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The determinants of CO_2in France and Swedenfrom 1960 to 2015.

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Abstract:
Background*: A number of studies in the environment-energy-growth literature aim to pin down the determinants of carbon dioxide (CO2) emissions as a result of large increases in CO2 emissions over the last few decades.*
Materials and Methods*: The data used in the survey are annual data referring to the period between 1960 and 2015 for the countries of Sweden and France. By using the ordinary least squares method, our research draws an econometric analysis of the relationship between carbon dioxide emissions, gross domestic product, electricity consumption, fossil fuel consumption, and urbanization.*
Results*: Positive effect on CO2 emissions by electricity consumption, fossil fuel consumption and urbanization are our findings. Gross domestic product is found to have a negative effect on CO2 emissions in both countries. Furthermore, in the empirical study, check of stationary was performed via augmented Dickey-Fuller test and cointegration test was performed using the Johansen methodology, attesting that there is a long-term equilibrium relationship for both countries. Finally, the Granger causality test was performed, showing that there is a causality relationship between the variables of urbanization and the per capita gross domestic product to carbon dioxide emissions for both countries.*
Conclusion:*By summarising this work indicates future directions by suggesting that electricity consumption, fossil fuel consumption and urbanization have positive effect on CO2 emissions.*
Key Word*:Carbon Dioxide Emissions,Gross Domestic Product, water quality,Cointegration, Regression Analysis*

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I. Introduction

For the last two centuries, the main aim of all human activity has been to optimize utility through the consumption of goods and maximize profits. This effort has increased greenhouse gas emissions, overconsumption, and environmental degradation. [1]Emissions of greenhouse gases due to human activities continue to increase year after year, and they are the main reason for global warming. The most significant and dangerous increase is carbon dioxide, a by-product of the combustion of fossil fuels, such as coal, oil, gasoline, gas, and other organic compounds. Climate change and other stresses are limiting the availability of clean water and cheap energy worldwide.

As we can see in Figure 1, CO2 has the most significant percentage among greenhouse emissions, where more specifically, 65% comes from industrial activity and 11% from agricultural or similar activities. 76% of the greenhouse gas emissions come from CO2, followed by Methane with 16%, Nitrous Oxide with 6%, and Fluorinated Gases with 2%. CO2 is the most dangerous gas, and all climate action worldwide aims to reduce it, and for this reason, it is the subject of study in this research.

Figure 1: Global greenhouse gas emissions. Source, Intergovernmental panel on climate change 2014

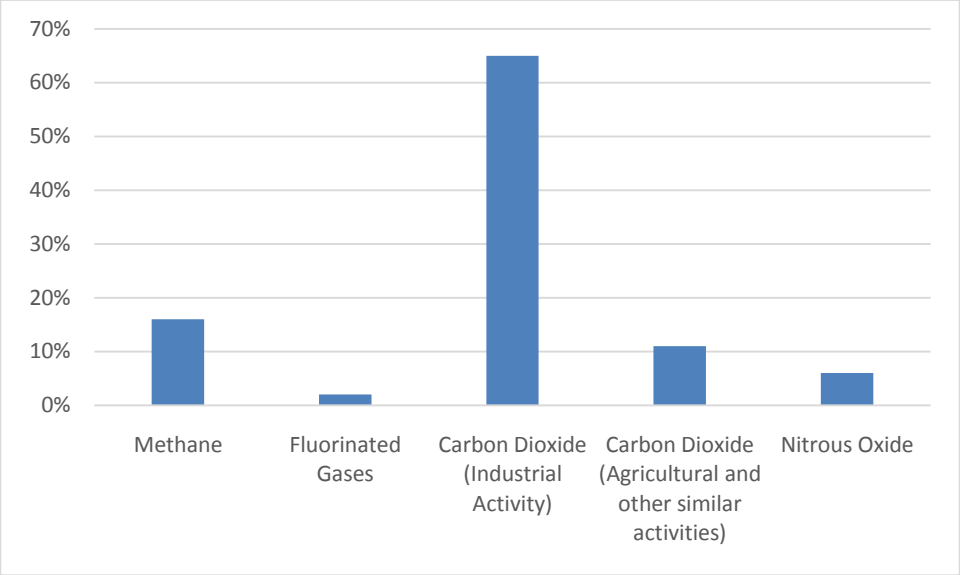
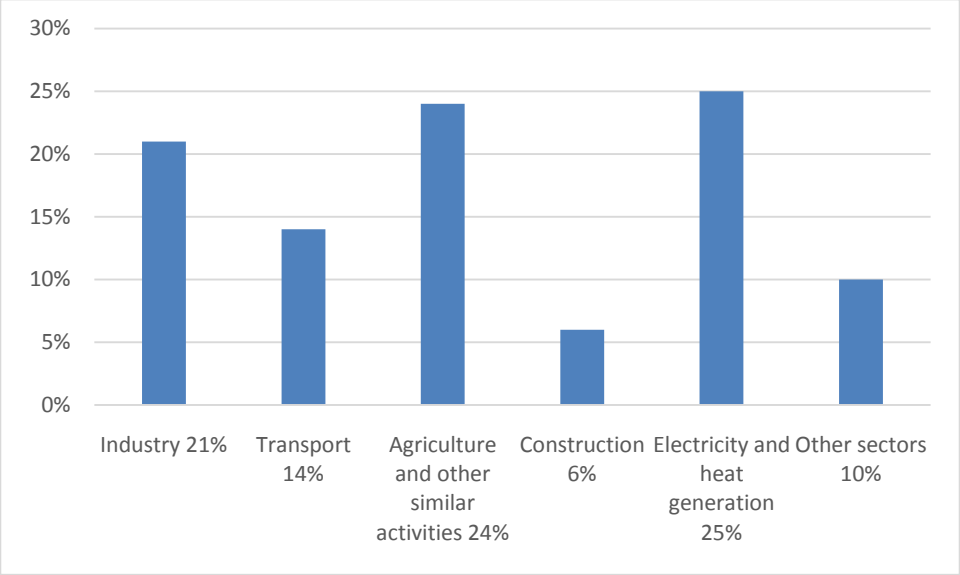


Figure 2. shows the economic sectors and the percentage they participate in the production of greenhouse gas emissions. As we can see in Figure 2, the most pollutant sectors are Electricity and Heat sector (25%), Agricultural and other similar activities (24%), Industry (21%) and they followed by Transport (14%), other sectors (10%) and Construction (6%).

Figure 2: Global greenhouse gas emissions by economic sector. Source, Intergovernmental panel on climate change 2014

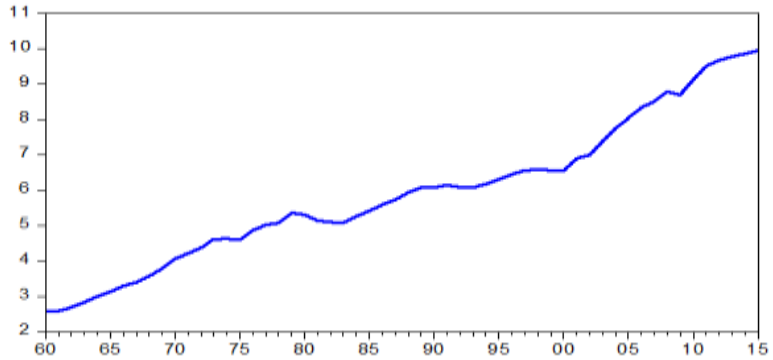


The year 2015 was marked by a historical event, signing a landmark agreement regarding climate change in Paris at the 21st COP21 forum (Sustainable innovation forum 2015, Climate Action: 2015) by 196 countries and the EU. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels. The Paris Agreement is a landmark in the climate change process because a binding agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects [2]

To achieve the goal of the Paris Agreement, all countries that sign it tries to reduce their Carbon Dioxide Emissions because it is the primary pollutant and has the most significant share among Greenhouse Gas Emissions. Carbon dioxide is a colorless and odorless gas substantially contributing to the greenhouse effect and global warming. It is not a typical major pollutant, as, at normal concentrations, it has no impact on health and does not react chemically to generate other air pollutants. However, carbon dioxide is the main greenhouse gas

for which emissions limits have been applied. The following figure (Figure 3) shows the increase in carbon dioxide emissions worldwide from 1960 to 2015. As we can see, CO2 emissions grow at a steady rate.

Figure 3:*Increase in global carbon dioxide emissions, 1960-2015 (metric tons per capita)*



In literature, the study of the relationship between GDP and carbon dioxide emissions is often tested through the existence of theKuznets curve[3]. were pioneers in the study of the relationship between economic growth and environmental burden. Through their study they conclude that there is a relationship between environmental burden and economic growth, which can be represented in a diagram with an inverted U-shape. By studying the relationship between GDP and CO2 emissions and applying the technique of division into three parts (scale effect, technique effect, and composition effect), [4] came to the same conclusion, namely the existence of an inverted [5] states that the main factors influencing CO2 emissions are per capita income, the contribution of the industrial sector to GDP, and the degree of trade openness. He found that the effect of trade openness on CO2 emissions depends on how the economy under study is structured; its influence increases when there is an increase in industrial activities. He also noted that increasing trade openness and industrialization significantly burden the environment. Urbanization is another variable whose increase is estimate to result in increased CO2 emissions, but this phenomenon is observed mainly in less developed countries and developing countries [6]. The relationship between CO2 emissions, energy consumption, and per capita income was studied using the method of panel cointegration analysis for the period between 1990 and 2011 in 85 countries; a positive correlation was found [7].Owoye and Onafowora[8]studied the determinants of per capita CO2 emissions in countries in South Africa, South America, and Central and South Asia, and they concluded that there is a positive and significant effect of energy consumption on per capita CO2 emissions. Sharma [9]used a dynamic panel data model in 69 countries and concluded that trade openness, per capita GDP, and energy consumption are all positively correlated with CO2 emissions, while urbanization is negatively correlated in high-income countries. Sadorsky[10]had similar results, using a different method, that of heterogeneous panel regression techniques in emerging economies; the only difference in his results being that urbanization has no statistically significant effect. Elena Stolayrova[11]studied the relationship between per capita CO2 emissions, per capita GDP, and energy mix, by applying the panel data method in 93 countries; she found that the per capita growth rate of CO2 emissions is positively dependant on the GDP per capita growth rate and negatively dependent on the energy mix growth rate. Dinda and Coondoo[12] studied the relationship between GDP per capita and CO2 emissions using IPS panel root test and Engel-Granger methodology of cointegration. The results show that series have a same order of integration and that a long-run relationship exists for Africa, Central America and Europe. In their article, Eunho Choi et al, [13], study the existence of the Kuznets curve using time series data for China (then a developing country), Korea (a neo-industrial country) and Japan (developed country). China shows an N-shaped curve, while Japan has a U-shaped curve. They also analyzed the dynamic relationship between the variables using a vector error correction model. The results showed high heterogeneity between countries and the effects of the variables studied. In their study for Austria, Friedl and Getzner[14]concluded that both linear and quadratic models were not suitable for analyzing the case of Austria, but the cubic model could offer a more suitable representation. Akbostanci et al. [15]investigated the relationship between income and environmental degradation in Turkey. By using a time series model spanning from 1968 to 2003, they found that CO2 emissions and income tend to have a monotonically increasing relationship in the long run. Using Granger causality and cointegration methods, and studying the long-term correlations between CO2 emissions, trade openness, and energy consumption in Italy, he concludes that the development of RES and environmentally friendly technologies should be strengthened and the use of fossil fuel should gradually stop. [finds a unidirectional long-run causality running from GDP per capita to energy consumption per capita of the fuel.

There are also studies that took place in Canada using a region-level panel dataset that do not demonstrate a link between CO2 emissions and GDP [16]. Determinants that affect CO_2 emissions have become

the most debated research topic for both environmental economists and researchers. For instance,StolyarovaE.[11]analysed the relationship of CO2 with GDP and Energy Consumption, while Cetin & Ecevit [17] analysed the relationship of CO2 with Energy Consumption and Urbanization. Zakarya et al. [18] have studied the relation of CO2 with GDP, energy consumption and Foreign direct investments and Ab-Rahim and Xin-Di [19] the relation with Energy consumption, trade openness and economic growth. Finally in a social prospective Jiang et al. research [20] has analysed the relation of CO2 with Social consumption and consumption behaviour.

II. Material And Methods

This paper studies variables, as presented in the table below.

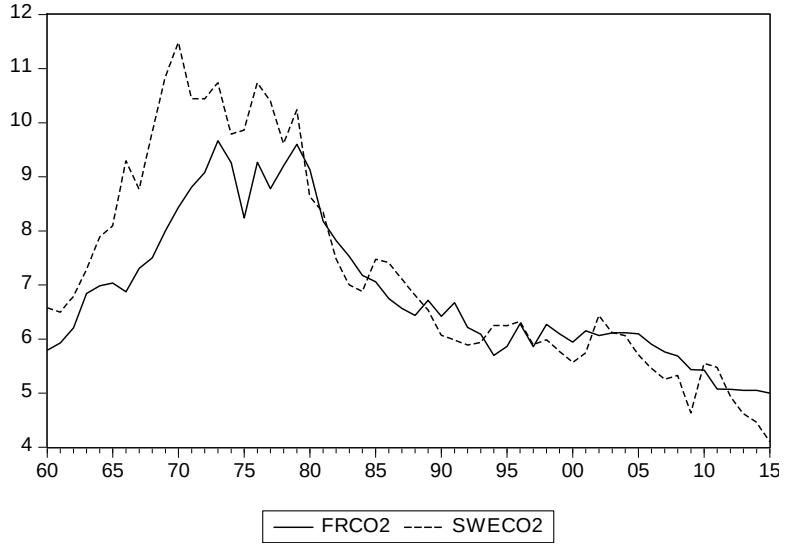
Table no 1: Variables

Variable	Data Used	Measurement Unit	Source
CO_2	Carbon dioxide emissions	Metric tons per capita	Carbon Dioxide Information Analysis Center
EPC	Electricity power consumption	kWh per capita	International Energy Agency Statistics
FFC	Fossil fuel consumption	% of total energy production	International Energy Agency Statistics
GDP	Gross domestic product per capita	Dollars	World Bank
LMUR	Logarithm of urbanization	Logarithm of the number of people living in urban areas	OECD

Carbon dioxide emissions counted are those derived from the combustion of fossil fuels and the production of cement. The cement industry contributes about 5% to global anthropogenic CO2 emissions, making the cement industry an important sector for CO2-emission mitigation strategies [21]. The global production of cement has grown very rapidly in recent years, and after fossil fuels and land-use change, it is the third-largest source of anthropogenic emissions of carbon dioxide [22]. Carbon dioxide produced from the consumption of solid, liquid, gaseous fuels and gas combustion is also taken into consideration.Carbon dioxide affects all environmental aspects, air, soil and water. More specifically one consequence of atmospheric CO2 dissolving into seawater is the formation of carbonic acid (H2CO3), which releases hydrogen ions (H+) and decreases pH, a process referred to as ocean acidification [23,24] One well-known effect of ocean acidification is the lowering of calcium carbonate saturation states, which impacts shell-forming marine organisms from plankton to benthic molluscs, echinoderms, and corals [25].

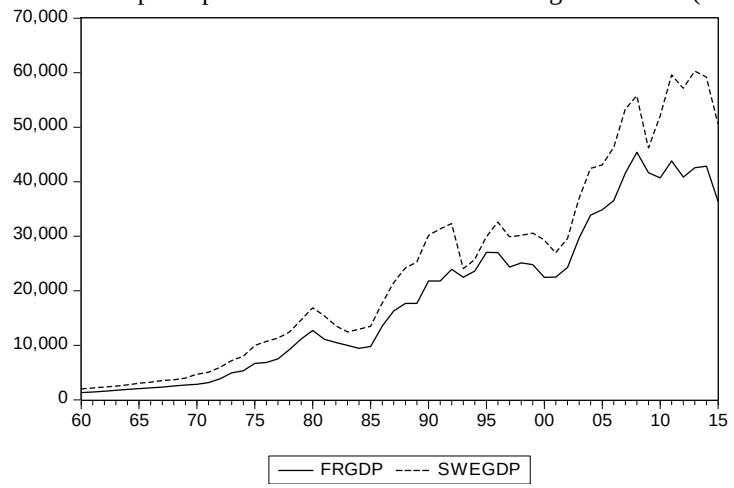
The Figure 4, which analyzes carbon dioxide emissions data in France from 1960 to 2015, demonstrates that there was a significant increase in carbon dioxide emissions until 1980 followed by a continuous downward trend. In 2015, France managed to reduce carbon dioxide emissions to a record low. Sweden is known as one of the most organized developed countries in terms of its socio-political and anthropocentric system worldwide. LikeFrance,as we can see in the Figure 4,carbon dioxide emissions in Sweden increased significantly until 1980 and then continuously declined. Remarkably, by 2015, Sweden's environmental policy enabled almost the complete elimination of carbon dioxide emissions.

Figure 4: Carbon dioxide emissions (CO_2) in France and Sweden between 1960 and 2015 (metric tons per capita)



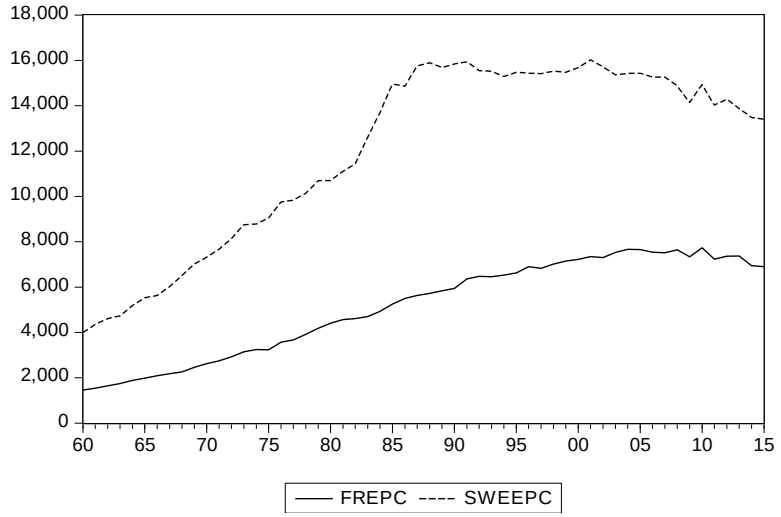
The need for economic growth has led to environmental degradation, which is often a resultant effect of development and industrialization in both developing and developed countries. Gross Domestic Product (GDP) is the sum of all products and goods that an economy produces during one year, expressed in monetary units. GDP measures two things at the same time: total income earned by all members participating in the economy and total expenditure on the product of the economy in goods and services. The reason that GDP can simultaneously express aggregate expenditure is that these two quantities are, in fact, the same thing [26]. In this study, the data were obtained from the World Bank and the measurement was made in GDP per capita, at the dollar exchange rate. GDP per capita is the gross domestic product divided by the population of the country and is undoubtedly the most representative indicator of economic growth and prosperity. In addition, the following chart, which displays information about the Gross Domestic Product (GDP), demonstrates that in France GDP per capita during that period followed a continuous upward trend until 2009 during the global financial crisis, which had a considerable effect on it. The negative impact of the crisis is reflected in the downward trend of GDP, which starts in 2010 and continues until 2015. Sweden's GDP per capita, one of the highest in the world displaying a continuous upward trend until 2009, was affected by the global crisis, but not as much as other countries, and recovered very quickly.

Figure 5: GDP per capita of France and Sweden during 1960-2015 (in dollars).



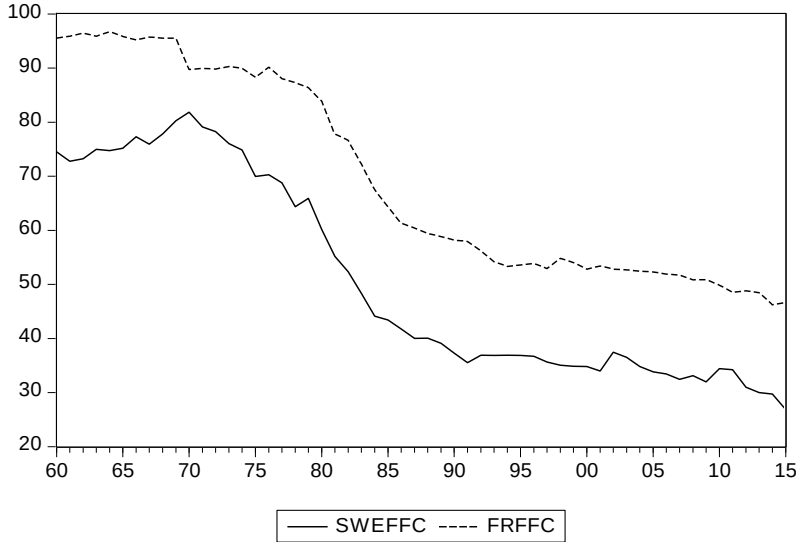
The key issue that many countries are facing is the level of carbon dioxide in the environment that is increasing significantly due to energy consumption and economic growth [27] Electricity consumption measures the production of power plants and combined heat and power plants minus the losses of transmission, distribution, and transformation, and usage by heat and power plants [28]. It is important to refer that a lot of Water is required for nearly all production and conversion processes in the energy sector, including fuel extraction and processing (fossil and nuclear fuels as well as biofuels) and electricity generation (thermoelectric, hydropower, and renewable technologies) [29].

Figure 6: Electricity consumption per capita (EPC) in Sweden and France during 1960-2015 (kWh/capita)



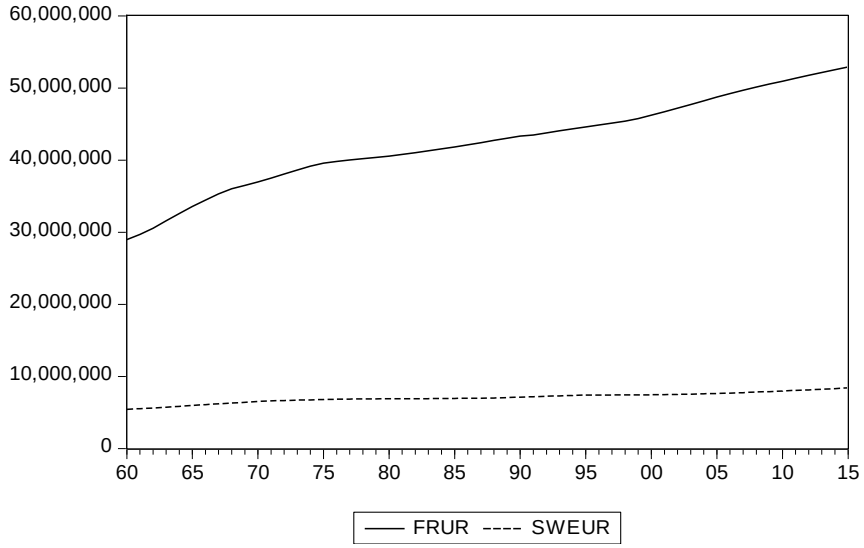
Energy production, through the combustion of conventional fossil fuels and their products, is the most common method for energy production. Fossil fuels include coal, oil, and natural gas products. Fossil fuels formed millions of years ago from the carbon-rich remains of animals and plants, as they decomposed and were compressed and heated underground. When fossil fuels are burned, the stored carbon and other greenhouse gases are released into the atmosphere [30]. According to Kasman and Dunman [27], a majority of the energy originates from fossil fuels such as coal and natural oil and gas, which also has resulted in the increase of CO2 emissions level [31]. In this study, measurements of electricity consumption produced using fossil fuels are depicted as a percentage of total energy consumption [28].

Figure 7: Energy consumption from fossil fuel combustion (FFC) in France and Sweden, during 1960-2015 (% of total)



Urbanization is a social process that involves the adoption of attitudes and behaviors that connect and characterize the inhabitants of large cities. The urban population consists of people living in urban areas as defined by the national statistical services. The effect of urbanisation on CO2 emissions are continuous and change in the short and long run. Urbanisation increases resident income, accelerates industrialisation, produces public transit networks or energy-free transport modes and decreases household size, all of which affect CO2 emissions in various ways [32]and is often directly linked to the degradation of environmental quality, including quality of water, air and noise [33].Effects on water resources are an understudied aspect of the environmental consequences of urbanization and more specifically affects and water withdrawals [34]. Furthermore, urbanization strongly affected water quality in the river basin. The more rapid the urbanization process the more seriously polluted urban rivers will become [35].

Figure 8: Urbanization (UR) of France and Sweden during 1960-2015



Estimation of the model

The function studied in this paper consists of the variables of carbon dioxide (CO2) emissions, electricity power consumption (EPC), fossil fuel consumption (FFC) as a percentage of total energy consumption, GDP per capita, and of the urbanization logarithm (LMUR). Carbon dioxide (CO2) emissions are set as the dependent variable, and the rest are defined as independent variables. The model has the following general form

$$U = f\,(CO2_t, EPC_t, FFC_t, GDP_t, LMUR_t) \quad (1)$$

III. Results

The following functions are derived as a result from using the Ordinary Least Squares (OLS) method, and after performing the regressions:

CO_2 function for France, following OLS regression:

$$CO2F_t = -185.99 + 0{,}00075\ EPCF_t + 0{,}137\ FFCF_t - 0{,}0001 GDPF_t + 10{,}33\ LMURF_t \quad (2)$$

CO_2 function for Sweden, following OLS regression:

$$CO2St = -145.58 + 0{,}0004\ EPCSt + 0{,}209\ FFCSt - 0{,}00000179\ GDPSt + 8{,}68\ LMURSt \quad (3)$$

According to the results of the regressions for both countries, the signs of the coefficients are fully in line with the economic theory. Moreover, by observing the Probability values of the variables, the statistical significance of the coefficients of the models is proven; namely, variable coefficients Prob. in both countries is less than 5%, therefore the coefficients are characterized as statistically significant.

The determination coefficient captures the percentage of deviation of the dependent variable and its values range between 0 and 1. For France, R^2= 0.889107, which means that the dependent variable is interpreted by the independent variables by 89%, and the remaining 11% is caused by the operational term or by unknown factors. Respectively, for Sweden, R^2= 0.977864, which means that the dependent variable is interpreted by the independent variables by 98%, and the remaining 2% is caused by the operational term or by unknown factors.The F-Statistic values, and especially Probability values (F-Statistic) demonstrate the statistical significance of the regression coefficients. Since Prob. (F-Statistic) <0.05 for both countries we studied, regression rates are statistically significant.

Regarding the coefficient stability test, the Brown-Durbin-Evans test was performed, along with the Cusum Test and Cusum Test of Squares test, and, as shown in the diagrams below, there is a lack of stability and correct prediction for France in the CUSUM Test (Figure 9), but we have good results in CUSUM Test of Squares (Figure 10), while the CUSUM Test for Sweden and the CUSUM Test of Squares indicate the existence of stability and good predictability for both countries.

Figure 9: Graph of the residues, France (CUSUM Test)

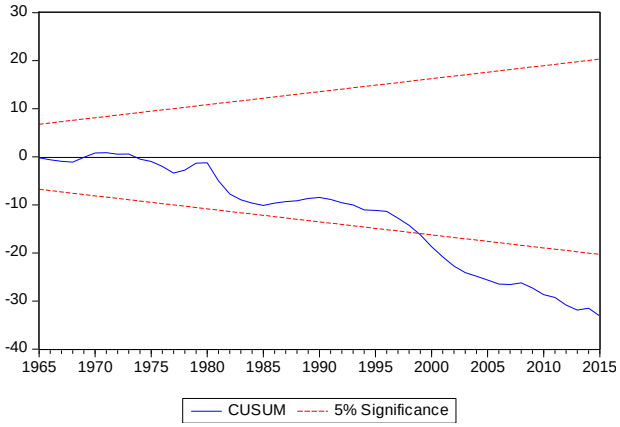


Figure 10: Graph of the residues, France (CUSUM of Squares Test)

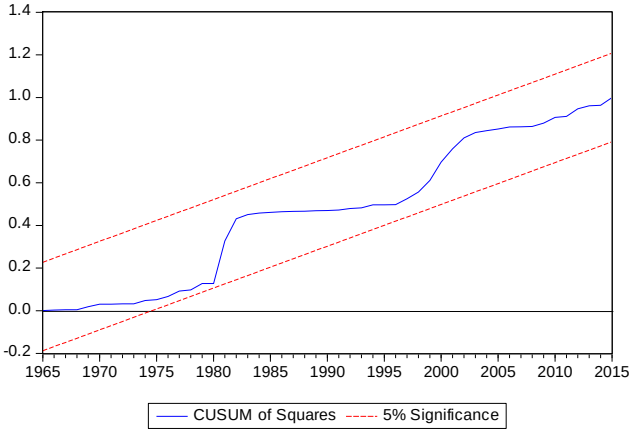


Figure 11: Graph of the residues, Sweden (CUSUM Test)

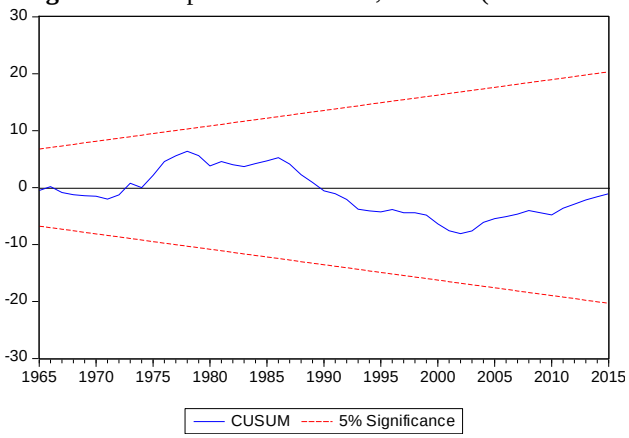
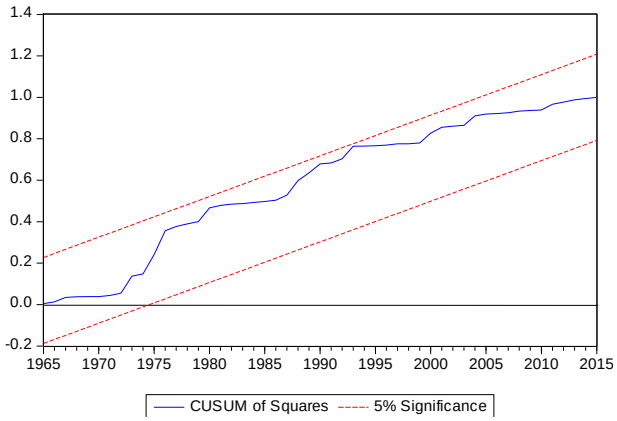


Figure 12: Graph of the residues, Sweden (CUSUM of Squares Test)

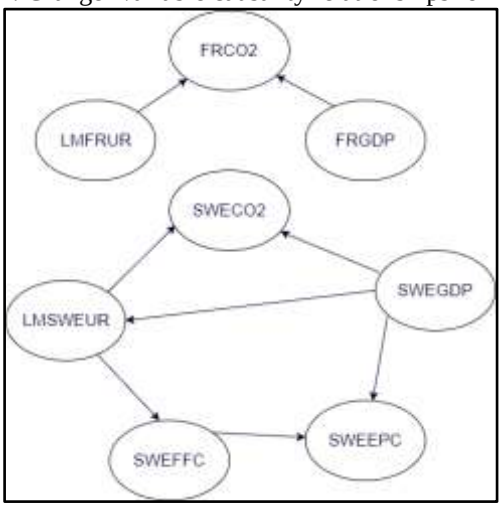


Stationary test was performed with the unit root test, specifically with the Dickey Fuller test. According to this test, when applied for France, it was observed that all variables are stationary in the first differences with constant and trend. The only exception is the variable of the urbanization logarithm, which it is stationary without a constant. For Sweden, variables have a similar behavior; they are all stationary in the first differences with constant and trend, while the logarithm of urbanization shows stationary without constant.

Cointegration between two or more variables was tested by a type of tests based on the methodology of the VAR models, where it is possible to determine the maximum number of cointegration relations that the test model variables can have. The most common method in this category is Johansen's 1988 method. In 1981, Johansen invented a VAR (Vector Autoregression) technique, based on which the exact number of integration vectors can be determined, within a multivariate system. Johansen's approach is known as the Johansen maximum likelihood cointegration test, because the model estimate and the statistical test procedure are based on the maximum likelihood method [36]. According to the results of the test, the order of the VAR model for Sweden was determined and it was found that it is second class. Subsequently, the Johansen Test was performed, and we observed that the statistical trace of Sweden is greater than the critical value, resulting in the existence of a cointegrated vector, and therefore a long-term equilibrium relationship. For France, the VAR model class was found to be fourth class, and we observed that the trace of France is greater than the critical value, resulting in the existence of a cointegrated vector, so there is a long-term equilibrium relationship.

According to the Granger causality test, there are causal relationships between the variables in France and Sweden. The specific causal relationship is presented in the Table below:

Table no2 : Granger variable causality relationships for France and Sweden



IV. Discussion and Conclusion

This paper examines the relationship between carbon dioxide emissions and GDP per capita, electricity consumption, fossil fuel consumption, and urbanization in Sweden and France, which are the two countries studied. The data used to evaluate the above variables were obtained for the period between 1960 and 2015. Carbon dioxide emissions were selected as the main variable to be considered, since carbon dioxide is the most important greenhouse gas and influences greatly the formulation of economic and environmental policies. The results of the model evaluation showed that all our variables are statistically significant, and the high values of

the determination coefficients indicate that the independent variables interpret our dependent variable to a great extent. The control and reinforcement tests of the model had satisfactory results.

According to the results of the regressions of this particular model, in order to achieve a reduction in carbon dioxide emissions, the most important measures/actions to be taken are to reduce the phenomenon of urbanization, to significantly reduce the consumption of fossil fuels for the production of electricity; moreover, having a lesser effect on the reduction of CO_2 emissions, total energy production should be reduced and per capita income should be increased. The inevitable impacts of climate change affect freshwater resources and the ecosystems they support which become less reliable and resilient. The effects of regression are very important because they give very strong feedback to economic and environmental policy makers who wish to reduce carbon emissions, which is a common goal worldwide.

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