting dependency between them and being applied for unbalanced panels. The CIPS test for most level variables rejects H0 which implies that there is no unit root and for variable in the first differences the null hypothesis is accepted, which means that series are I(1). It can be said that there is a presence of I (0) and I (1), which implies that the presence of borderline variables are accepted for the ARDL model.

Table 3: Descriptive statistics

Variables	Descriptive Statistics				
	Obs	Mean	Std. Dev	Min.	Max.
LGPPC	230	7.380791	1.167885	5.08657	9.088047
LINVT	230	1.797989	1.294329	-0.6387012	4.895129
LEXP	230	4.748347	0.5516652	3.218999	6.44067
LENERW	230	3.95624	0.6468186	2.436904	4.588458
LENERFF	230	3.153559	1.131524	0.4945336	4.479025
LACCT	230	3.159418	1.164779	-3.905805	4.599152
DLGPPC	220	0.0163612	0.0582077	-0.3167124	0.2072339
DLINVT	220	0.0685523	0.1726534	-0.7789741	0.6112615
DLEXP	220	0.0588061	0.1744882	-0.5959249	0.7985713
DLENERW	220	-0.011402	0.0522716	-0.4656892	0.1191523
DLENERFF	220	0.0047099	0.1014244	-0.4582767	0.37547
DLACCT	220	0.0642601	0.2004156	-0.4146268	1.581053

Note: The prefix's "L" and "D" means natural logarithm and first differences respectively.

Table 4: Cross-sectional dependence

Variables	Cross-sectional dependence (CSD)				2 nd generation panel unit root test CIPS	
	CD-test	P-Value	Corr.	Abs(corr)	No trend	Trend
LGPPC	12.31***	0.000	0.383	0.789	1.406	2.542
LINVT	20.14***	0.000	0.626	0.750	-0.732	-1.021
LEXP	24.37***	0.000	0.757	0.757	-4.767***	-4.858***
LENERW	5.65***	0.000	0.176	0.610	0.762	3.371
LENERFF	2.13**	0.033	0.066	0.575	0.861	-0.945
LACCT	15.02***	0.000	0.467	0.809	-3.725***	-6.753***

DLGDPPC	7.57***	0.000	0.241	0.303	-7.467***	-7.430***
DLINVT	-0.81	0.417	-0.026	0.156	-8.008***	-6.588***
DLEXP	0.77	0.439	0.025	0.172	-11.627***	-10.776***
DLENERW	-0.87	0.384	-0.028	0.177	-6.580***	-6.179***
DLENERFF	-0.63	0.531	-0.020	0.170	-9.756***	-8.288***
DLACCT	2.74**	0.006	0.087	0.242	-14.010***	-13.081***

For assess the eventual presence of collinearity between variables, the VIF (Variance inflation factor) was calculated; The results in table 5, show absence of collinearity due to its low values being 3.11 for the mean of the variables in level and 1.05 for variable in the first differences. In addition to correlations, although these present some high correlations, they are not reasons of concern.

Table 5: Correlation Matrix and VIF

	Lgdppc	Linvt	Lexp	Lenerw	Lenerff	Lacct
Lgdppc	1.0000					
Linvt	0.4397	1.0000				
Lexp	-0.0298	0.2324	1.0000			
Lenerw	-0.8845	-0.3601	0.0486	1.0000		
Lenerff	0.9350	0.3247	-0.1875	-0.8511	1.0000	
Lacct	0.7838	0.4541	0.2058	-0.6725	0.7361	1.0000
VIF		1.32	1.50	3.85	5.76	3.12
Mean VIF				3.11		
	Dlgdppc	Dlinvt	Dlexp	Dlenerw	Dlenerff	Dlacct
Dlgdppc	1.0000					
Dlinvt	0.1801	1.0000				
Dlexp	0.2405	0.0322	1.0000			
Dlenerw	-0.0854	-0.0711	0.0789	1.0000		
Dlenerff	0.2460	-0.0585	0.0580	-0.2932	1.0000	
Dlacct	-0.1237	0.0066	-0.0371	0.0203	0.0435	1.0000
VIF		1.01	1.02	1.12	1.11	1.01
Mean VIF				1.05		

Hausman test was designed to understand what type of model, from fixed effect (FE) or random effects (RE), could be the best option to estimate final model. The Hausman test was performed, where the null hypothesis is rejected ($X^2= 49.43$) at a significance level of 1%, which implies that fixed effect (FE) model is the appropriate one. Due to the presence of fixed effects, in order to select the robust estimator, additional specification test were made them being: presence of heteroscedasticity, autocorrelation of the first order,

contemporaneous correlation and cross sectional dependence. To check heteroscedasticity the Modified Wald test was performed. Followed by, Wooldridge test, that was used to verify the existence of first order autocorrelation. The Pesaran test was performed to appraise contemporaneous correlation. Frees and Friedman test are used to analyse the presence or non-presence of cross sectional dependence, this test is ideal for studies with fixed effects. To verify the presence of heteroscedasticity the Wald test was conducted, and the result shows the existence of heterocedasticity because the null hypothesis is rejected at a significance level of 1%.

The specification tests results are showed in table 6. The Wooldridge test reveals autocorrelation of the first order in panel data, existence of contemporaneous correlation was confirmed by Pesaran test. Friedman test there is cross sectional dependence, because the null hypothesis of the test is rejected, and for Frees test the null hypothesis H0 is accepted, which implies that there is sectional dependence. Afterwards the Driscoll Kraay estimator was used, as it can be observe in table 7.

Table 6: Specification test

	Statistics
Pesaran's test	1.657*
Frees	0.036
Friedman	37.921***
Wooldridge test	8.938**

Notes: *** denotes significance at 1% to 10%; the results of the Modified Wald test, Wooldridge test and Pesaran test, are based on Chi-squared distribution, F distribution and standard normal distribution, respectively. The null hypothesis of the modified Wald test. Wooldridge test is autocorrelation of the first order and Pesaran test the existence of contemporaneous correlation.

Table 7: Estimation result

Dependent variable GDPPC	
Model	FE D.K
DLINVT	0.0648879**
DLEXP	0.0498043*
DLENERFF	0.0767485**
LLGDPPC (-1)	-0.1378405***
LLINVT (-1)	0.0448129***
LLACCT (-1)	0.0135667***
LLENERW (-1)	-0.057618***
Constant	1.131105 ***
Diagnostic statistics	
N	220
R2	0.2776
F	28.60

Table 8: Semi elasticities and elasticities

Dependent variable GDPPC	
Model	D.K
Semi-elasticities	
Constant	1.131105***
DLINVT	0.0648879**
DLEXP	0.0498043*
DLENERFF	0.0767485**
Elasticities	
LLINVT (-1)	0.3251072***
LLACCT (-1)	0.0984233***
LLENERW (-1)	-0.4180046***
ECM	-0.1378405***

Notes: ***, ** and * represent a significance level of 1% to 10%, respectively

In order to evaluate the magnitude of the effects, semi elasticities and elasticities were verified. The results presented at table 8 show a positive effect on fossil fuel energy consumption, as well as Export volume index for economic growth on a short run. The results also reveal that the total investment has a positive effect in both short and long term in economic growth. Regarding the Access to electricity variable, it has a positive effect on economic growth on the long run. A different scenario is observed for renewable energy consumption. Indeed, the results suggest that an increase of 1% (one per cent) decreases economic growth by -0.4180046%. This result turns out to be surprising, as for the renewable energy consumption where the biggest sources are the hydroelectric, which are known to be low-cost sources, were the majority.

5. Discussing of Results and Policy recommendations

What really matters to be discussed in this section, are the results of the relation between the renewable and fossil fuel energy consume and economic growth, and the relation between total investment and economic growth. When we talk about the energy consumption, we tend to have the idea of an increase in the economic production.

The result shows that fossil fuel energy consumption gives a positive contribution to the economic growth, even though it is on the short run. This result suggests that the subsidies from G20 countries that finance fossil fuel in some countries, makes the fossil fuel energy consume a boost for economic growth. The fossil fuel energy consumption also contributes to the phenomenon of climate change. Kofi Annan (2015), supports this concept of growth by saying that Africa needs to take up the challenge of embracing a judicious and dynamic energy mix, in which renewable sources will gradually replace all fossil fuels, while building the foundation to a competitive energetic infrastructure and low carbon emission. To continue with carbon emission, would be the equivalent to a climate catastrophe, and consequently the economy will be influenced negatively. Having into account the positive relation between the fossil fuel energy consumption and economic growth. The creation of partnership policies between the SADC states member and the investors and cooperation partners, is important to develop necessary infrastructures projects for the energy consume. Most states have big mineral reserves, from which fuel can be obtain, this potential can be used to increase the electricity production that will decrease significantly the lack of electricity.

The SADC suggests that the nuclear technology can be a safe option of electricity generation and aims to win the population and government trust to support the nuclear energy implementation in the region. Please note that, currently only South Africa has the nuclear capacity. It is important to highlight that fossil fuel sources run out and go through volatile prices. As such, it is necessary to create ways to prevent these variations from affecting negatively on the long run, as in a short run it can conduce to the economic growth effect. Still concerning the energy policies, the fossil fuel sources can be only used as a backup.

The contrary happens to renewable energy that presents a negative effect on the long run. This result turns out being surprising to this study, as most part of the energy consumed in these countries come from hydroelectric, which is not a high cost source. To Ocal and Aslan (2013), the negative effects of the renewable energy are justified by the high cost of these sources, as they force a high investment.

Even though the results are unexpected, this effect already was detected by other authors such as Ocal and Aslan (2013), Bhattacharya et al., (2016) and Marques et al., (2018), that studied the relationship between multiple renewable sources and the economic growth. Results like these, could have been brought by the fact that these countries did not use renewable sources effectively, in the process of production to increase economic production. Most of the existing energy policies emphasize the availability of trustworthy enough and low-cost services and energy. SADC's concern is not only attracting investments and promoting competitiveness, but it is also in the need of environmentally sustainable use of energetic resources. The region has a big potential for renewable energy, as it already has been explored in commercial scale. During drought periods, the energy supply from hydroelectric sources is totally compromised, causing a supply restriction, it is important diversify the renewable sources. Meanwhile the necessary infrastructure to network connection is bad, and in the last years the renewable energy technology costs have been decreasing. It is important to define some policies in the energy sector in order to change this scenario, starting by increasing international partnerships that can bring something innovative to the SADC energy system. Improve the connection infrastructures to energy distribution and consume, though private or government investments is required. Fiscal benefits to promote the use of renewable sources. A strategic plan on a long term to growth the sustainability of the usage of renewable sources, in order to turn the renewable energy consumption in a big ally in economic growth.

Throughout the study it can be verified that many authors have already mentioned the importance that access to electricity would have on economic growth. As expected, this study ends up confirming this mind-set. The bigger the access to electricity, the bigger the GDP per capita. This result shows how important it is that more people have access to energy in these countries to allow the growth on the GDP. Having into account that most of the population in this region does not have access to electricity, it is fundamental to create policies to motivate the access to the electricity grid. One of them would be to support small credit institutions providing loans to the implementation of energy projects suited to each region reality. And the creation of small energy agencies with an independent system for the population with low income, in order to facilitate its installation and payment facilities. A good example of independent systems are photovoltaic solar panels and hybrid systems.

The total investment result shows a positive relation with the economic growth in short and long run. This result is not a surprise, as the investments have a tendency to generate return. What shows how important investments are in developing countries for economic growth.

Concerning investments and financing the SADC countries face some barriers namely: poor projects preparation, low tariffs, as well as limited off takers⁴, that can sign power purchasing agreement under single buyer models and other required policies or regulatory frameworks. Based on the results founded, there is not much to be done concerning energy policies, but it is important to create some policies that can improve professional training and the staff qualification that directly handles investments issues to better prepare the projects. Also there should be a periodic supervision on the ongoing investment projects, conducted by an independent organ.

The export volume index concerns all goods and services exported, and this index analyses the products' external market evolution and price fixing. As observed, a big part of the economy of the countries under the study is supported by agricultural goods exportation and mineral resources. The positive result emphasizes this variable's economic dependency. In the recent years the exportation went through some variations, making the commodities of price fluctuation vulnerable in the global market. Also climate change that this region has been suffering, causing drought and even irregular rains, compromising the agricultural goods exportation. It is necessary to come up with severe climate policies to reduce environmental impact, as for example the effective implementation and the control of the environmental regulation.

Due the limitation to obtain data it is necessary to look at the results with a certain attention and caution taking into consideration this limitation. It is recommended to take this into account on the next investigation in future and more studies are conducted in this subject and that new variables can be included in the studies, in such a way the public political influence in energy production, distribution and consumption in economic growth. For the obtained results it is recommended that at an initial phase a mix of energy generation sources is used, and afterwards replace the fossil fuel sources by the renewable source. It is necessary to create politics that supports existing suppliers in the market and an opening to the entrance of new investments in the energy sector to create start-up.

⁴ An agreement entered between a producer and a buyer to buy/sell a certain amount of the future production. It is generally negotiated long before the construction of a facility to guarantee a market for the facility's future production and improve chances of getting financing for the installation concerned.

6. Conclusions

This study is focused on the relationships between total investments and renewable and fossil fuel energy consumption with economic growth. The countries chosen belong to a specific group located in Southern Africa. It is important to highlight that there are only a few studies done on this group of countries, mainly due to the lack of data. The panel data was subjected to an exhaustive battery of tests with the aim to analyse and to guarantee the use of appropriate estimators. The estimator Driscoll Kraay was used. The ARDL was conducted in an approach to determine the effects on a short and long run. Economic growth is measured by the GDP per capita variable, such as vast majority of literature focused on the energy-growth nexus. The results are enough to sustain that the fossil fuel energy consumption has a positive effect on short run on economic growth. The contrary happens to renewable energy consumption that presents a negative effect on a long run on economic growth, what can also be observed is that, for variable of total investment, there are more contribution for economic growth.

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