EVALUATING THE IMPACT OF ELECTRICITY SUBSIDIES FOR INDUSTRIES IN RWANDA

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Thesis research

Topic: "EVALUATING THE IMPACT OF ELECTRICITY SUBSIDIES FOR INDUSTRIES IN RWANDA"

Declaration

I declare that this thesis is the result of my own work and has not been submitted for any other degree at the University of Rwanda or any other institution.

Valens KUBWIMANA date…………….

Dedication

I dedicate my thesis to my beloved family and friends

Acknowledgements

The cooperation of many contributors to this study is gratefully acknowledged. I acknowledge the various government and private sector institutions that have collaborated in furnishing the information for this report of research project entitled “Evaluating the impact of Electricity subsidies for industries in Rwanda’’

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Thank you.

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Abstract

Electricity one of the forms of energy has proven to be indispensable to improved social and economic welfare and is the most important factor for reducing poverty and raising living standards since it has a direct positive link with industrial production growth. However, its affordability is still a real challenge especially for industrial sector. In Rwanda, in order to support industrial sector, the Government prioritized to offer subsidies to industrial sector by offering low electricity tariffs to industrial customers comparing to other customers. This study evaluates how the consumption of electricity has affected the production of industrial sector from 2005 to 2019. It also examines the impact of electricity subsidies versus industrial output.

In this study, the assessment of such subsidies was undertaken by execution of the complementary F-statistic, Dummy variable and structural break tests using a statistical software STATA.

In fact, according to the empirical outcomes of the study, there is a positive long-run relationship between the consumption of electricity and the production growth within the industries. i.e subsidizing electricity rises electricity consumption and this affects positively the industrial productivity. The study proves that subsidizing electricity for industries in the country causes the industrial productivity to be increased by almost twelve percent.

However, even if the research empirically proves that subsidizing electricity for industries stimulates the production growth, it is alleged that the total expected contribution of such subsidies do not match to the total expected production growth. Therefore, the Government should aim to redesign or amend the subsidization policy by including provisions that should reassure the efficiently use of the offered subsidies to balance their cost with the desired production growth

Key words: Electricity subsidies, industrial production growth

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Acronyms

AFDB: African Development Bank

CAP: Capital formation

EDPRS: Economic Development and Poverty Reduction Strategies

GDP: Gross Domestic Product

IAEA: International Atomic Energy Agency

IELC: Industrial Electricity consumption

IMF: International Monetary Fund

LAF: Labor force

MINICOFIN: Ministry of Finance and Economic Planning

MINICOM: Ministry of Trade and Industry

MININFRA: Ministry of Infrastructure

NST: National Strategy for Transformation

RAM: Rwanda Association of Manufacturers

RDB: Rwanda Development Board

REG: Rwanda Energy Group

RURA: Rwanda Utilities Regulatory Authority

TOP: Trade Openness

UNIDO: United Nation Industrial Development Organization

Executive summary

Energy specifically electricity is fundamental to any country's economy and growth targets. It supports almost all sectors, including, manufacturing, food processing, household, mining, transport and information & technology services. Thus, offering efficient electricity is an essential tool of achieving the national goals for any country. However, its cost may obstruct the achievement of the targeted productivity goals within a given sector. In order to support the achievement of the targeted industrial production, the Government may adopt a subsidization policy.

In Rwanda, financial support given to industries in the form of electricity subsidies to yield their production, exceeds the ones spent on other sectors like health centers, hotels, telecom towers, and sometimes 100 % of government electricity subsidies are allocated to industries (RURA, 2020). However, the results of the policy of subsidizing electricity for industries are not yet examined.

Though electricity subsidies increase industry's productivity and its revenues, we haven't yet explored the efficiency cost of those subsidies.

This research basically focuses on the assessment of the impact of Electricity subsidies for industries in Rwanda.

To assess the impact of Electricity subsidies for industries in Rwanda, appropriate time series model for annually data on average manufacturing value added, industrial electricity consumption, Labor force and capital formation was applied;

We assumed that, an electricity subsidy increases electricity consumption, and we predicted that this kind of subsidy increases electricity demand for industrial activities. Increasing electricity demand for industrial operations generates in turn an increase in industrial production. A statistical software "STATA" was used to evaluate the influence of the subsidized electricity in industries and check if there were any significant changes caused by the subsidization scheme.

This research developed and empirically tested a typical way that defines the level at which these kind of subsidies affect the industrial production. From the empirical results, we found that there is a positive long-run relationship between the consumption of electricity and the growth in production. The results of the study revealed that electricity consumption influences

positively the manufacturing sector output. Furthermore, industrial productivity output after the adoption of the subsidization policy was enough higher than the productivity before the adoption of the policy. Subsequently, the electricity subsidization scheme which was started in 2015 contribute positively on industrial productivity growth especially from 2016. Nevertheless, the increase of industrial production due to subsidies do not correspond to the total cost of such subsidies as expected.

In addition, in 2012 it was observed a structural break which implies an increase in the industrial production output because of the electricity consumption. But the production growth in 2012 had no relationship with the electricity subsidization which started in 2015. But the break that occurred in 2012 was influenced by several critical policy interventions and strategies that were adopted and implemented during that period aiming at reducing the dependence on products from abroad. Those strategies include the National Industrial policy which was adopted in 2011. The enforcement of the said policy was focused on making operational the energy productive uses called udukiriro.

CHAPTER ONE: INTRODUCTION

1.1 Background

Energy plays an important role in the growth and development process of any country. Particularly access to electricity like other modern energy has proved to be a certainly necessary key to completely revolutionize people's lives and fast-track the country's development in general. Electricity as essential to improved social and economic welfare is a key for reducing poverty and raising living standard as it supports in almost all other sectors.

Adequate and sustainable electricity facilities have been proven to be essential to making incomes and to transformation from traditional unindustrialized economies style to prevalent industrialized and service-oriented society. Providing sustainable electricity access to the population is considered a prerequisite to modernization and progress. However, high price of electricity becomes a big challenge to achieving the targets set by industrial sectors everywhere in the world. It is in this regard that many countries adopted energy subsidization policies to support their industrial sectors to achieve the projected production outcomes.

Different literatures show that the global energy subsidies were 0.7 percent of global GDP in 2011 and 2013 this include 0.2 % of electricity subsidies alone, while in 2015 was 0.4 percent of global GDP including 0.15% of electricity (IMF Working Paper, 2015).

In Rwanda, The Government has initiated different programs that could contribute to the citizens' lives improvement such as educational grants, solar water heater systems, solar photovoltaic, Biogas program, health insurance, subsidization of agricultural activities (seeds, pesticides), health strategies like nutritional complements and vaccination plans (MINICOM, 2012). Many studies assessed the impact of such subsidized programs and found that some of these agendas attained their expected objectives at the expense of efficiency but one dominant industrial promoter –electricity subsidies for industries has been overlooked that is why in this research, we evaluated the effect such ignored grants (electricity subsidies for industries).

According to the Ministry of Finance, Rwanda' economic development and the achievement of the goals that were set out in the Vision 2020 relied on industrial development. As stipulated in the Vision 2020 and the Economic Development and Poverty Reduction Strategy (EDPRS II), the extensive goals of Rwanda Industrial Policy were to create and build the transformational industrial growth that would make Rwanda regionally and internationally competitive. Besides accessibility of electricity at reasonable price to citizens and electricity productive users will support the delivery of Vision 2050 to achieve high income status (MINICOFIN, 2012).

To provide affordable and standard infrastructure, including electricity service, was among the four core driving force for the manufacturing sector development in Rwanda. The aim of that strategy was to increase the revenues by achieving the per capita GDP of $900 by 2020 (equivalent to eight percent of GDP growth rate on average per annum), initiate the structural transformation of the sector to contribute at 26% in the GDP by 2020, and enhance job creation to 1.4million of new employment (MINIFRA, 2018).

To ease investments, the Government of Rwanda adopted a policy of subsidizing industries and other big investment projects by offering electricity low price to industrial customers compared to non-residential electricity customers. From 2005 the electricity tariff for industrial customers was separated from tariff for non-industrial customers and their prices from 2007 to 2011 lowered at 6% compared to non-industrial customers, 3% from 2012 to 2013, a reduction of 18% was observed in 2014. Alike in September 1st 2015, the Rwanda Utilities Regulatory Authority (RURA) launched a tariff framework for electricity whereby for the medium voltage rates/industrial customers the tariff was Frw 126 per kilowatt-hour, while for non-residential customers the tariff was Frw182 per kilowatt-hour (the reduction of 31%). Furthermore, the electricity end-user tariff launched in January 2020 shows an incredible difference between industrial customers and non-residential customers' tariffs Frw 94 and Frw 255 per kilowatt-hour respectively (RURA, 2020). These differences between industries and non-residential customers' tariff rose from electricity subsidies offered to industries. It is in this regard that this research aims to measure the effectiveness of such subsidies policy and evaluate the significance of changes brought about by that policy

1.2 Objectives of the study

In this research, we measure the extent to which electricity subsidies influence industry's production. It determines empirical evidence of the impact to which electricity demand caused by subsidies responds to a change in industries productivity output.

The specific objective of this research is to assess and demonstrate

1. the impact and necessity of electricity subsidies on industrial production growth in the country;

This research analyzes the level/status and main challenges and evaluates the effectiveness of such policy as a Government transfer, then finally recommendations are provided to policy makers on where and when to allocate such subsidies.

1.3 Research questions

This thesis has addressed the following sub questions to achieve the main objective of this research.:

1. Is there any long-run relationship between electricity consumption and industrial productivity or production?
2. Does total cost of subsidies match the actual benefits nexus expected production growth?
3. Do electricity subsidies contribute positively or negatively to industrial growth?

1.4 Significance of the study

The results of this study can help to analyze the level/status and main challenges, calculate the cost to society caused by the inefficient allocation of such subsidies or determination of their success as the Government grants.

This research provides recommendations to policy makers on where and when to allocate such subsidies and monitor the correlation between the consumption of electricity and industrial productivity

The study' findings provide guidance on the preparation of action plans of various actions related to the allocation of subsidies.

Also from this research, the country may learn the lessons of the past with regard to electricity sustainability while exploring options for the future.

This study will instigate the development of regulatory tools that encourage the improvement of efficient electricity use like power saving policies. It is also of both academic and realistic significance to analyze and acknowledge the bond between the consumption of electricity and the production growth of industries.

For who will go through this report, will get the necessary scope of national databases and some important statistics on electricity and industrial productivity situation in Rwanda.

1.5 Scope and limitation

The scheme of industries subsidization was adopted in order to yield the industries' productivity and attract investment within the sector. This research was conducted in order to determine the impact of electricity subsidies offered to industries to achieving national development goals and targets for the benefit of all citizens. Considering that the effect of other poverty alleviation programs except electricity subsidies for industries have been looked at; this research focused on this unnoticed industrial supporter scheme. However, because of the time constraint, instead of looking at huge indicators, it mainly focused on evaluating the relationship between the production of industries represented by manufacturing value added per GDP and other key factors that influence the productivity of industries especially electricity consumption in industries, Labor force and capital formation. This research evaluated the effect of such subsidies vis a vis electricity consumption, industry productivity and the industrial sector growth status.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Energy plays an important role in the growth and development process of any country. Particularly, the use of electricity makes it to be an essential booster of modern technology and socio-economic development. It is used at high levels for industrial activities that contribute to economic value-added products. It is also used at low levels for devices such as lights and mobile phones, computers, etc. and all of these activities resulting to the job creation. Subsequently, there exist many literatures examining the fundamental relationship between the consumption of electricity and the increase in industrial production but few literatures have looked at the impact caused by subsidizing electricity for industries to yield their production. In addition, many of the studies on the linkage between the consumption of electricity and the manufacturing output provide dissimilar results and have not been conclusive, especially on the direction of that relationship. This may be due to differences in situations of the country, data quality or the econometric method used (Abokyi & Isaiah, 2018).

The promotion of socioeconomic development needs availability of energy that includes electricity in particular as a vibrant promoter. Increase in industrial electricity consumption is a key indicator of a country's economic development according to J.Mawejje and D.N.Mawejje, 2016. This means that, the direct evidence of economy improvement of any country is level of electricity consumption in that country (IAEA, 1999). The amount of empirical researches and policy interest on electricity consumption that have been conducted over the historical many years, make a confirmation of the vital role of that type of energy in the economic growth and industrial development (J.E.Payne, 2010).

Rwanda manufacturing industry is still small but growing as it contributed about 17 % to the country's GDP in 2019 (RDB, 2019). The sector is characterized by gradual diversification from basic manufacturing to more value-adding activities in other sub-sectors. During the fiscal year 2013/2014, the industrial sector has raised by 6 percent (MINECOFIN), while during 2012/2013 fiscal year, the sector grew by 6 percent (RAM). It is to be noted that during those periods and before, the Rwandan economic system was severely dependent on imported products. To reduce such dependence, the Government of Rwanda developed and adopted different policies and programs such as the national industrial policy which was adopted in 2011, Made in Rwanda Policy which was adopted in 2015. This policy is a complete roadmap with the objective to encourage competitiveness and people satisfaction through the enhancement of local market and inspiring the exploitation of domestic resources and value chain development (AFDB, 2013). According to NST1 2017-2024, the above policy on the promotion of industrial sector, emphasis was put on the development of the country's economy by the private sector for not only the production growth but also for job creation favorably in sectors like manufacturing, tourism, agro-processing and knowledge-based services and ICT (MBONIGABA, 2019). In addition, as indicated by RDB reports, Entrepreneurship Development Policy (EDP), SEZ policy, the Domestic Market Recapturing Strategy (DMRS), the National Export Strategy, Small and Medium Enterprises (SMEs) Development Policy, the National Export Strategy and Cross Border trade strategy were developed and adopted among other developed policies (RDB).

However, according to Rwanda Development Board (RDB), agro-processing in Rwanda is a successful sector that contributes up to a third of Rwanda's GDP.

2.2 Brief on Rwandan Energy sector

Rwanda 's energy balance indicates that about 85% of the overall primary energy consumption is based on biomass. 99% of all households use biomass for cooking, the consumption of petroleum and related products that include diesel, kerosene and liquefied petroleum gas (LPG) computes 13percent of the total energy consumed in the country. These categories of energy are mainly used for transport, electricity generation and industrial use. Electricity accounts for only 2% of total energy consumed in the country (MINIFRA, 2018).

The figure bellow shows the energy consumption level per each form of energy

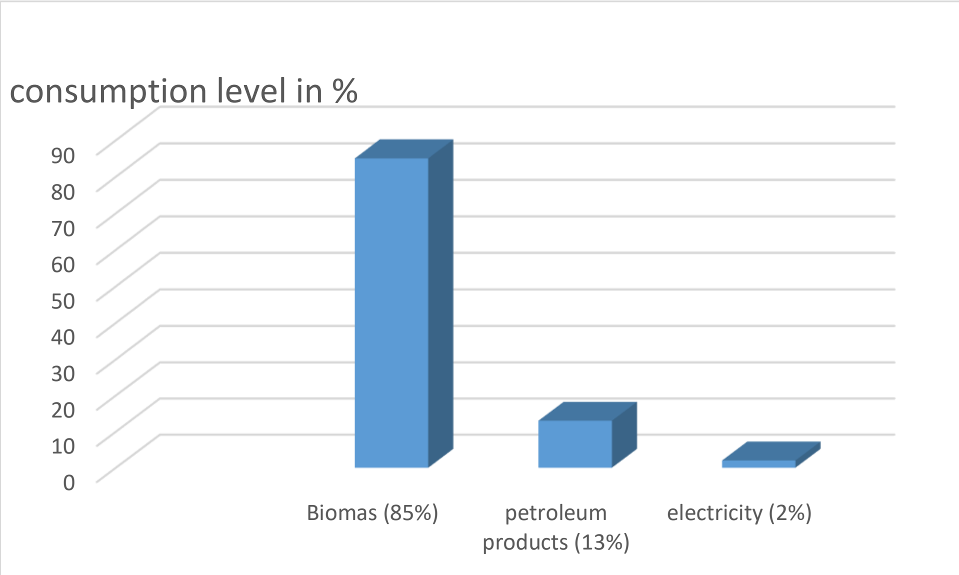

Figure 1: Energy consumption level per type of energy form

Energy consumed in households is the largest compared to energy consumption for other sectors. households' consumption accounts 82% of all energy consumed in the country whereas transport sector consumes 8%, industries 6% and others consume 4%.

Regarding the electricity sub sector, as of 2020 the total available capacity was 238 MW (REG, 2020). Regarding the accessibility of electricity, up to December 2020 households with access to electricity was 59.7% (REG, 2020). However, the government's target is 100% of households with access to electricity and all productive users get connected to electricity from the current level of 72%. This target was set to be achieved by 2024 (MININFRA, 2018).

In addition, as productive users play a significant role in the economy growth, the government has to improve the sustainability of such kind of sector by keeping connecting productive users especially those located away from cities in order to support rural economic development.

Up to 2020 electricity generation capacity was 218MW from more than forty power plants, mainly hydropower compared to 160 MW as of 2016. Among 238.36 MW of the available capacity, only 1.62% is imported from DRC and Uganda while the rest is locally generated (REG, 2020).
Apart from the increase in generation capacity, the technology mix has also been varied where 45.17% of total installed capacity is from hydrological resources, diesel & HFO 26.76%, Lake Kivu natural (methane) gas makes up 13.89%, peat 6.94%, solar generates 5.59% and 1.62% is imported (energypedia.info).

The figure below provides brief information on the Rwandan electricity generation technology mix:

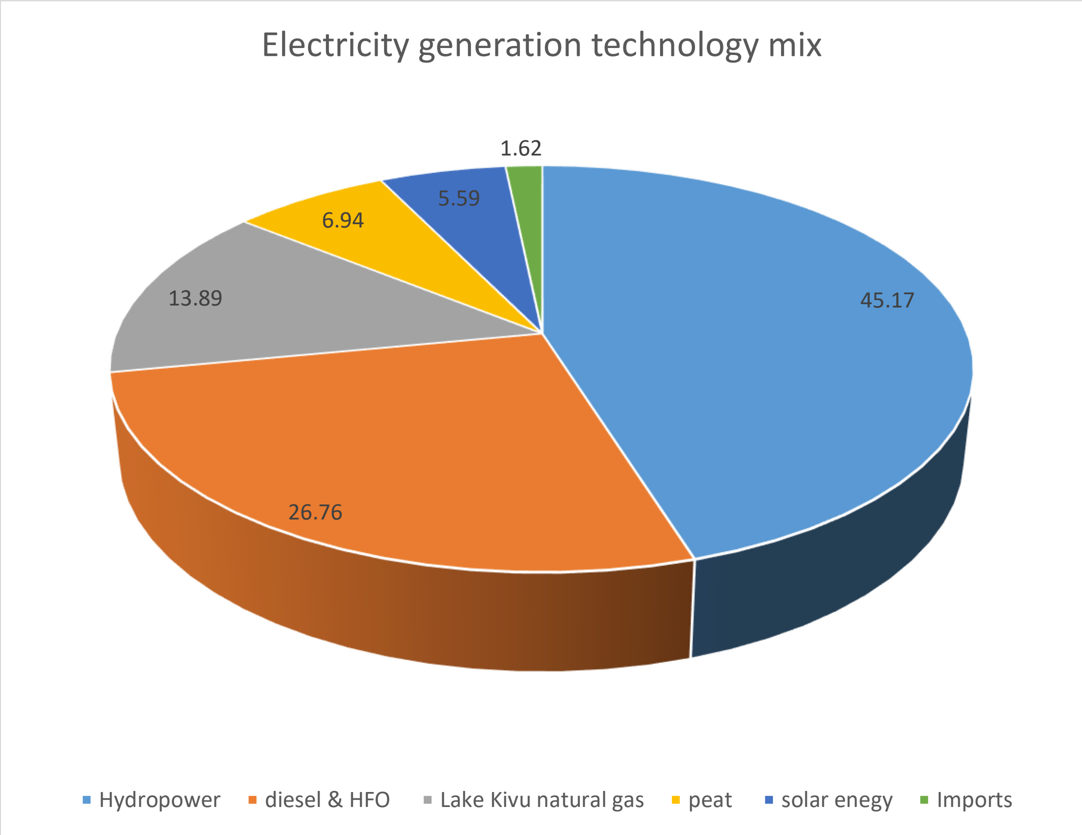

Figure 2:Electricity generation technology mix in Rwanda

On the side of electricity consumption, it is noticeable that households are the largest electricity consumer category where it consumes up to 51% of all available electricity, with lighting the primary use on the average of 10Kwh in rural and 29 kWh for urban areas. The industrial sector consumes 42% of total electricity consumption while the rest consumption of 7% is for powering of public buildings, street lighting and water pumping as public sector (Mudaheranwa, Ye-Obong & Liana)

As of 2019, the total household's connections were 1,371,950 that include on-grid connections of 1,021,734, and off- grid connections of 350,216 (REG, 2019). To achieve the present targets of 100% households with access to electricity by 2024 while all productive users including industries have to be all connected before the end of 2022, REG anticipates to rise the number of new connections by 500,000 every year that includes 200,000 on-grid connections.

2.3 Electricity Tariff in Rwanda

According to Energy Information Agency (EIA), a "Energy Tariff" is the pricing structure a retailer charges a customer for energy consumption. Therefore, an electricity tariff is the price unit at which electricity is sold and it is measured in rate per kilowatt hour of power consumed (kWh).

The Rwanda Utility Regulatory Authority (RURA), responsible for regulating certain public utilities, in its mandate has to make adjustment of tariffs when deemed necessary and control service providers including electricity sub sector.

RURA prior to deciding on tariffs 'amendments and enforcing any charges to the service provider, has to consider the involved producing and supplying cost, the return on assets in the electricity sector, interest of both parties (investor and consumer), and ensure that the promoted tariff is competitive and do not create barrier to anyone of the beneficiaries but encouraging the market growth (RURA, 2019);

For the above reasons, RURA carries out regular tariffs review in which the new pricing regime has to be adjusted and tariffs are different for different types of consumers due to offered supports. Nevertheless, electricity subsidies are offered to industries for not only encouragement of non-peak usage but also to help the industries' owners to boost up the productivity and sometimes all money preserved for electricity subsidization scheme are allocated to industries only (case of 2018-2019 all 10.5 Billion Frw of Government subsidies were allocated to industries. See table 1).

Table 1: Government electricity subsidies allocation in 2018/2019

Total subsidies	10,500,000,000				
Customer category	**Targeted allocated subsidies**		**Resulting Subsidy**	**Resulting Tariff**	
	%	**million of Frw**	**Frw/kWh**	**Frw/Khw**	**$Cents/Kwh**
Residential	0.00	-	0.000	185	20
Non Residential	0.00	-	0.000	243	27
WTP & WPS	0.00	-	0.000	126	14

Telecom towers	0.00	-	0.000	201	22
Hotels	0.00	-	0.000	201	22
Health Facilities	0.00	-	0.000	201	22
Broadcasters(TVs and Radios)	0.00	-	0.000	201	22
Small industries	4.00	420,000,000.00	56.104	146	16
Medium Industries	15.00	1,575,000,000.00	53.992	132	14
Large Industries	81.00	8,505,000,000.00	55.838	113	12

The tariff methodology consists of determining the base period tariff by looking at revenue requirements including the necessary incentives and benchmarks to induce the utility to reduce costs. The base tariff is set so that the forecast revenue will cover the forecast operating and capital costs over the tariff period (MININFRA, 2018).

The tariff prices are usually computed using the financial and tariff models developed to determine tariff for each segment of the industry (generation, transmission, and distribution/retail). The tariff results for each segment are then combined to determine the end-user tariff, based on the cost of supply to each customer or tariff class (REG, 2020).

In the determination of the Tariffs, the Regulatory Authority considers macroeconomic parameters for the previous years where some of technical, economic and financial factors such as energy mix, technical losses, correction rate, inflation, tariff adjustment and exchange rate have to be taken into consideration (MININFRA, 2018):

The following table provides a summarized statement on electricity price computed by customer categories

Table 2:Electricity price by customer categories

Period	Electricity Price (Frw/Kwh)												
	Residential			Non-Residential		WTP&WPS	Hotels	Health Facilities	Telecom Towers	Broadcasters	industries		
	[0-15]	]15-50[	>50	[0-100]	>100						small	Medium	Large
1995	17	17	17	17	17	17	17	17	17	17	17	17	17
1996	17	17	17	17	17	17	17	17	17	17	17	17	17
1997	42	42	42	42	42	42	42	42	42	42	42	42	42
1998	42	42	42	42	42	42	42	42	42	42	42	42	42
1999	42	42	42	42	42	42	42	42	42	42	42	42	42
2000	42	42	42	42	42	42	42	42	42	42	42	42	42
2001	42	42	42	42	42	42	42	42	42	42	42	42	42
2002	42	42	42	42	42	42	42	42	42	42	42	42	42
2003	42	42	42	42	42	42	42	42	42	42	42	42	42
2004	42	42	42	42	42	42	42	42	42	42	42	42	42
2005	81.26	81.26	81.26	81.26	81.26	81.26	81.26	81.26	81.26	81.26	81.26	81.26	81.26
2006	112	112	112	112	112	112	112	112	112	112	112	112	112
2007	112	112	112	112	112	112	112	112	112	112	105	105	105
2008	112	112	112	112	112	112	112	112	112	112	105	105	105
2009	112	112	112	112	112	112	112	112	112	112	105	105	105
2010	112	112	112	112	112	112	112	112	112	112	105	105	105
2011	112	112	112	112	112	112	112	112	112	112	105	105	105

2012	134	134	134	134	134	134	134	134	134	134	130	130	130
2013	134	134	134	134	134	134	134	134	134	134	130	130	130
2014	158	158	158	158	158	158	158	158	158	158	130	130	130
2015	182	182	182	182	182	182	182	182	182	182	126	126	126
2016	182	182	182	182	182	182	182	182	182	182	126	126	126
2017	89.00	182.00	189.00	189.00	192.00	126.00	189.00	192.00	126.00	192.00	126.00	90.00	83.00
2018	89.00	182.00	210.00	204.00	222.00	126.00	126.00	192.00	185.00	184.00	110.00	87.00	80.00
2019	89.00	182.00	210.00	204.00	222.00	126.00	126.00	192.00	185.00	184.00	110.00	87.00	80.00

Source : RURA report 2017, RURA Board’s decisions, REG and NISR

2.4 Electricity price in Rwandan compared to neighboring countries

In East African countries, Rwanda has the highest price of electricity for households compared to other countries but due to the offered subsidies to business activities, the price of electricity for business activities is low compared to the price of electricity in neighboring countries as shown in the table 2.

The globalpetrolprices.com report indicates that as of June 2020, in Rwanda residential electricity price was 0.258$ per Kwh and 0.096 $ for businesses which includes all components of the electricity bill such as the cost of power, distribution and taxes. This information shows that, the Rwandan electricity price for residential is high compared to the World's average price of 0.139 $ per kWh for households for that period, while for business activities Rwanda had low price (0.096 $) compared to the average price of electricity of 0.123 $ in the World for businesses activities.

For households, the exposed number is calculated at the average annual level of household electricity consumption. For businesses, the displayed data point uses 1,000,000 kWh annual consumption (globalpetrolprices.com).

In fact, while more than half of Rwandans have access to electricity in their home, the cost of electricity is the highest in the region

Table 3: prices of electricity in east African countries

Country	**Price of electricity ($/Kwh)**	
	households	businesses
Rwanda	0.258	0.096
Burundi	**-**	**-**
Kenya	0.201	0.161
Tanzania	0.099	0.102
Uganda	0.185	0.156
DRC	0.062	0.099

The underlying connection between the consumption of electricity in industrial sector and productivity output is not yet proven by the existing studies. Therefore, such relationship is analyzed in the following sections of this research in the case of Rwanda especially when the increase in electricity consumption was motivated by subsidies.

Table 4:electricity consumption per category of consumer

	Category of consumer				
	Residential		**Industrial**		**Non-residential**
period	**Consumption level (Kwh)**	**Consumption price (Frw/ Kwh)**	**Consumption level (Kwh)**	**Consumption price (Frw/ Kwh)**	**Consumption price in Frw per Kwh**
2005		81.26	47,664,683	81.26	81.26
2006		112	38,298,301	112	112
2007	147,884,021	112	54462243	105	112
2008	167,360,693	112	58,002,979	105	112
2009	190, 105,864	112	55, 506,267	105	112
2010	223,528,205	112	63, 057,665	105	112
2011	258,674,075	112	67, 733,083	105	112
2012	302,086,071	134	77, 384,985	130	134
2013	309,324,238	134	78, 734,160	130	134
2014	355,355,136	158	82900654	130	158
2015	233,300,604	182	96259936	126	182
2016		182	98858954	126	182
2017	142,341,521	153	149,418,381	86.5	190.2
2018	106,038,835	160	148,157,018.50	83.5	213
2019		160		83.5	213

Source: Statistical yearbooks of NISR (2010-2019)

Considering that in 2018/2019 with the subsidies of 10.5billions shared at 100% to the industries, which means that it caused an increase in electricity consumption. However, many Studies on the fundamental link between electricity consumption and economic growth have been conducted and dissimilar results were exposed: (Abokyi & Isaiah, 2018) have been exposed but most of them revealed that there exists a relationship between electricity consumption and industrial production growth.

In different studies, the results were obtained by using different methods such as the ARDL method, Pedroni, Kao, Johansen co-integration tests, Johansen co-integration test and Granger causality, etc.

Considering that in our case, the hypothesis is that manufacturing output increases with electricity consumption increase due to electricity subsidies, to test the in between long-run relationship; we employed the complimentary Chow, dummy variable and F-tests to investigate whether parameters slopes and the intercepts of our data before the subsidization scheme are different from those of the data after the subsidization scheme. It examines whether there is a structural break among data.

CHAPTER THREE: RESEARCH METHODOGY

3.1 introduction

In this section, the impact of industrial electricity subsidies on industrial production growth is assessed using three interdependent tests namely structural break, dummy variable and F-statistic tests to investigate whether industrial production growth before the implementation of a subsidization scheme is different from the production growth after the subsidization scheme. We examine whether there is a structural break among data.

This section is focused on an application of the proposed methodology to the variables described above in order to produce the existing relationship between them and determine the period when the break occurred.

3.2 Methodology

This study is descriptive in nature by the fact that it involves the analysis of quantifiable data.

Thought; electricity subsidies increase electricity consumption, we predicted that electricity subsidies for industrial production increase electricity demand for such industries and the increase of electricity demand generate an increase in production as well as revenues.

Since the study examined the fundamental linkage electricity consumption and manufacturing output growth in Rwanda, the model which made predictions on the connection of the variation in the consumption of electricity and how it affects production of industries was estimated.

The estimated econometric model is an industrial production (manufacturing value-added per GDP) model. Our model made predictions of how variation in electricity consumption affects productivity of industrial sector.

We first connected the hypothetical framework to the analytical approach and afterward, a strategy to test the predictions of model was formed and pursued

The time series data that are used in this research cover the period from 2005 to 2019. This period was taken because of data on electricity consumption for industries (IELC) exist for this period only while Manufacturing value added (MNF) data, Trade openness (TOP), Labor force (LAF) and Gross capital formation (CAF) are available even before the period under study.

Upon the acquisition of data, a statistical computer based program used to analysis the time-series oriented econometric data, ‘’Stata’’ was used to manage data, make statistical analysis, perform simulations & regression and to estimate the model.

Since the data on annual basis were available since 2005 to 2019 especially data for industrial electricity consumption and this caused to have less observations, in order to have enough observations required by stata software, we converted annual time series data into quarterly data and the conversion was performed using another statistical computer based program called Eviews.

To evaluate the impact of electricity subsidization scheme for industries, we performed complementary three tests namely the Chow or F statistic test, dummy variable and structural break tests because the aim of this research was to compare the output of industrial sector before the scheme of subsidization was put in implementation (before 2015) and the output of such industrial sector after the implementation of such subsidization scheme (from 2015).

3.3 Source of data

The research data set were collected in different sources such as literatures and review of relevant documents from the different institutions that collect and compile statistics, consultation with policy makers and other relevant stakeholder. Some data were collected from different statistical year books of the national Institute of statistics (NISR), World Bank Development Indicators (2020) as well as International Energy Agency which are updated on monthly basis.

3.4 Theoretical framework

Anticipating that electricity subsidies increase electricity consumption, we predicted that electricity subsidies for industrial production increase electricity demand for such industries and the increase of electricity demand could generate an increase in production as well as revenues. Therefore, to evaluate the impact of electricity, we first computed the relationship between consumption of electricity in industries and industrial production which is represented by manufacturing value added indicator. Considering that, the production of an industry doesn't depend on electricity consumption as the only one variable, there is a need to consider other prominent variables. Therefore, for further determination of impact of electricity consumption on productivity of industry sector in Rwanda, there had been a consideration of other variables, that is why this research addressed the following variables while predicting the econometric model:

3.4.1 Manufacturing value added (MNF)

According to the UNIDO, MNF of an economy is taken as the net production of the industries resulting from the difference of gross output and intermediate consumption. As in our research we took into consideration into the entire manufacturing sector therefore, the manufacturing value added of the whole industrial sector is theoretically, the sum of the production value added of all manufacturing activities. In this research the above mentioned value is computed as a percentage of GDP and it is a dependent variable in our model

3.4.2 Industrial Electricity consumption (IELC)

Electricity consumption is the form of energy consumption that uses electric energy. in fact, it is based on the calculated consumption whereby it equals the electric energy supplied minus transmission and distribution losses. Therefore, industrial electricity consumption is all quantities of electric energy consumed in industrial sector. It considers the net electricity consumed for the operations of industries and it is measured in Kwh.

3.4.3 Trade openness (TOP)

The trade openness is the ratio of the value of all imports and exports by the gross domestic product. It measures the level at which a country is involved in the international trading arrangement.

3.4.4 Labor force participation rate (LAF)

According to the International Labor Organization (ILO), Labor force participation rate is the group of working population have the age between 16-64 in the economy already being employed or looking for employment but excluding homemakers and full time students. It is the group of people who work for the production of goods and services in an identified period. In fact, the labor force participation rate is the measure of estimating working-age in an economy.

3.4.5 Capital formation (CAF)

Capital formation also called investment; is a measure of the net increases to the real capital business of an economic sector of the country in a narrative interval. It may be also defined as the amount by which the entire real capital stock improved during a computing period.

3.5 Description of Data

This work is aimed at evaluating the impact of the electricity price (subsidized electricity price) to industrial production. The corresponding data are annually time-series. The data used in this study cover the period from January 2005 to December 2019 with a total of 15 observations

Because of data on consumption of electricity in industries (IELC) are available from 2005 only, while other data on Manufacturing value added (MNF), Trade openness (TOP), Labor force (LAF) and Gross capital formation (CAF) are available even before the period under study, this study uses annual time series from 2005 to 2019.

Upon the acquisition of data, a statistical computer based program used to analysis the time-series oriented econometric data, ''Stata'' was used to manage data, make statistical analysis, graphics, perform simulations & regression and to estimate the model.

We tested the fundamental relationship between electricity consumption and industrial production growth in Rwanda. In this research, industrial production means response variable or dependent variable while consumption of electricity is one of the independent variables.

Since the data on annual basis were available since 2005 to 2019 especially data for industrial electricity consumption which made to have less observations, thus, in order to have enough observations that are required by stata software, we have converted annual time series data into quarterly data and the conversion was done using another statistical computer based program called Eviews.

This section presents an industrial production (represented by the percentage of manufacturing value-added per GDP) model. our model makes predictions of how variation in the electricity consumption affects production growth of industrial sector.

Anticipating that electricity subsidies increase electricity consumption, we predicted that electricity subsidies for industrial production increase electricity demand for such industries and the increase of electricity demand will generate an increase in production as well as revenues. Therefore, to evaluate the impact of electricity, we first computed the relationship between consumption of electricity (ELC) and Industrial production which is represented by manufacturing value added indicator (MNF)

3.6. Variables

3.6.1 Dependent variable

Dependent variable is variable that depends on the other factors called independent variables. In fact, the dependent variable is considered to see if and how much it varies as the independent variables vary. In this research the dependent variable is "*Manufacturing value added*" which representing industrial production growth.

3.6.2 Independent variables

Independent variable is a variable that stays or stands alone without being changed by the other variables somebody is trying to measure. Actually, when checking if there exists a relationship between variables, it means that someone is trying to check if the independent variable causes a kind of change in the other variables called dependent variables. It is to be noted that independent variable causes a change in dependent Variable nevertheless, it is not possible that dependent Variable can cause a change in independent Variables.

In this study, the following are independent variables that have been considered:

a. Industrial Electricity consumption (IELC)
b. Trade openness (TOP)
c. Labor force participation rate (LAF)
d. Capital formation (CAF)

3.7 Values of variables

3.7.1 Values of variables on annual basis

In Rwanda electricity charges per customer category or segregating consumer by category was taken into consideration from 2005, which means that before the period of 2005 all customers were charged the same amount on one Kwh consumed (refer to the table 2). From 2005 consumer categories (Industries, residential, non-residential, water treatment plants, hotels, Health Facilities, Telecom Towers and Broadcasters) began receiving different electricity charges. Moreover, in 2015 some of these categories of consumers especially industries started getting subsidies in order to yield their productivity (as shown in table 1 allocation of subsidies 2018/2019)

Considering that information on electricity charges by consumer category are available from 2005, we have chosen the period from 2005 to 2019 to examine the relevance of subsidies offered to industries from 2015 compared to the period before 2015 when industries were not offered such subsidies. Data on industrial electricity consumption were sourced from the Nation Institute for Statistics of Rwanda while other data on manufacturing value added, Trade openness were obtained from the World Bank national accounts data, and OECD National Accounts data files whereas , capital formation and Labour force are sourced from International Labour Organization, ILOSTAT database. Values of variables under this study are specified in table I.1 of Annex I of this report.

3.7.2 Values of variables in logarithm transformation

To manage the situation of the enormous changes in sizes due to units of measurement and in order to reduce heteroskedasticity, we included natural logarithm transformation.

Values of variables and steps that resulted to have values in logarithm transformation are shown in annex I.3 of this report.

3.8 Modeling

3.8.1 Mathematical model

The following equation provides the mathematical correlation between electricity consumption and industrial production output:

$logMNFt = \alpha 0 + \alpha 1 \log ILCt + \vartheta Xt + \varepsilon t$ ... ...(Equ.1) (Holmes, Illowsky & Susan, 2019)

It is important to note that other parameters like trade openness, labor force participation and capital formation influence production too, they could be taken into consideration in order to avoid simultaneity bias (D.Gujarati, 1995).

We assumed that these variables influence industrial production. Therefore, an increase in the above variables (trade openness, labor force, and capital formation) also increase the productivity of industries.

Hence; $X_t = f$ ($\log TOP_t$, $\log LAF_t$, $\log CAF_t$) ………. (equ.2)

Subsisting (equ.2) into (equ. 1) we have (equ.3)

$\log MNF_t = \alpha_0 + \alpha_1 \log ELC_t + \alpha_2 \log TOP_t + \alpha_3 \log LAF_t + \alpha_4 \log CAF_t + \varepsilon_t$ …………………(equ. 3)

3.8.2 designation of variables

$\log MNF$ is the natural logarithm of manufacturing which is dependent variable in this research.

$\boldsymbol{\alpha_0}$ is a constant,

$\log IELC$ represents the natural logarithm of electricity consumption in industries;

$\boldsymbol{\varepsilon}$ refers to the error correction term, and

$\boldsymbol{X}$ denotes other macroeconomic characteristics that influence the increase of productivity.

$\log TOP$ is the natural logarithm of trade openness;

$\log LAF$ symbolizes labor force in natural logarithm transformation form

$\log CAP$ represents capital formation in natural logarithm transformation form.

α_1, α_2, α_3 and α_4 are o elasticity coefficients.

3.8.3 Restricted model

Considering the following econometric model:

$Y_t = \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} + \alpha_3 x_{3t} + \alpha_4 x_{4t} + \varepsilon_t$

Restricted model presumes that α_5, α_6, α_7, α_8 and α_9 all are equal to zero and if all these five coefficients are equal to zero that means that the restricted specification is to be Y as a function of X1, X2, X3 and X4; hence,

$Y = \alpha o + \alpha 1X1 + \alpha 2X2 + \alpha 3X3 + \alpha 4X4 + \varepsilon$ ……… restricted

or

$\log MNF_t = \alpha_0 + \alpha_1 \log ELC_t + \alpha_2 \log TOP_t + \alpha_3 \log LAF_t + \alpha_4 \log CAF_t + \varepsilon_t$...... restricted

Therefore, our Ho null hypothesis is $a_5=a_6=a_7=a_8=a_9=0$ if all are zero it means that the restricted model is better specification. Thus, in the case of Ho we choose the restricted.

Ho: $\alpha_5=\alpha_6= \alpha_7= \alpha_8 =\alpha_9=0$ restricted- nonstructural break

In restricted specification, we use an ordinary F test where the null hypothesis to be tested is that the coefficients are equal in the two samples and are presumed to be equal to zero. it means that the restricted model is better specification in the case of the Ho.

To test the null hypothesis to agree if there is no structural break, we have to test for statistical significance as another way of saying that the probability of value (*p*-value) of a statistical test is small enough to reject the null hypothesis of the test.

It is to be noted that the probability value or P-value informs how likely the observed data is to have occurred under the null hypothesis. It means that if the p-value is below the chosen threshold of significance (normally $p < 0.01$, $p < 0.05$ or $p < 0.001$), then the null hypothesis is rejected, but it does not automatically mean that the alternative hypothesis is true.

Considering that in numerous literatures, the most common threshold which is also known as alpha value is 0.05; it is why in our study we preferred to use the threshold of 5%

3.8.4 Unrestricted model

It is the model which includes independent variables X1, X2, X3, X4 but also it includes a dummy variable that allows for a change in the constant and to interact variables to slope variables.

We have, either α_5, α_6, α_7, α_8 and α_9 are not equal to zero. It means that unrestricted specification is preferred. Then it is H1 in the alternative hypothesis which says that there is a structural break.

Therefore, the econometric model is as follows:

$Y_t = \alpha_0 + \alpha_1 x_{1t} + \alpha_2 x_{2t} + \alpha_3 x_{3t} + \alpha_4 x_{4t} + \alpha_5 D + \alpha_6 x_1 Dt + \alpha_7 x_2 D_t + \alpha_8 x_3 D_{4t} + \alpha_9 x D_5 + \varepsilon_t$…..unrestricted

H1: either $\alpha_5 \neq \alpha_6 \neq \alpha_7 \neq \alpha_8 \neq \alpha_9 \neq 0$ unrestricted- there is structural break

In this study Y= logMNF

X1= logIELC

X2= logCAF

X3=logLAF

X4= logTOP

Rejecting the null hypothesis for restricted specification doesn't mean that the alternative hypothesis H1 is true; that is why we proceeded to test the alternative hypothesis where unrestricted model has to be regressed by considering both independent variables X1, X2, X3, X4 and also a dummy variable. The alternative relaxes that by adding a group dummy multiplied by each regressor there are twice as many coefficients. By regressing the unrestricted model, the following is the displayed ANNOVA table from which we conclude whether to not consider the null hypothesis but to consider the other hypothesis which says that there is a structural break.

3.8.5 interactive variables in modeling

It is also possible to use the interaction between electricity consumption and dummy variable in order to check the variation of elasticity of dependent variable before and after the break point.

Therefore, the interactive variable interaction industrial electricity consumption dummy2016 has to be created whereby once we executed we had new variable and it took value zero where dummy is zero and different values for the remaining observations where dummy is different from zero

3.9. Test for break

3.9.1 Structural breaks

If we choose unrestricted version in order words if we choose to include dummy variables X1D, X2D, X3D and X4D, it implies that the model presents a significant improvement in the residual sum of squares once we control for differences in the slope and differences in the constant. Hence, having choosing the unrestricted model is equivalent to saying that there is a structural break while having choosing the restricted model means that we do not include either a control for the constant or the slop. It is equivalent to saying that there is no a structural break. Therefore, we have to run these two models in stata:

The first way requires to estimate both models where estimating restricted model is needed and also estimating by inclusion of dummy variables is also needed.

3.9.2 F-statistic

We used Chow test or F-statistic test to compare the situation of industrial productivity before the electricity subsidies scheme was implemented (before the period 2015) and the industrial productivity after the implementation of such subsidies from the period of 2015. This means that if the structural break existed, it could be occurred after the period of 2015.

Therefore; we want to examine whether splitting data into two groups could bring changes between the two periods. It is in this regard that the Chow test examines the Residual Sum of Squares (RSS)

If F –statistic is significant, the null hypothesis of no break point is rejected

Ho= no structural break

H1= there is structural break

The Chow test is an F-test with F-statistic. To check if the drop is statistically significant we computed F-statistic using the following equation and compare both critical values (estimated F and F- critical at 5% level)

$$F = \frac{(RSSr-RSSu)/q}{RSSu/(n-k)}$$

RSSr is the residual sum of squares for restricted model

RSSu is the residual sum of squares for unrestricted model

q is the number of constant and coefficients for independent variables or total number of restrictions

n is the number of observations

k= number of parameters in unrestricted model

In this study, k is equal to one constant and four coefficients for four independent variables which means that k=5 and

n=60, the number of observations (on quarterly basis)

Chow test is a test of whether the true coefficients in two linear regressions on different data sets are equal. the Chow test is often used to determine whether the independent variables have different impacts on different subgroups of the population. It is used to test for the presence of a structural break at a period which can be assumed to be known *a priori*.

3.9.3 Dummy variable in modelling

To estimate unrestricted specification model, the inclusion of dummy variables is needed.

In statistics and econometrics especially in regression analysis, a dummy variable is one that takes only the value 0 or 1 to indicate the absence or presence of some categorical effect that may be expected to shift the outcome. A dummy variable is an independent variable or dummy explanatory variable which for some observation has a value of 0 and will cause that variable's coefficient to have no role in influencing the dependent variable, whereas when the dummy takes a value 1 its coefficient acts to adjust the intercept. Even if the dummy variable has some limitations like to accommodate only quantitative response and explanatory variables but it is useful because it enables the researcher to use a single regression equation to represent multiple groups. Dummy variable is incorporated in the same way as independent or explanatory variable is included in regression models.

The following are the commands that were run to generate dummy variables.

gen qdate=yq(Year , Quarter)

format qdate %tq

tsset qdate, quarterly

gen d2=0

replace d2=1 if Year>=2015

replace d2=1 if Year >=2015

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

4.1 Introduction

To check if electricity subsidization scheme has an impact on industrial productivity output, we used three complementally tests namely structural break, dummy variable and chow (or F-test) tests. The chow test or F-test is based on the difference between the residual sum of squares (RSS's) from the constrained and unconstrained regressions.

4.1 Descriptive statistics of the variables

This section gives the summary of the characteristics of our data set. It gives an information on the mean, median, and mode as the measures of central tendency and an information on minimum and maximum variables as measures of variability.

Analysis of our data reveals that the Rwandan industries' net output which was computed as a ratio of GDP is 2.05858 on avarage and the minimum output is 1.92 while the maximumu output is 2.2 as indicated in table II.1 of annex II of this report.

The results from our study provide that industries in Rwanda consume 18.32Kwh of electricity on avarage whereby the minimum consumption is 17.46 Kwh while the maximumu consumption is 20.48Kwh.

The extent to which a country is engaged in the global trading system (the ration of aggregate value of imports and exports over the gross domestic product for the same period) is 3.73 on average, the minimum is 3.56 while the maximum is 3.98

The outcomes of our study show that the average of the percentage of working population (in the age group of 16-64 years old) within a Rwandan industrial manufacturing economy is 4.43. The minimum is 4.427 while the maximum is 4.44

The results also revealed that the average of the net increases to the physical capital business per GDP is 3.06 and the minimum is 2.71 while the maximum is 3.298

4.2 Significance of variables

To select variables to be used in the model with regard to their relevance, we tested for statistical significance of our variables within our data set in order to verify how strongly our desired independent variables should influence our dependent variable. To test the likelihood that a relationship between our independent variables (industrial electricity consumption in industries, labor force, capital formation and trade openness variables) and dependent variable (industrial production output) in our analysis is not purely accidental and also to prove that our independent variables are reliable, we regress our model as follows and test for the significance of the variables:

Table 5: Regression table of test for significance of variables

regress logMNF logIELC logCAF logLAF logTOP				
logMNF	coef.	t	p>|t|	
logIELC	0.34261	3.11	0.003	
logCAF	-0.308	-3.36	0.001	
logLAF	28.79372	3.81	0.000	
logTOP	0.138661	0.71	0.481	
constant	-131.408	-3.75	0.000	
number of observations				60
R-squered				0.6446
Adj R-squared				0.6188

The results displayed in the above table show that the probability of values for Industrial electricity consumption, labor force, and capital formation variables (0.003, 000 and 0.001 respectively) are less than the selected threshold of 5% which means that they are statistically significant; while for the trade openness variable, the test rejects its significance since its probability value is greater than the selected threshold of 5%. In addition, from the t- distribution critical value table at five percent of significance level, thought there are sixty observations, the t- critical value is 2.000 while the displayed absolute value for t- statistic values of 3.11, 3.36 and 3.75 (for the independent variables specifically Industrial electricity consumption, Capital formation and Labor force respectively) are greater than the critical value of 2.000. Thus our three independent variables Industrial electricity consumption, labor force, and capital formation are statistically significant and are consistent to be considered in the model. The intercept for the regression line is justified by the coefficient on the constant term -131.408 which is obviously large and significant. It is the default predicted value of dependent variable manufacturing value added.

Also in our regression, the R squared of 0.6446 or 64.5% (which measures the goodness of fit of the regression model) shows that there is a good relationship between the model and the Manufacturing value added as the dependent variable. It means that the difference between the observations and the fitted or predicted values are small and unbiased.

4.3 Impact of electricity consumption on industrial production output

on the side of electricity consumption in industries, the results from the regression table reveal the existence of relationship between manufacturing productivity and electricity consumption. the findings confirm that industrial sector relies on electricity; it equally reveals that electricity consumption increases with manufacturing productivity.

4.3.1 Test of structural break with known date

Since the implementation of electricity subsidization policy was started in 2015, we assumed that the structural break could occurred in any period of time after 2015. It means that the break dates are known and can be found in the periods between 2015 and 2019. This break can be tested using the stata with the structural break with a known break date command. To determine if at a known time a structural break has been occurred, the following command has been used for the periods of time within the subsidization scheme period.

Assuming that the break is fixed in the first quarter of 2015, the test is as follows:

estat sbknown, break(time[41]) breakvars(logIELC)

Where (time [41]) means the first quarter of 2015 and by running the above command, the results displayed in the table below gives that the test accepts the null hypothesis at selected threshold of 5% which says that there no structural break.

```
.  estat sbknown, break( 41) breakvars( logIELC)

Wald test for a structural break: Known break date

                                  Number of obs  =         60
Sample:      1 - 60
Break date:  41
Ho: No structural break

             chi2(1)      =    2.7132
             Prob > chi2  =    0.0995

Exogenous variables:           logIELC logCAF logLAF
Coefficients included in test: logIELC

.
```

To determine if the overall model is statistically significant, the probability of obtaining the chi-square statistic (Prob > chi2) which is taken as the probability value (p-value) was compared to critical value or threshold of 0.05.

The probability value (Prob > chi2) is the probability of obtaining the chi-square statistic given that the null hypothesis is true. In other words, it is the probability of obtaining this chi-square statistic (chi1) if there is no effect of the independent variables taken together on the dependent variable.

In this study, the model is statistically significant when the p-value (Prob > chi2) is equal to 0.000 or the probability value is less than the selected threshold of 5%.

Therefore, since (Prob > chi2) of 0.0995 is greater than the preferred threshold of 0.05, the test accepts the null hypothesis which says there is no structural break in the first quarter of 2015. The same for all other quarters of 2015 the probability values are greater than the threshold and as conclusion there is no structure break in 2015.

By assuming that the break is fixed in the first quarter of 2016, the test is as follows:

estat sbknown, break(45) breakvars(logIELC)

Wald test for a structural break: Known break date

Number of obs = 60

Sample: 1 - 60

Break date: 45

Ho: No structural break

chi2(1) = 16.4230

Prob > chi2 = 0.0001

Exogenous variables : logIELC logCAF logLAF

Coefficients included in test: logIELC

The above results indicate that the test rejects the null hypothesis with the significance of thresholds 1% and 5%. The Prob > chi2 of 0.0001 is less than the threshold of 0.01 and 0.05, thus, there is a structural break from the 45th quarter i.e. the first quarter of 2016. As conclusion, we find that there exists a break point in 2016 which means that the structural break started from 2016 one year after the implementation of the policy.

i. Impact of electricity consumption on industrial production before the 45th quarter

To statistically prove the influence of electricity consumption before the subsidization scheme on industrial productivity, we regress the subsets of our samples before the break occurred in the first quarter of 2016 which means 44 observations. Therefore, the following regression was performed to check the relationship between industrial production output and industrial electricity consumption:

Table 6: Electricity consumption VS Productivity before the break point

regress logMNF logIELC logCAF logLAF if Year<2016

logMNF	coef.	t	p>|t|	[95% Conf. Interval]
logIELC	0.187408	2.04	0.048	
logCAF	-0.06135	-0.63	0.532	
logLAF	33.32991	5.93	0.000	

Number of obs = 44
Prob > F = 0.0000
R-squared = 0.8155

Considering that the R-squared of 0.8155 is fairly high, it shows that the model is generally fit and statistically significant as the Prob > F = 0.0000.

STATA automatically conducts an F-test, testing the null hypothesis that there is no influence of our independent variables to dependent variable, with the Prob > F = 0.0000, we reject this null hypothesis with extremely high confidence above 99.99% and confirm that the independent variables influence our dependent variable.

Therefore, the effect of electricity consumption on industrial productivity before 2016 is justified by the coefficient of 0.187 and it shows that electricity consumption affects positively the production of industries.

It means that the results reveal that before the first quarter of 2016, the elasticity of industrial productivity with respect to consumption of electricity was 0.187 which means that before quarter one of 2016, the 1% increase in the consumption of electricity leads to 0.187% increase in manufacturing productivity.

ii. Impact of electricity consumption on industrial production output after the 45th quarter

To empirically test the influence of electricity consumption in the period from the first quarter of 2016, we regress the subsets of our samples taking into consideration that the break had occurred from the first quarter of 2016 and above (twelve observations). Therefore, the following regression was performed to check the relationship between industrial electricity consumption and manufacturing output after the break date:

Table 7: Productivity VS electricity consumption after the break point

regress logMNF logIELC logCAF logLAF if Year>=2016

logMNF	coef.	t	p>|t|	[95% Conf. Interval]
logIELC	-0.16516	-20.3	0.000	
logCAF	0.23552	18.98	0.000	
logLAF	-87.8481	-59.11	0.000	
_cons	393.367	58.38	0.000	
Number of obs = 16				
Prob > F = 0.0000				
R-squared = 0.9991				
Adj R-squared = 0.9988				

From the analysis we find that the elasticity of manufacturing productivity with respect to the consumption of electricity after the break point in the first quarter of 2016 is – 0.165 which means that the consumption's increase of 1% of electricity leads to the decrease of the manufacturing productivity by 0.165%. Disappointingly, this assumption is challenging probably because of the sample only twelve observations after the break is not enough large that is why we proceed with other tests.

4.3.2 Use of dummy variable with break identified in 2016

In our research dummy variable is used to differentiate productivity after and before the break occurs. Therefore, the following results are displayed from regressing our model that includes dummy variable:

Table 8: Regression that includes dummy

regress logMNF logIELC logCAF logLAF DUMMY2016

logMNF	coef.	t	p>|t|	[95% Conf. Interval]
logIELC	0.290003	4.38	0.000	
logCAF	-0.13122	-1.53	0.133	
logLAF	35.64091	6.16	0.000	
DUMMY2016	0.115723	4.01	0.000	
Number of obs = 60				
Prob > F = 0.0000				
R-squared = 0.7224				
Adj R-squared = 0.7022				

Subsequent to the results, we see that the probability value 0.000 for dummy2016 is less than the threshold of 0.05, hence, dummy variable is statistically significant to influence the decision on the hypothesis which means that it shows a break period from 2016 quarter 1. In other words, the coefficient of the dummy variable shows that after 2016 quarter 1, the manufacturing productivity is enough higher than the manufacturing productivity before that period of 2016 quarter 1. Taking into consideration that, the R-squared of 0.7224 or adjusted R squared of 0.7022 are objectively high, it means that the model is generally fit and statistically significant as the Prob > F = 0.0000.

Thus, the use of the dummy variable is conclusive. The break of 2016 quarter 1 is affirmative, it tells that there is a positive change in the industrial production output caused by subsidizing electricity for industries.

The dummy coefficient of 0.115723 implies that, there is a difference of 11.6% of increase in industrial production output after the implementation of electricity subsidization scheme compared to the production output before the subsidization scheme. While the coefficient of 0.290003 implies that after the subsidization policy, the elasticity of industrial productivity with respect to consumption of electricity was 0.29 with subsidies, the 1% increase in the consumption of electricity leads to 0.29% increase in manufacturing productivity.

The decision on the use of dummy variable is supported by the use of the interaction between electricity consumption and dummy variable to compare the production elasticity before and after the break point.

Table 9: Regression that includes interaction dummy

regress logMNF logIELC logCAF logLAF interactionIELCDUMMY2016

logMNF	coef.	t	p>|t|	[95% Conf. Interval]
logIELC	0.284784	4.29	0.000	
logCAF	-0.12679	-1.47	0.147	
logLAF	35.56045	6.17	0.000	
interactionIELCDUMMY2016	0.006327	4.05	0.000	
Number of obs = 60				
Prob > F = 0.0000				
R-squared = 0.7238				

From the above regression table, the values 0.7238 of R-squared and 0.7038 of adjusted R squared are tangibly high to make the model normally fit and considering that the Prob > F = 0.0000 along with t values of 4.29 and 4.05 for industrial electricity consumption and interaction dummy variables respectively are greater that the t - critical value of 2; we insure that these two variables are statistically significant.

Thus, the interactionIELCDUMMY2016 coefficient of 0.0063269 indicates that the production elasticity increases by 0.63% after the first quarter of 2016 compared to the elasticity of production before the first quarter of 2016. (i.e It was 0.285 before first quarter of 2016 plus 0.0063 of increase due to the given subsidies and resulting to 0.2913 of production elasticity after the break (2016 quarter1). An increase in consumption of electricity by 1% leads to the industrial production increase of 0.2913% after the break date; while this increase of 1% in consumption of electricity leads to the manufacturing production increase of 0.285% before the break date or without subsidies.

4.3.3 F statistic test or chow test

As it is mentioned in the previous chapters, the chow test or F-statistic test is based on the difference between the residual sum of squares (RSS's) from the constrained and unconstrained regressions where the following formula has to be executed:

$$F = \frac{\left(RSS_R - RSS_{UR}\right)/\left(k-1\right)}{RSS_{UR}/\left(n-2k\right)}$$

Considering that from the regression as indicated in tables II.2 and II.3 of Annex II, the residual sum of squares for restricted specification RSSr is 0.173907366 while the residual sum of squares for unrestricted specification is 0.134621502 and considering that k= 3, n=60. Therefore, our F-statistic is

$$F=\frac{(0.173907366\text{-}0.134621501)/(3-1)}{0.134621501/(60-6)}$$

$$F=\frac{(0.039285865)/2}{0.00249299}=\frac{0.0196429325}{0.00249299}$$

$$F=7.8792665$$

Thus, the calculated F or F statistic is higher than the critical value of 3.18 (from the F table); the null hypothesis which says that there is no structural break is rejected in favor of the alternative hypothesis which says that there is a structural break. Hence, the conclusion is that, from the model there is a structural break.

In addition, while testing the structural break with unknown date, the command "estat sbsingle, breakvars(X)" was used and the results are shown in the table II.4 of annex II where X is selected considering the period of subsidization of electricity consumption.

The results reveal that there is a structural break which occurred in the second quarter of 2012. However, this break is not due to electricity subsidies but it is in line with electricity consumption since by testing all other variables (labor force and capital formation) we find that there are not statistically significant to influence industrial production output for that period (see the test results in table II.5 of Annex II).

To check the validity of our test results on the availability of break in the second quarter of 2012, we regressed the subset of samples and regression results are displayed in table II.6 of Annex II.

These results indicate that the coefficient of industrial electricity consumption is positive for the two subsets of the sample. Before the second quarter of 2012 (or 30^{th} quarter), the coefficient of independent variable industrial electricity consumption is 0.288, meaning that the 1% increase in the consumption of electricity leads to 0.288% increase in the manufacturing productivity.

After quarter two of 2012 (including that quarter), the coefficient of independent variable industrial electricity consumption is 0.305, meaning that the 1% increase in the consumption of electricity leads to 0.305% increase in the manufacturing productivity. Which means that there is an increase in elasticity of 0.017 (i.e 0.305-0.288=0.017). This break has not the relationship with the electricity subsidization, which began in 2015. The break that occurred in 2012 was influenced by several critical policy interventions and strategies that were adopted and implemented during that period aiming at reducing the dependence on products from abroad. Those strategies include the National Industrial policy which was adopted in 2011. The enforcement of the said policy was put on making operational the energy productive uses called udukiriro and this made the contribution of the manufacturing sector to rose to 12% in the 2012/2013 compared to 6% in 2011 (RAM).

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 introduction

The whole study focused on analyzing the relationship between manufacturing value added as industrial production output and electricity consumption along with other variables labor force and capital formation for the period from 2005 to 2019. We used three complementary methodological approaches: the first one is structural break test which determines if there is a structural break to enable to perform the comparison of the productivity output between the two periods (before and after the implementation of subsidization scheme). The test results reveal that there is a structural break from the first quarter of 2016. Before 2016, the one percent increase in the consumption of electricity led to 0.187% increase of manufacturing productivity while after the first quarter of 2016, the electricity consumption's increase of one percent led to the decrease of the manufacturing productivity by 0.165%. The inference from this test alone is challenging probably because the sample after the break is not enough large reason why we proceeded for other approaches.

The second approach is Dummy variable approach which determines if the manufacturing productivity after the break period was enough higher than the manufacturing productivity before the break period (i.e first quarter of 2016). The coefficient of the dummy variable from the test ascertains that the manufacturing productivity after the break period was enough higher than the manufacturing productivity before that period. An increase in consumption of electricity by one percent leads to the manufacturing production increase of 0.2913% after the break date while this increase in electricity consumption leads to the manufacturing production increase of 0.285% before the break date.

The last approach is F-statistic which was used to confirm the existence of structural break. With this test, the null hypothesis is rejected in the favor of the alternative hypothesis since the calculated F is higher than the critical F. Therefore, the result is that there is a structural break.

In fact, the results reveal that there exists a positive relationship between manufacturing productivity and electricity consumption. i.e electricity consumption increases the manufacturing productivity output which means that industrial sector relies on electricity.

Finally, the findings of the study prove that subsidizing electricity for industries in the country causes the industrial productivity to be increased by almost twelve percent either 11.6% whereby an increase of one percent in electricity consumption due to the subsidization policy causes the elasticity of production to be increased by 0.63%. This means that even if these subsidies lead to the increase of productivity, the total expected contribution for such subsidies do not correspond to the total actual benefits or to the expected production growth.

5.2 Recommendations

Even if the research empirically proves that subsidizing electricity for industries stimulates the production growth, it is alleged that the total expected contribution of such subsidies do not match to the total expected production growth. Therefore, the Government should aim to redesign or amend the subsidization policy by including provisions that should reassure the efficiently use of the offered subsidies to balance their cost with the desired production growth.

Enforcement of the above recommendation, will assist the policy makers to limit subsidies and electricity usage for industries whose electricity consumption does not improve their production growth.

For future researches, in order to examine and have a summary of status, main issues, trends of the electricity consumption and allocated subsidies vis a vis industrial production development, the concerned institutions are urged to make available all relevant data for each energy productive user.

REFERENCES

1. Rwanda Utilities Regulatory Authority (2020), Press release for New Electricity End -User tariffs retrieved from https://www.reg.rw/fileadmin/user_upload/Press_release_for_Electricity_Tariffs.pdf
2. Ministry of Trade and Industry (2012). Industry and Entrepreneurship Development. Retrieved from http://www.minicom.gov.rw/index.php?id=146
3. Ministry of Finance and Economic Planning (2012). Rwanda Vision 2020 Revised 2012. Retrieved from http://www.minecofin.gov.rw/fileadmin/templates/documents/NDPR/Vision_2020_.pdf
4. IMF Working Paper (2015). How Large Are Global Energy Subsidies? Prepared by David Coady, Ian Parry, Louis Sears, and Baoping Shang. Retrieved from https://www.imf.org/en/Publications/WP/Issues/2016/12/31/How-Large-Are-Global-Energy-Subsidies-42940
5. Ministry of Infrastructure (Sept 2018), Energy sector strategic plan 2018/19 - 2023/24. Retrieved from https://www.reg.rw/fileadmin/user_upload/Final_ESSP.pdf
6. Rwanda Utilities Regulatory Authority (Jan, 2020). Press release for New electricity End-user tariff, retrieved from https://rura.rw/fileadmin/publication/Press_release_for_Electricity_Tariffs.pdf
7. United Nation Industrial Development Organization (UNIDO). What is manufacturing value added? Retrieved from: https://stat.unido.org
8. Eric Abokyi, Paul Appiah-Konadu, Isaiah Sikayena, and Eric F. Oteng-Abayie, Jun, 2018 Journal of Energy: Consumption of Electricity and Industrial Growth in the Case of Ghana. Retrieved from https://www.hindawi.com/journals/jen/2018/8924835/
9. J. Mawejje and D.N.Mawejje (Aug, 2016) : Journal of Economic Structures,vol.5,no.1,articleno.21,2016. Electricity consumption and sectoral output in Uganda: an empirical investigation. Retrieved from https://www.researchgate.net/publication/305805051_Electricity_consumption_and_sectoral_output_in_Uganda_an_empirical_investigation
10. I. Vera, L. Langlois, H.-H. Rogner International Atomic Energy Agency (IAEA), 1999. Indicators for sustainable energy development https://www.un.org/esa/sustdev/publications/energy_indicators/chapter2.pdf
11. J.E.Payne, 2010, A survey of the electricity consumption growth literature, “Applied Energy,vol.87,no.3,pp.723–731,2010 https://www.sciencedirect.com/science/article/abs/pii/S0306261909002748#!

12. Rwanda Development Board (RDB, 2019). Manufacturing sector. Retrieved from http://rdb.rw/export/export/products-directory/manufacturing-sector
13. Rwanda Association of Manufacturers (RAM), Overview of Rwandan Manufacturing Industry. Retrieved from http://www.ram.org.rw/?page_id=253
14. African Development Bank Group (2013). Rwanda Energy Sector Review and Action Plan 2013. Retrieved from https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and Operations/Rwanda__Energy_Sector_Review_and_Action_Plan.pdf
15. Dr. MBONIGABA Celestin (Dec, 2019) International journal of Engineering Technology Research and Management (IJETRM): Made in Rwanda trading policy and their effect on performance of textile industries in Rwanda analysis of its pillars. Retrieved from https://www.researchgate.net/publication/338169878_made_in_rwanda_trading_policy_and_their_effect_on_performance_of_textile_industries_in_rwanda_analysis_of_its_pillars
16. Rwanda Development Board (RDB). Overview-Investment opportunities. Retrieved from https://rdb.rw/investment-opportunities/manufacturing/
17. MININFRA (2018): 2016-2017 Infrastructure sector annual report: Retrieved from https://www.mininfra.gov.rw/fileadmin/user_upload/Mininfra/Publications/Reports/2016-2017_Infrastructure_sector__Annual_report.pdf
18. Rwanda Energy Group (REG, *Dec 2020*): Facts and figures details. Installed Generation capacity on the National Grid. Retrieved from https://www.reg.rw/facts-figures/facts-figures-details/facts/installed-generation-capacity-on the-national-grid/
19. Rwanda Energy Group (REG, *Dec 2020*): Facts and figures details. Percentage of households with access to electricity. Retrieved from https://www.reg.rw/facts-figures/facts-figures-details/facts/of-households-with-access-to-electricity/
20. Ministry of Infrastructure. Energy Sector Strategic Plan 2018/19-2023/24 (Sep 2018) retrieved from https://www.reg.rw/fileadmin/user_upload/Final_ESSP.pdf
21. Rwanda Energy Group (REG, *Dec 2020*): Facts and figures details. Installed Generation capacity on the National Grid. Retrieved from https://www.reg.rw/facts-figures/facts-figures-details/facts/installed-generation-capacity-on the-national-grid/
22. Rwanda Energy situation. Retrieved https://energypedia.info/wiki/Rwanda_Energy_Situation
23. Mudaheranwa, Ye-Obong & Liana. Centre for Integrated Renewable Energy Generation and Supply Cardif University Cardiff, UK. Rwanda’s Energy Profile and Potential Renewable Energy Resources Mapping toward Sustainable Development Goals. Retrieved from http://orca.cf.ac.uk/123115/1/Cipcigan%20L%20%20Rwanda%27s%20energy%20profile%20....pdf

24. Rwanda Energy Group (REG, 2019) Off Grid Electricity Access Expansion Programs in Rwanda; 5th Mini Grids Action Learning Event. Retrieved from https://atainsights.com/wp-content/uploads/2019/06/9
25. Ministry of Infrastructure: Cabinet brief, July 2018, Ministry of Infrastructure
26. Rwanda Energy Group (REG, 2020): Electricity tariffs, as reviewed by the RURA Board of Directors in its decision N°01/BD/ER-EWS/RURA/2020 are effective from 21st January 2020. Retrieved from https://www.reg.rw/customer-service/tariffs/
27. Republic of Rwanda, Ministry of Infrastructure: cabinet brief, July 2018: Electricity end User tariff
28. globalpetrolprices.com: Electricity prices retrieved from https://www.globalpetrolprices.com/electricity_prices/
29. Eric Abokyi, Paul Appiah-Konadu, Isaiah Sikayena, and Eric F. Oteng-Abayie, Jun, 2018 Journal of Energy: Consumption of Electricity and Industrial Growth in the Case of Ghana. Retrieved from https://www.hindawi.com/journals/jen/2018/8924835/
30. D.Gujarati Basic Econometrics, Mcgraw-Hill, NewYork,1995
31. Wikipedia, the free encyclopedia: Stata. Retrieved from https://en.wikipedia.org/wiki/Stata
32. Alexander Holmes, Barbara Illowsky and Susan Dean, 2019: Introductory Business Statistics-The Regression Equation. Retrieved from https://opentextbc.ca/introbusinessstatopenstax/

ANNEXES

Annex I: **Summary of values of variables**

Table I.1: values of variables under study

Period	**Industrial Electricity consumption IELC (Kwh)**	**Manufacturing value added-MNF (% of GDP)MNF (% GDP)**	**Trade openness TOP (% of GDP)**	**Labor force- LAF (% of active population)**	**Capital formation-CAP (% of GDP)**
2005	47664683	9.04564022	35.884865	84.893997	15.1511596
2006	38298301	8.18858661	35.121822	84.787003	15.0265722
2007	54462243	7.99013845	38.290458	84.708	16.7922035
2008	58002979	8.03094934	39.623733	84.644997	21.3461037
2009	55506267	8.32068739	39.117189	84.577003	21.0175079
2010	63057665	8.4437539	39.470578	84.488998	20.5330251
2011	67733083	8.36664438	41.678277	84.403	20.8998259
2012	77384985	6.89255995	42.527127	84.291	23.3011746
2013	78734160	6.89814348	44.677024	84.151001	24.4305676
2014	82900654	6.93567557	37.327333	83.984001	23.2265379
2015	96259938	6.81520109	41.86134	83.920998	24.2343109
2016	98858954	7.67786631	40.811422	83.823997	25.6705844
2017	149418381	7.55145372	50.511019	83.755997	23.8350302
2018	148157019	8.19292758	49.48682	83.668999	22.6196464
2019	152157258	8.626714	53.661383	83.654999	27.0547024

Source: World Bank national accounts data, and OECD National Accounts data files and International Labour Organization, ILOSTAT database. Data retrieved in June 21, 2020

Table I. 2: value of variables on quarterly basis

Year	Quarter	MNF	IELC	CAF	LAF	TOP
2005	1	9.688432	54689469.5	15.24458	84.9475	36.45714
2005	2	9.474168	52347874	15.21344	84.9475	36.26638
2005	3	9.259904	50006278.5	15.1823	84.92075	36.07562
2005	4	9.04564	47664683	15.15116	84.894	35.88486
2006	1	8.831377	45323087.5	15.12001	84.86725	35.6941
2006	2	8.617113	42981492	15.08887	84.8405	35.50334
2006	3	8.40285	40639896.5	15.05772	84.81375	35.31258
2006	4	8.188587	38298301	15.02657	84.787	35.12182
2007	1	8.138975	42339286.5	15.46798	84.76725	35.91398
2007	2	8.089363	46380272	15.90939	84.7475	36.70614
2007	3	8.03975	50421257.5	16.3508	84.72775	37.4983
2007	4	7.990138	54462243	16.7922	84.708	38.29046
2008	1	8.000341	55347427	17.93068	84.69225	38.62378
2008	2	8.010544	56232611	19.06915	84.6765	38.9571
2008	3	8.020747	57117795	20.20763	84.66075	39.29041
2008	4	8.030949	58002979	21.3461	84.645	39.62373
2009	1	8.103384	57378801	21.26395	84.628	39.4971
2009	2	8.175818	56754623	21.18181	84.611	39.37046
2009	3	8.248253	56130445	21.09966	84.594	39.24383
2009	4	8.320687	55506267	21.01751	84.577	39.11719
2010	1	8.351454	57394116.5	20.89639	84.555	39.20554
2010	2	8.382221	59281966	20.77527	84.533	39.29388
2010	3	8.412987	61169815.5	20.65415	84.511	39.38223
2010	4	8.443754	63057665	20.53303	84.489	39.47058
2011	1	8.424477	64226519.5	20.62473	84.4675	40.0225
2011	2	8.405199	65395374	20.71643	84.446	40.57443
2011	3	8.385922	66564228.5	20.80813	84.4245	41.12635
2011	4	8.366644	67733083	20.89983	84.403	41.67828
2012	1	7.998123	70146058.5	21.50016	84.375	41.89049
2012	2	7.629602	72559034	22.1005	84.347	42.1027
2012	3	7.261081	74972009.5	22.70084	84.319	42.31491
2012	4	6.89256	77384985	23.30117	84.291	42.52713
2013	1	6.893956	77722278.75	23.58352	84.256	43.0646
2013	2	6.895352	78059572.5	23.86587	84.221	43.60208
2013	3	6.896748	78396866.25	24.14822	84.186	44.13955
2013	4	6.898143	78734160	24.43057	84.151	44.67702
2014	1	6.907527	79775783.5	24.12956	84.10925	42.8396
2014	2	6.91691	80817407	23.82855	84.0675	41.00218
2014	3	6.926293	81859030.5	23.52755	84.02575	39.16476
2014	4	6.935676	82900654	23.22654	83.984	37.32733
2015	1	6.905557	86240475	23.47848	83.96825	38.46083

2015	2	6.875438	89580296	23.73042	83.9525	39.59434
2015	3	6.84532	92920117	23.98237	83.93675	40.72784
2015	4	6.815201	96259938	24.23431	83.921	41.86134
2016	1	7.030867	96909692	24.59338	83.89675	41.59886
2016	2	7.246534	97559446	24.95245	83.8725	41.33638
2016	3	7.4622	98209200	25.31152	83.84825	41.0739
2016	4	7.677866	98858954	25.67058	83.824	40.81142
2017	1	7.646263	111498810.8	25.2117	83.807	43.23632
2017	2	7.61466	124138667.5	24.75281	83.79	45.66122
2017	3	7.583057	136778524.3	24.29392	83.773	48.08612
2017	4	7.551454	149418381	23.83503	83.756	50.51102
2018	1	7.711822	149103040.5	23.53118	83.73425	50.25497
2018	2	7.872191	148787700	23.22734	83.7125	49.99892
2018	3	8.032559	148472359.5	22.92349	83.69075	49.74287
2018	4	8.192928	148157019	22.61965	83.669	49.48682
2019	1	8.301374	149157078.8	23.72841	83.6655	50.53046
2019	2	8.409821	150157138.5	24.83717	83.662	51.5741
2019	3	8.518267	151157198.3	25.94594	83.6585	52.61774
2019	4	8.626714	152157258	27.0547	83.655	53.66138

Table I. 3: steps and values of variables in logarithm transformation

Data were imported to the stata software, variables were also labeled according to their significances and logarithm transformation was generated using generate command where logarithm of each variable was generated by the following command gen logvariable=log(variable)

import excel "F:\Valens local disk\Documents\personal\Msc Eco Reg 2018-2019\Thesis\Ref for thesis\2quarterly data 02.03.21.xls", sheet ("quarterly data 02.03.21") firstrow

label variable Year "time on yearly basis"

label variable Quarter "time on quarterly basis"

label variable MNF "Manufacturing value added (% of GDP)"

label variable IELC "Industrial electricity consumption (Kwh)"

label variable CAF "Capital formation (%of GDP)"

label variable LAF "Labor force participation (% of total active population)"

label variable TOP "Trade openness (%of GDP)"

gen logMNF=log(MNF)

gen logIELC=log(IELC)

gen logCAF=log(CAF)

gen logLAF=log(LAF)

gen logTOP=log(TOP)

Year	Quarter	logMNF	logIELC	logCAF	logLAF	logTOP
2005	1	2.270933	17.81718	2.724224	4.442033	3.596137
2005	2	2.248569	17.77342	2.722179	4.442033	3.590891
2005	3	2.225694	17.72766	2.72013	4.441719	3.585617
2005	4	2.202283	17.6797	2.718077	4.441403	3.580316
2006	1	2.178311	17.62933	2.716019	4.441088	3.574986
2006	2	2.15375	17.57628	2.713957	4.440773	3.569627
2006	3	2.128571	17.52026	2.711891	4.440458	3.564239
2006	4	2.102741	17.46092	2.70982	4.440142	3.558823
2007	1	2.096664	17.56123	2.738772	4.439909	3.581127
2007	2	2.09055	17.65238	2.766909	4.439676	3.602944
2007	3	2.084398	17.73592	2.794276	4.439443	3.624295
2007	4	2.078208	17.81302	2.820915	4.43921	3.645201
2008	1	2.079484	17.82914	2.886513	4.439024	3.653868
2008	2	2.080759	17.84501	2.948072	4.438838	3.662461
2008	3	2.082031	17.86063	3.00606	4.438652	3.670981
2008	4	2.083303	17.87601	3.060869	4.438466	3.679428
2009	1	2.092282	17.86518	3.057013	4.438265	3.676227
2009	2	2.101181	17.85425	3.053143	4.438064	3.673016
2009	3	2.110001	17.84319	3.049257	4.437863	3.669794
2009	4	2.118745	17.83201	3.045356	4.437663	3.666562
2010	1	2.122436	17.86545	3.039576	4.437402	3.668818
2010	2	2.126113	17.89782	3.033763	4.437142	3.671069
2010	3	2.129777	17.92916	3.027916	4.436882	3.673315
2010	4	2.133427	17.95956	3.022035	4.436621	3.675555
2011	1	2.131141	17.97793	3.026491	4.436367	3.689442
2011	2	2.12885	17.99596	3.030927	4.436112	3.703138
2011	3	2.126554	18.01368	3.035344	4.435858	3.716649
2011	4	2.124253	18.03109	3.039741	4.435603	3.72998
2012	1	2.079207	18.06609	3.068061	4.435271	3.735059
2012	2	2.032036	18.09991	3.0956	4.434939	3.740112
2012	3	1.982529	18.13263	3.122402	4.434607	3.74514
2012	4	1.930443	18.1643	3.148504	4.434275	3.750142
2013	1	1.930645	18.16865	3.160548	4.43386	3.762701
2013	2	1.930848	18.17298	3.172449	4.433444	3.775105
2013	3	1.93105	18.17729	3.184211	4.433029	3.787356
2013	4	1.931252	18.18159	3.195835	4.432613	3.799459
2014	1	1.932612	18.19473	3.183438	4.432117	3.757463
2014	2	1.933969	18.2077	3.170885	4.43162	3.713625
2014	3	1.935325	18.22051	3.158172	4.431123	3.667777
2014	4	1.936678	18.23315	3.145296	4.430626	3.619726

2015	1	1.932326	18.27265	3.156084	4.430439	3.64964
2015	2	1.927955	18.31065	3.166758	4.430251	3.678686
2015	3	1.923565	18.34725	3.177319	4.430064	3.706912
2015	4	1.919156	18.38256	3.187769	4.429876	3.734363
2016	1	1.95031	18.38929	3.202477	4.429587	3.728073
2016	2	1.980523	18.39597	3.216972	4.429298	3.721743
2016	3	2.00985	18.40261	3.23126	4.429008	3.715373
2016	4	2.038342	18.4092	3.245346	4.42872	3.708962
2017	1	2.034217	18.52952	3.227308	4.428516	3.766681
2017	2	2.030075	18.63691	3.208939	4.428314	3.821249
2017	3	2.025916	18.73387	3.190226	4.428111	3.872993
2017	4	2.02174	18.82226	3.171156	4.427908	3.922192
2018	1	2.042754	18.82015	3.158327	4.427648	3.917109
2018	2	2.063336	18.81803	3.14533	4.427388	3.912001
2018	3	2.083503	18.81591	3.132162	4.427128	3.906867
2018	4	2.103271	18.81378	3.118819	4.426868	3.901706
2019	1	2.116421	18.82051	3.166673	4.426826	3.922576
2019	2	2.1294	18.82719	3.212342	4.426785	3.94302
2019	3	2.142213	18.83383	3.256015	4.426743	3.963053
2019	4	2.154864	18.84043	3.297861	4.426701	3.982694

Annex II: outcomes from regression of the model

Table II.1: Descriptive statistics of the variables

```
. summarize logMNF logIELC logTOP logLAF logCAF

    Variable |        Obs        Mean    Std. Dev.       Min        Max
-------------+---------------------------------------------------------
      logMNF |         60     2.05858    .0890999   1.919156   2.202283
     logIELC |         60    18.32014    .7153486   17.46092   20.48417
      logTOP |         60    3.730341    .1211721   3.558823   3.982694
      logLAF |         60     4.43378     .004949   4.426701   4.441403
      logCAF |         60    3.061827    .1757013    2.70982   3.297861

.
```

Table II.2 ***Residual sum of squares for restricted model (RSSr)***

```
. reg logMNF logIELC logCAF logLAF

      Source |       SS           df       MS      Number of obs   =        60
-------------+----------------------------------   F(3, 56)        =     33.39
       Model |  .311033092         3  .103677697   Prob > F        =    0.0000
    Residual |  .173907366        56  .003105489   R-squared       =    0.6414
-------------+----------------------------------   Adj R-squared   =    0.6222
       Total |  .484940458        59   .00821933   Root MSE        =    .05573

------------------------------------------------------------------------------
      logMNF |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     logIELC |   .4043032   .0672575     6.01   0.000     .2695703    .5390361
      logCAF |  -.2868317   .0864312    -3.32   0.002    -.4599741   -.1136892
      logLAF |   31.58611    6.41764     4.92   0.000     18.73004    44.44219
       _cons |  -144.4574   29.69314    -4.87   0.000    -203.9399   -84.97487
------------------------------------------------------------------------------
```

Table II. 3 Residual sum of squares for unrestricted model (RSSu)

```
. reg logMNF logIELC logCAF logLAF interactionIELCDUMMY2016

      Source |       SS           df       MS      Number of obs   =        60
-------------+----------------------------------   F(4, 55)        =     36.04
       Model |  .351021389         4  .087755347   Prob > F        =    0.0000
    Residual |  .133919069        55  .002434892   R-squared       =    0.7238
-------------+----------------------------------   Adj R-squared   =    0.7038
       Total |  .484940458        59   .00821933   Root MSE        =    .04934

-------------------------------------------------------------------------------------------
                   logMNF |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
--------------------------+----------------------------------------------------------------
                  logIELC |   .2847843   .0664572     4.29   0.000     .1516012    .4179674
                   logCAF |  -.1267882   .0861211    -1.47   0.147    -.2993787    .0458024
                   logLAF |   35.56045   5.766645     6.17   0.000     24.00383    47.11706
interactionIELCDUMMY2016 |   .0063269   .0015612     4.05   0.000     .0031981    .0094556
                    _cons |   -160.431   26.58626    -6.03   0.000    -213.7111    -107.151
-------------------------------------------------------------------------------------------

.
```

Table II.4: ***structural break with unknown date***

```
. estat sbsingle, breakvars( logIELC) trim(33)
────┼─── 1 ───┼─── 2 ───┼─── 3 ───┼─── 4 ───┼─── 5
....................

Test for a structural break: Unknown break date

                             Number of obs =        60

Full sample:                 1  - 60
Trimmed sample:              21 - 41
Estimated break date:        30
Ho: No structural break

     Test            Statistic          p-value
───────────────────────────────────────────────
     swald            48.2703           0.0000
───────────────────────────────────────────────
Exogenous variables:           logIELC logCAF logLAF
Coefficients included in test: logIELC
```

Table II.5: structural break with unknown date for Labor force and capital formation variables

```
. estat sbsingle, breakvars( logCAF ) trim(33)
────┼─── 1 ───┼─── 2 ───┼─── 3 ───┼─── 4 ───┼─── 5
..........

Test for a structural break: Unknown break date

                             Number of obs =         30

Full sample:                 31 - 60
Trimmed sample:              41 - 51
Estimated break date:        47
Ho: No structural break

     Test            Statistic         p-value
───────────────────────────────────────────────
     swald             4.4113          0.1778
───────────────────────────────────────────────
Exogenous variables:           logIELC logCAF logLAF
Coefficients included in test: logCAF

. estat sbsingle, breakvars( logLAF ) trim(33)
────┼─── 1 ───┼─── 2 ───┼─── 3 ───┼─── 4 ───┼─── 5
..........

Test for a structural break: Unknown break date

                             Number of obs =         30

Full sample:                 31 - 60
Trimmed sample:              41 - 51
Estimated break date:        47
Ho: No structural break

     Test            Statistic         p-value
───────────────────────────────────────────────
     swald             4.2305          0.1935
───────────────────────────────────────────────
Exogenous variables:           logIELC logCAF logLAF
Coefficients included in test: logLAF
```

Table II.6 : Regress Subset of samples

```
. reg logMNF logIELC logCAF logLAF if TIME<=30

      Source |       SS           df       MS      Number of obs   =        30
-------------+----------------------------------   F(3, 26)        =     11.37
       Model |  .047147488         3  .015715829   Prob > F        =    0.0001
    Residual |  .035945004        26    .0013825   R-squared       =    0.5674
-------------+----------------------------------   Adj R-squared   =    0.5175
       Total |  .083092492        29  .002865258   Root MSE        =    .03718

------------------------------------------------------------------------------
      logMNF |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     logIELC |   .2878031   .0816617     3.52   0.002      .119945    .4556612
      logCAF |  -.1554662   .1132835    -1.37   0.182    -.3883238    .0773913
      logLAF |   23.65815    7.54219     3.14   0.004     8.154957    39.16134
       _cons |  -107.5592   34.07812    -3.16   0.004    -177.6078   -37.51061
------------------------------------------------------------------------------

. reg logMNF logIELC logCAF logLAF if TIME>30

      Source |       SS           df       MS      Number of obs   =        30
-------------+----------------------------------   F(3, 26)        =     43.05
       Model |   .14074019         3  .046913397   Prob > F        =    0.0000
    Residual |  .028334854        26  .001089802   R-squared       =    0.8324
-------------+----------------------------------   Adj R-squared   =    0.8131
       Total |  .169075044        29  .005830174   Root MSE        =    .03301

------------------------------------------------------------------------------
      logMNF |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
     logIELC |   .3049135   .0612059     4.98   0.000      .179103    .4307239
      logCAF |   .3922229   .1678713     2.34   0.027     .0471584    .7372874
      logLAF |   8.006942   6.992706     1.15   0.263    -6.366771    22.38066
       _cons |  -40.34908   32.23676    -1.25   0.222    -106.6127    25.91452
------------------------------------------------------------------------------
```

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