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From classical and neoclassical economic growth to degrowth in Europe. Challenges for public administration

Alina HALLER[1]

Abstract: *The world is facing with challenges that were hard to imagine a few decades ago. The last century was one in which the world experienced the enthusiasm of progress as a result of the implementation of methods proposed by neoclassical growth theory. The effects of climate change cause us to reflect, asking ourselves whether neoclassical growth has reached its limits. We answer to this question by analyzing, with the simple and multiple linear regression method, the relationship between economic growth, measured by GDP per capita, and greenhouse gas emissions, on the EU28, for the period 1980-2016 when UK was European member. We show that the European economic growth depends, overwhelmingly, on activities that produce negative spillovers in the form of emissions. The relationship between growth and total emissions, on the one hand, and between growth and emissions by categories, on the other, is positive and strong. The activities that produce natural gas emissions have the biggest influence on European economic growth followed by those from coal and coke and, by ones from petroleum and derivatives.*
We notice a great heterogeneity between the European states both of all EU28 members and within the four groups that we formed depending on GDP per capita growth. This conclusion shows that a common emission reduction policy in EU28 is not possible. The individual economic characteristics must be taken into account for the adoption and for the implementation of environmental and development policies. As a result of this study we will see to what extend Europe is in position to choose between continuing on the same path of progress or opting to apply the principles of degrowth economy. In the current crisis situation, the role of the public administration grows but the challenges will be greater than ever, the objective pursued in the future being not only economic growth but also the pollution reduction, even degrowth principles, in a very heterogeneous and sick Europe, where it is not possible to apply common environmental policy measures.

Keywords: *neoclassical growth, degrowth, EU28, greenhouse gas emissions, public administration*

JEL: O11, P25, Q01, R11

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Introduction

Economic growth is one of the four cornerstones of the *magic square* and one of the four main objectives of short term economic policy. The importance of growth lies in the compatibility of growth with the other three goals, inflation, unemployment, and external balance. Growth concerns the all world's economies. What differs substantially are the pathways taken to achieve this objective. The public administrations have at their disposal various growth directions, and the results differ likewise. Capitalizing the comparative advantages makes the difference between a performing economy and a less performing one. All public administrations also have the role of transposing growth in what matters most, namely in development, a process superior to growth but dependent on it. If the economic growth is not find in development, it will be translated in the lack of public administration activity of a country. There is no possibility for an economy and a society to develop if there was no progress in the line of growth. Conversely, it is possible. Over time, remarkable progress has been made all over the world. Economies have grown, and this is seen in the people quality of life.

The growth, as a complex, long-term process, from several decades has shown a neglected side in practice, although it has been brought to light since the eighteenth century. The excessive pollution and the consumption of resources in parallel with the demographic growth puts humanity in the face of a colossal challenge related to the ecosystem and its ability to sustain humanity as it is currently configured. This challenge impetuously demand to find solutions and, most theoretically acceptable, these solutions are related to degrowth economy.

Before any concrete measures have been taken by the economic agents with decision-making power, nature adjudged this role and, in the first part of 2020, applied the concepts of degrowth, leading humanity towards a large economic crisis. The crisis that is emerging over the coming years will bring the public administrations and the solutions of the classics to the fore, but in a reconfigured framework. The difficulty will be even greater as the future growth will be based by degrowth principles, and this in the situation of economic and social difficulties that humanity has not faced since 1929.

The current reality demonstrates the destructive effects of some generally superficial and only, so far, theoretically considered risks. The pandemic of 2020 effects are sending humanity into a crisis whose proportions will be so tragic that is hard to imagine. The economic reconfiguration rests with the state as it happens after any other crisis. Public administrations must prove their decision-making efficiency and ability to support the resumption of growth on principles totally different from those so far manifested, that of degrowth.

The objective of the research is to argue that the process of economic growth continues to find its valves in the factors considered important in the classical and neoclassical literature, but the operating framework is changing. Two challenges shake the economy and society: one is about a possible ecological collapse and one is about a possible economic collapse. The crisis of 1921-1933 offered us a recovery recipe based on public administration intervention. The state will have the mission to support economic and social recovery but on other principles than those of the classical and the neoclassical ones, namely those of degrowth. In this paper we are concerned with the first challenge, that of the environment. We analyze the relationship of economic growth and greenhouse gas emissions from various sources to see in what extent European economic growth depends on intensely polluting activities. We structured the research into four parts. Initially, we consider it necessary to provide conceptual explanations, we continue with the methods and methodology presentation, with the results and their explanation, and, in the end, we draw the research conclusions.

1. Literature Review

Economic growth is a complex process which is manifesting in a sinusoidal form, in the long term, being supposed to some limitation such as demographic expansion, limited resources, inadequate infrastructure, with inappropriate institutional and cultural models (Haller, 2008). Small differences in growth rates become substantial, through cumulation, over long periods of time. This is the reason why the process is so important. Our quality of life depends to a large extend on economic growth.

1.1 About classical and neoclassical economic growth in brief

The process of economic growth allows the increase of economic dimensions, the rise of macroeconomic indicators, especially GDP per capita, ascending but not necessarily linear and the improving of well-being (Haller, 2008). The non-linearity of growth is something normal and indicated, an aspect who emerges from economic cyclicality but, the positive growth remain vital.

Historically speaking, the world has discovered the positive effects of growth since the XV-th century when, in some parts of the world, it was tried to find viable answers to a nation enrichment. Surely, the XIX-th century has started the efforts of progress beginning in England and after this whole world was concerned on economic growth as a vital process for improving the wellbeing. Anyway, Confucius (551-479 B.H.) advised us about what we need to do to increase the wealth of a nation and he had said that the best method for the wealth growth is for those who produce to be multiplied, and for those who spend to be less and less; those who work must double their forces, and those who manage must be economic and, in these way, the wealth will be always sufficient (Maurant, 2014).

But, in doctrinal field, the classics gave rise to growth analysis, and then the theory was developed by neoclassics. Once understood the major role of growth for economy and society, growth was put on the account of demographic increase, and then on the reactivation of labor force. Neoclassics come to point out that the growth process does not have to be unstable, and what improves the production function is the high technology. Human capital, education and evolving institutional structures at microeconomic level play an important role in boosting the economy. Starting from the works of Schumpeter, Mises and Hayek it was developed a whole literature around the entrepreneur role, that of knowledge and that of technological innovations and economic structures. Discussions about the engines of economic growth have not been limited to this. Investments in industry and infrastructure, industrialization through import substitution and export promotion, improvement of education level, large-scale implementation of technological progress, preferential treatment of emerging states in international trade, political stability were all considered separately or together to be factors of economic growth.

The 1960s brought in attention the importance of culture for economic growth as results from Myrdal`s work, where was offered the example of Asian countries to highlight the role played by culture on the economic and social life development. Later, Galbraith (1982) mentioned that the improvement of quality is more than a business strategy, it is a personal responsibility, a part of cultural heritage and a source of national pride.

Growth is a phenomenon far too complex for being summarised to a unicausal relation. Technical progress is mainly the economic growth driver from Solow`s point of view (1988), followed by capital and labor.

Nicolas Stern (1991) mentioned that health, education, political freedoms and environment have an important contribution to economic growth, given that the factors that determine it are the accumulation of capital, human capital that includes the learning process, research and innovation, management and organization, the infrastructure, the output allocation between the productive sectors, and the state plays an important role in improving them. Alexander Cairncross (1992) emphasized the importance of market growth, capital accumulation and technical progress. Peter Drucker (1993) bring into attention the relation between innovation, production, demand and market, a relation with multiplier effect, and Simon Ramo (1996) considered that the only way to improve a nation's standard of living is to excel from a technological point of view. The technological progress allows the development of another growth-generating activity, the international trade. International trade extends and deepens where and to the extent that there are conditions for the technical progress manifestation (Popa&Filip, 1999) in a rationalized production context or integrated at international level (Miron, 2003). Trade has the industrial revolution effect in a country with limited resources (Mill, 2003).

Bauer (2000) considers that economic performance depends on political, cultural and personal factors, on human's aptitudes and motivations, on political and social institutions. Porter (2001) dichotomously classifies economic growth factors and divides them into basic factors (natural resources, low skilled labor force, climate type, geographical conditions - common to all countries) and into top factors (infrastructure, highly skilled labor force, research and development activities - factors specific to developed countries).

Lipsey and Chrystal (2003) mention, as a growth factor, the labor force whose influence derives from demographic expansion and from participation rate, investments in human and physical capital, and the institutional environment. Information becomes an important element with the boosting effect and it shortens the time required for having an economic leap due to the low costs of multiplying information (Watson et al, 2003).

Competitiveness is another economic growth factor, being intensified like a consequence of corporation activities (Rainelli, 2004), those entities that place their activity in the countries that offer the most attractive advantages, without take into account the national specificity (Reich, 1992).

1.2. From classical and neoclassical economic growth to degrowth

In recent years, the interest for low economic growth, zero growth and degrowth in the countries characterized by high consumption has returned (Victor, 2011). The concept of degrowth has its roots in the Nicolae Georgescu-Roegen`s entropy theory, returning powerfully in attention in France, Italy, Spain and not only (Kerschner, 2010). Degrowth movement is gaining ground, albeit slowly as a consequence of the degrowth movements, which require changes in the way of people thinking and acting but also in the macroeconomics (Thomson, 2011).

There is a quasi-unanimity consensus among specialists that substantial changes are absolutely necessary for avoiding ecosystem degradation (Sandberg et al, 2019). Economic growth is not compatible with environmental sustainability (Alier, 2009). After all discussions about growth over time two alternatives, a-growth and degrowth, have been formulated (Jeroen et al, 2015; van den Berg&Kallis, 2015). The degrowth orientation has attracted, since 2006 when it appeared in France, enough discussions that have been favoured by the concomitant manifestation of four crises, the environmental one manifested by climate change, the social one manifested by inequalities growth, the political one manifested by the decommissioning of political environment, and the human one manifested by the loss of direction (Baris, 2007). The economic growth has been based on energy production from fossils fuels, and the social metabolism is also based on the energy consumption with negative impact generated by the growth in the population number and density above a certain level that will affect the food security as well as economic growth and implicitly technological development (Fischer-Kowalski&Haberl, 2016). Economic growth has reached its limits through others from environmental reasons, production frontiers, economic policies, economic scenarios, crises, population and social movements (Kallis et al, 2012).

The effects of growth on resources and on environment have not gone unchallenged. So, Fischer-Kowalski and Haberl (2016) believe that it is impossible to maintain the current economic growth based on energy consumption simply by changing the source from fossil fuel to bioenergy. Given that emissions are causing negative effects on growth, it is developed the concept of sustainable degrowth, a concept defined from ecological and economical perspective, being a equitable and social sustainable, and possibly stable, reduction of production (Kallis, 2011), but also being a way of maintaining the environmental integrity (Jakob&Ottmar, 2013).

Degrowth is also associated with the reduction of four dimensions: the GDP, consumption, working time and physical quantities of the economy, to which is added the fifth dimension, that of radical change of the economy (van der Bergh, 2010).

Since 2009, Europe has agreed that carbon dioxide emissions should be reduced by 20-30% from the 1990`s level untill 2020, and this is just the beginning to improve the impact of environmental indicators (Alier et al, 2010). The impact on environment is reflected by the energy consumption and the emission quantities (Nørgård&Xue, 2016). In this article we have stopped on the analysis of relationship growth - quantity of emissions for the particular case of the EU28 area.

1.3. Economic growth and the quantity of emissions relationship. Do we need degrowth?

The relationship between economic growth and the amount of emissions is a frequent concern in the research activity because greenhouse gas emissions are a negative spillover that reduces social welfare (Mendez&Santos, 2008). The effects of greenhouse gas emissions have become a global concern since 1992 when, within the frame of the United Nations Framework Convention on Climate Change (UNFCCC), it were taken measures to reduce them by developed countries; than, in 1997, it was signed one of the most comprehensive protocols on this subject, the one in Kyoto, as in 2009, in the Copenhagen Accord, it was specified the need to keep the average temperature rise below 2 degrees Celsius (Jackson et al, 2015; Mert et al, 2019).

A study of the link between growth and the total amount of CO2 emissions in the European perimeter between 1981 and 1995 reveals a large disparity between the developed states and the rest, pointing out that a common policy for reducing emissions cannot be applied in the EU, because of the particularities of each country, in particular of the industrial characteristics (Bengochea-Morancho et al, 2001). European states use both forms of energy, renewable and non-renewable, at the same time. The economy is entering in a new stage, that of the transition towards the use of new forms of energy, based on renewable, green sources. Historically speaking, the world has evolved from the use of renewable sources to non-renewable sources and back to renewable ones (Tahvonen&Salo, 2001). Developed states have greater capacity for adopting measures to implement green energy that meet the principles of degrowth.

An analysis of the economic growth sources in relation to greenhouse gas emissions in the OECD countries during 1982 and 1997 shows that the growth process, measured by the evolution of GDP per capita and by the demographic expansion, and the boosting of primary energy consumption generates the increase in greenhouse gases quantity (Hamilton&Turton, 2002). Transport activity generates 3.5% of all anthropogenic radiative forcing affecting the environment in a major way (Mendez&Santos, 2008). Other studies, focusing on certain forms of transport, shows that, for example, the air transport, although it has a negative contribution on the environment and the ecosystem, it is a reduced one (Anger, 2010).

The manifestation of a long-term relationship between CO_2 emissions, energy consumption and economic growth is demonstrated by the example of 19 European states (Acaravci & Ozturk, 2010). However, there is a reduction in the amount of emissions in the EU27 in all sectors except construction domain, given that the economic growth has been registered in agriculture, energy, industry and construction (Jaeger et al, 2011). The study of Jaeger et al (2011) argues that the reduction of emissions is possible as a result of the energy production growth and of the renewable energy production implementation by giving up the consumption of that obtained from coal. This was made possible by the investments increase that allowed to replace the fossil fuel with renewable sources and to increase the energy efficiency.

The relationship between economic growth, CO_2 emissions and foreign direct investments is studied in the context of tourism activity, also on the European model, from 1988 to 2009, highlighting its long-term manifestation and the positive impact of tourism, emissions and foreign direct investments on the economic growth, like this one, in turn, to exert its influence on the quantity of emissions, without the tourism and the investments to have the same effect but, on the contrary (Lee & Brahmasrene, 2013).

Another study of the relationship between growth and CO_2 emissions, on a sample of 18 European countries between 1995 and 2012, shows that economic progress is based on high energy consumption that generates greenhouse gases, but it is not a sustainable relationship in the long term due to the implementation of new technologies (Rafal, 2015).

On the sample of 23 European states in the time horizon 1990-2013, the influence of the renewable electricity production by sources of CO_2 emission was studied, reaching the conclusion that, in the long term, economic growth, urbanization and financial development determine the increasing of the amount emissions while the trade liberalization has the opposite effect, their reduction (Al-Mulali et al, 2015). The most responsible for increasing emissions are China, US and Europe, which together produce nearly half of global GDP, proving that the environmental policy is as inefficient when it comes to reduce the emissions despite progress that has been made. (Averchenkova et al, 2016).

More recent analysis of the dynamic relationship between pollutant emissions, economic development and energy consumption for 14 European countries divided into three groups according to the degree of knowledge development showed similarities between countries in the same group (Pilatowska&Wlodarczyk, 2018). A research focused on a cluster of five developed European states (Germany, France, Italy, Spain and UK), between 1985-2016, shows that new regulations on renewable energy are required in order to identify new energy sources, to promote innovations in the energy field but also to reduce the degree of environmental degradation caused by the energy consumption from fossil fuels (Balsalobre-Lorente et al, 2018).

A sample of 116 countries was the base for an analysis of the causal relationship between economic growth, CO_2 emissions and energy consumption in the temporary horizon 1990-2014. The study found that at regional and global level economic growth is not the cause of energy consumption with the exception of Latin America and the Caribbean, however, energy consumption is negatively impacting global economic growth and it is positive only in the Middle East, North Africa, Asia-Pacific, Latin America and the Caribbean (Acheampong, 2018). More recently, an analysis of the relationship between CO_2 emissions, GDP, renewable energy, non-renewable energy and foreign direct investment inflows across a group of 26 European countries shows that the use of renewable energy attenuates the amount of emissions, which is why European countries have to improve energy technologies and efficiency but also have to improve the environmental regulations regarding foreign direct investments (Mert et al, 2019).

2. Method and methodology

In the analysis we correlate GDP, as a measure of economic growth, with pollutant emissions, total and by sources (total CO_2 emissions, emissions from coal and coke, from natural gas processing, from oil processing and other liquefied products). We analyze, according to the data accessed, the situation for EU28, between 1980 and 2016. The European area includes the UK by the nature of the data. The temporary horizon stops, due to the validity of the data, in 2016 when the UK was EU member.

For the regression analysis we use the acronyms: ECO_2 to express the total carbon dioxide emissions (MMtons CO_2), ECC to express the emissions from coal and coke processing (MMtons CO_2), ENG to express the emissions from the use of natural gas (MMtons CO_2) and EPL to express emissions from the use of petroleum products and other liquefied products (derivatives) (MMtons CO_2).

We divided the 28 European member states into four groups according to their GDP growth during the period 1980-2016 and we compared the growth with that of the EU28 GDP, which has increased about 2.4 times. Thus, we have formed the G4 group of countries whose for which GDP increased about 1.5 times to the level of the comparison year (Greece and Italy); the G3 group of countries whose for which GDP increased about 2 times to the level of the comparison year, but below the European average (Austria, Belgium, Bulgaria, Finland, Croatia, Cyprus, Czech Republic, Hungary, France, Romania, Portugal, Germany, Denmark, Latvia, Lithuania, Slovenia - for Croatia, Cyprus, Czech Republic, Hungary, Germany, Latvia and Lithuania the comparison period is 1992-2016 due to unavailability of data from 1980); the G2 group of countries whose for which GDP has increased more than twice compared to the beginning of the analyzed period, but above the European average (Spain, UK, Estonia, Poland, Slovakia - for Estonia the period of GDP growth starts in 1992, for Slovakia in 1993, and for Poland in 1989, in all cases the comparison is made with 2016, the reason being the data unavailability since 1980), and the G1 group consists of countries whose GDP has increased more than 3 times compared to the level of comparison year (Ireland, Luxembourg, Malta - for Luxembourg and Malta the comparison period starts with 1988, in all cases the comparison is made with 2016, due to lack of data from 1980). Thus, in Annexes, we specified the main emission trends and the group of which each country belongs to see to what extent the economic growth is supported by the energy production.

The rregression analysis is based on the following research hypotheses:

H1: classical and neoclassical growth supports future European development.

H2: classical and neoclassical economic growth will be possible on the same principles as before.

To demonstrate the research hypotheses, we used the method of simple and multiple linear regression analysis. The method of multiple linear regression analysis was used to study the relationship between growth and total emissions and the relationship between growth and the emissions resulting from oil and derivatives processing for all 28 European states. The simple linear regression was used to study the relationships between growth and emissions from coal and coke processing for 27 European states because we did not have data for Malta, and between growth and emissions from natural gas use for 26 European states because we did not have data for Malta and Cyprus.

In the three cases we started from the analysis of equations whose shapes are:

$$Y = \beta_0 + \beta_1 ECO_2 + \beta_2 EPL + \varepsilon \qquad (1)$$

$$Y = \beta0 + \beta1ECC + \varepsilon \qquad (2)$$

$$Y = \beta0 + \beta1ENG + \varepsilon \qquad (3)$$

The variable Y represents the dependent one, assimilated to GDP, and ECO2, EPL, ECC and ENG are independent variables assimilated to the forms of emissions analyzed, β_i represents the regression parameters, and ε is the error term.

Parameters β_0 and β_1 are the parameters or regression coefficients, intercept and slope respectively. The first is a free term, associated with a constant, and the second shows the rate of variation of the dependent variables relative to the independent one. The estimation of the parameters will be done according to the formulas:

$$\hat{\beta}_0 = \frac{\sum_i y_i \sum_i x_i^2 - \sum_i x_i \sum_i x_i y_i}{n\sum_i x_i^2 - \left(\sum_i x_i\right)^2} \qquad (4)$$

and,

$$\hat{\beta}_1 = \frac{\sum_i (y_i - \hat{y})(x_i - \bar{x})}{\sum_i (x_i - \bar{x})^2} \qquad (5)$$

The determination coefficient is the one that measures how much of the total variation of the dependent variable is explained by the model. Its estimation is based on the relationship below.

$$R^2 = \frac{\sum_i (b_0 + b_1 x_i - \bar{y})^2}{\sum_i (y_i - \bar{y})^2} \quad (6)$$

We use the t test (Student) to test the regression parameters and F test (Fisher) to test the model. The calculated values of the two tests are obtained from the formulas presented below.

$$t_{calc} = \frac{b_1}{\sqrt{\frac{\sum_i e_i^2}{(n-2)\sum_i (x_i - \bar{x})^2}}} \quad (7)$$

and,

$$F_{calc} = \frac{\sum_i (b_0 + b_1 x_i - \bar{y})^2}{\sum_i (y_i - b_0 - b_1 x_i)^2} \cdot \frac{n-k}{k-1} \quad (8)$$

In the formula of calculated F, *n* represents the volume of the sample, and *k* is the number of the model parameters, and the difference (*n*-*k*) represents the degrees of freedom. Both tests, Student and Fisher, help us to reject the null hypotheses and to take the decision by comparing the calculated values with the theoretical ones. For a better acuity of results we chose to use the logarithm of input data.

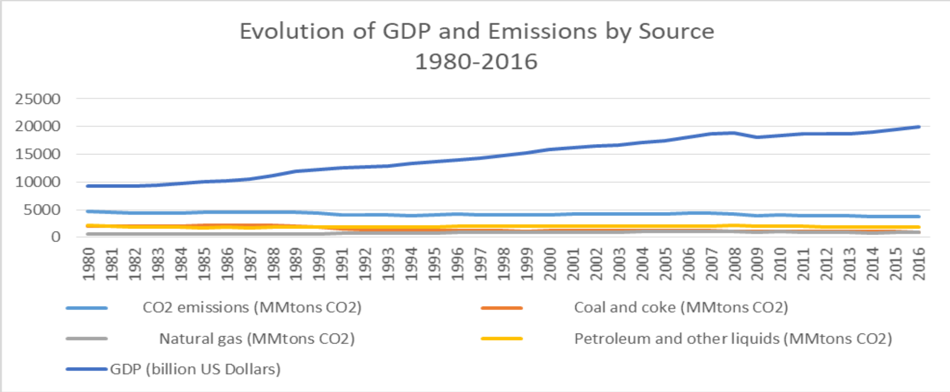
3. Results and discussions

The evolution of GDP and carbon dioxide emissions and those from certain sources (coal and coke, natural gas, oil and derivatives) are shown in Figure 1. Trends show that the process of economic growth illustrated by the GDP per capita evolution and the quantities of polluting emissions evolve relatively similar, with some differences between the type of emissions in certain periods. GDP per capita grows faster than the total amount of emissions, which is part of the nature of things, the growth being supported also by factors that do not generate spillovers in the form of emissions.

Graph 1 shows that over the period 1980-2016, on average, European GDP followed an upward trend. The quantities of emissions, overall and by their sources of production, reflect about the same evolution. The amount of carbon dioxide emissions fluctuated on an overall upward trend during the reference period. The total amount of emissions was reduced only in the first half of 1990s and in the period 2010-2015. Emissions from coal and coke processing, followed a relatively constant evolution until 1984, after that followed a strong upward trend until the 1990s when we observed a decline, but then the growth was resumed. The amount of emissions resulting from natural gas processing was continuously rising with two peaks in 1996 and 2010. Only in 2012 and 2014 the growth was interrupted.

Regarding the quantity of emissions from oil and derivative sources, this was slightly down in the early 1980s. From 1982 until the horizon of 2010 the increase of these emissions was slight but continuous, with a significant reduction in the first half of the 2010 decade.

Figure 1. The Evolution of GDP and the emissions



(*Source:* https://www.eia.gov/)

Graph 1 reflects the fact that the evolution of GDP per capita was in tandem with that of the emissions quantity. Periodically, the economic growth was supported by the production based on different energy sources with energofag effect. In the 1980s, emissions from coal and coke processing were at the same rate as GDP per capita. The 1990s were marked by higher emissions from oil and derivatives processing compared to the amount of emissions from coal and coke processing. This trend was maintained at the beginning of the 2000s, but the year 2008 changed the economic picture by entering the European economy in the global crisis. In these circumstances, with the reduction of the European GDP per capita, we noticed the emissions reduction. The economic revival after 2010 was made against the background of the increase in the quantity of emissions, with the mention that those based on coal and coke registered a significant decrease.

However, in the EU28 perimeter, there was a detachment of the economic growth from the growth of emissions. This is explained by the reduction of the energy-intensive activity as a result of the adoption of clean technologies for the developed members and the reduction of the industrial activities for the developing members. The states whose economic growth is based on the tertiary sector are again in a position to motivate development other than by polluting actions. However, there are situations where economic growth is supported precisely by the activities that generate carbon dioxide emissions as we show in Table 1 (see Annex 1). EU28 total emissions decreased between 1980 and 2016, but not those from natural gas (ENG).

There is no concrete link between increasing GDP per capita and decreasing emissions (Table 1). Even if we expect the fastest-growing countries to record increases in emissions and we expect that the states with the smallest increases in GDP per capita to record low emissions, this is not always the case. The three G1 countries confirm this hypothesis with the exception of Luxembourg, which has managed to maintain the quantity of emissions during the period 1980-2016. From the G2 group, only Spain registered an increase in emissions during the analyzed period. In the case of G3, we notice the formation of two subgroups of European states, some for which the economic growth is accompanied by the increase of the emissions quantity and some for which the economic growth is not realized under the conditions of the emissions quantity increase. In G3 are included both developed and developing European states. Some members of the G3 already apply measures to reduce the amount of emissions, including through the use of advanced technologies, while others have low levels of industrialization. From G4 only two states, Italy and Greece, do not comply with a common rule, meaning that Italy is recording decreasing emissions while Greece is recording their growth.

Multiple regression analysis shows that when total emissions (ECO_2) and those resulting from oil and derivatives processing (EPL) are non-existent (equal to zero), then GDP per capita would increase by 0.6736 units. If the EPL level were zero or constant and ECO_2 would increase by one unit, the GDP per capita would increase by approximately 0.79 units, and when the total emissions would be constant and the EPL would increase by one unit, the GDP per capita would increase by about 0.27 units.

This can be seen from the rewriting of equation (1) as:

$$GDP_{\text{per capita}} = 0.6736 + 0.7870*ECO_2 + 0.2686*EPL \quad (4)$$

The regression coefficients fall within the confidence intervals, according to Table 2. The correlation coefficient, of 0.9675435, shows an extremely close connection between the two types of independent variables, and the value of the coefficient of determination of 0.9568 shows that 95.68% of the GDP per capita variation is explained by the variation ECO_2 and EPL.

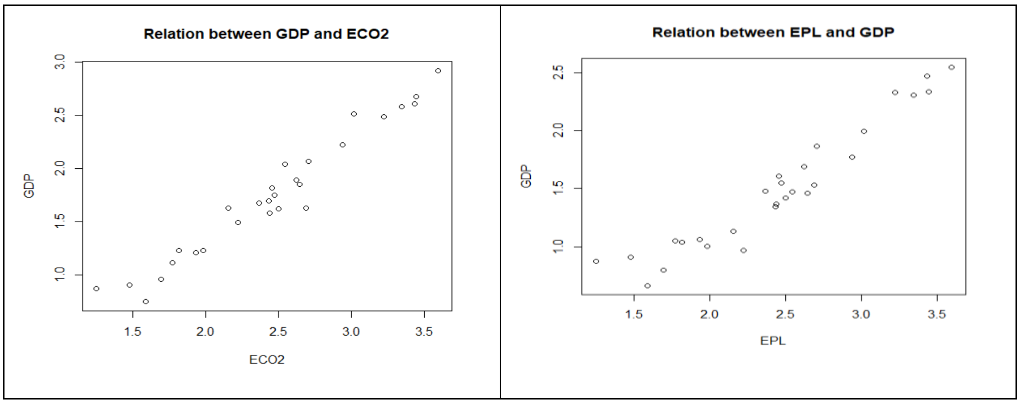
Table 1. Multiple regression specific values for ECO_2 and EPL

Confidence Intervals			t Test		F Test	
	2.5%	**97.5%**	**Calculated Value**	**Theoretical Value**	**Calculated Value**	**Theoretical Value**
Intercept	0.5080917	0.8390581	8.383	2.074	277.2	3.443
ECO_2	0.4332316	1.1406708	4.582			
EPL	-0.1257494	0.6629126	1.403			

(*Source:* author`s calculations)

The relationship between economic growth (GDP per capita) and total emissions (ECO_2) and those resulting from the processing of oil and its derivatives (EPL) is presented in Figure 2 where the relationship of linearity and dependence between the analyzed variables is observed.

Figure 2. The relationship between European economic growth ($GDP_{per\ capita}$) and total emissions (ECO_2) and those resulting from oil and derivatives processing (EPL)



(*Source:* author`s contribution)

In order to test the regression coefficients we formulated the following hypotheses:

H_0: $\beta_1 = 0$ and $\beta_2 = 0$; H1: $\beta_1, \beta_2 \neq 0$

To test the hypotheses, we used t test whose values are presented in Table 1. Based on the calculated and theoretical values of the test we applied the decision rule and we stated that, with a probability of 95%, the null hypothesis (H0) is rejected in the case of the relationship between growth and ECO_2, and in the case of the one between growth and EPL the null hypothesis is rejected under the conditions of a lower probability.

In order to test the model, we formulated the hypotheses:

H_0: $\beta_0 = \beta_1 = \beta_2 = 0$; H_1: $\beta_0 \neq 0$, $\beta_1 \neq 0$, $\beta_2 \neq 0$

The calculated and theoretical values of the F test show that the null hypothesis with a probability of 95% is rejected, which means that the model explains significantly the dependence between the variables.

The analysis of the relationship between economic growth and emissions from coal and coke processing (ECC) shows that eliminating these emissions would allow a GDP per capita increase of 2.1870 but a variation with one unit of ECC allows an increase of 0.3857 units of the dependent variable. Also, eliminating ENGs or keeping them at a constant level allows GDP per capita growth of 1.6468 units, and variation with one unit of ENC will result in an economic growth of 0.8068 units. We reproduce this by rewriting Equations 2 and 3 as follows:

$$GDP_{per\ capita} = 2.1870 + 0.3857*ECC \quad (5)$$

$$GDP_{per\ capita} = 1.6468 + 0.8068*ENG \quad (6)$$

The regression coefficients belong to the confidence intervals, and the correlation coefficient shows that, in the proportion of 81%, the economic growth depends on activities that produce ECC and, in proportion of 92.21%, of activities that produce ENG (table 2).

Table 2. Multiple regression specific values for ECC and ENG

		Confidence Intervals		t Test		F Test	
		2.5%	**97.5%**	**Calculated Value**	**Theoretical Value**	**Calculated Value**	**Theoretical Value**
ECC	*Intercept*	2.0186216	2.3553317	26.754	2.060	47.94	3.049
	ECC	0.2709382	0.5003718	6.924			
ENG	*Intercept*	1.4646906	1.8288460	18.67	2.064	136.3	3.073
	ENG	0.6641982	0.9494273	11.68			

(*Source:* author`s calculations)

We tested the regression parameters, both in the study of the relationship between growth and ECC but also in that of the study of the relationship between growth and ENG, formulating the hypotheses: H_0: $\beta_1 = 0$; H1: $\beta_1 \neq 0$

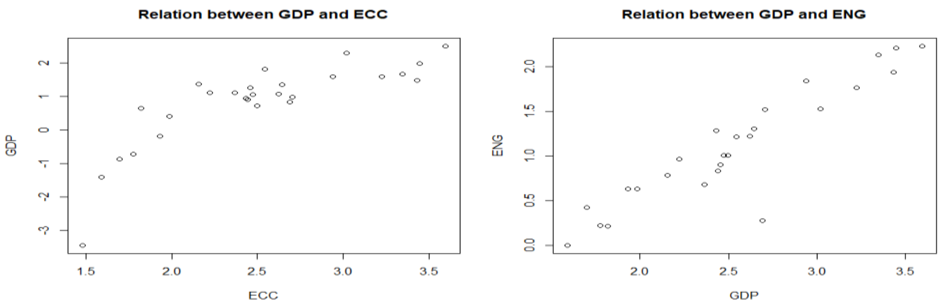
Table 2 presents the values of the tests we used to validate the hypotheses. The parameters were tested, in this case also, with the help of the t test. In the case of the relationship between growth and ECC and ENG, the null hypothesis is rejected, so the decision is that, with a probability of 95%, a connection between the dependent variable and the independent ones is manifested .

To test the model we formulated the hypotheses: H_0: $\beta_0 = 0$, $\beta_1 = 0$; H_1: $\beta_0 \neq 0$, $\beta_1 \neq 0$.

We tested the model using the F test and, according to the calculated and the theoretical values, we reject the null hypothesis and we make the decision that, with a probability of 95%, ECC and ENG determine the economic growth.

Figure 3 reflects the causal relationship between growth and ECC and ENG. In the case of all types of emissions, we concluded that, in relation to economic growth, the influence is positive and increasing. The activities that produce natural gas emissions have the biggest influence on European economic growth followed by those from coal and coke and, by ones from petroleum and derivatives.

Figure 3. Relationship between European economic growth ($GDP_{per\ capita}$) and emissions from coal and coke processing (ECC) and those from natural gas (ENG) processing



(*Source:* author`s contribution)

The results of regression analysis show that in the EU28 economic growth is based on polluting activities with harmful effects on the population and the ecosystem, and these conclusions validate the first research hypothesis but rejects the second hypothesis. Obviously, we are in a position to rethink the principles of European growth in the future, the solution being found in both the proposed solutions of sustainability and degrowth.

Table 3. Synthesis of the Regression Coefficients

<table>
<tr><td colspan="5">Multiple Linear Regression (GDP~ECO2+EPL)</td></tr>
<tr><td colspan="5">Coefficients:</td></tr>
<tr><td></td><td>Estimate</td><td>Std. Error</td><td>t value</td><td>Pr(>|t|)</td></tr>
<tr><td>(Intercept)</td><td>0.67357</td><td>0.08035</td><td>8.383</td><td>9.91e-09 ***</td></tr>
<tr><td>ECO2</td><td>0.78695</td><td>0.17175</td><td>4.582</td><td>0.00011 ***</td></tr>
<tr><td>EPL</td><td>0.26858</td><td>0.19147</td><td>1.403</td><td>0.17298</td></tr>
<tr><td colspan="5">Residual standard error: 0.1353 on 25 degrees of freedom</td></tr>
<tr><td colspan="3">Multiple R-squared: 0.9568</td><td colspan="2">Adjusted R-squared: 0.9534</td></tr>
<tr><td colspan="3">F-statistic: 277.2 on 2 and 25 DF</td><td colspan="2">p-value: < 2.2e-16</td></tr>
<tr><td colspan="5">Simple Linear Regression (GDP~ECC)</td></tr>
<tr><td colspan="5">Coefficients:</td></tr>
<tr><td></td><td>Estimate</td><td>Std. Error</td><td>t value</td><td>Pr(>|t|)</td></tr>
<tr><td>(Intercept)</td><td>2.18698</td><td>0.08174</td><td>26.754</td><td>< 2e-16 ***</td></tr>
<tr><td>ECC</td><td>0.38566</td><td>0.05570</td><td>6.924</td><td>2.94e-07 ***</td></tr>
<tr><td colspan="5">Residual standard error: 0.3533 on 25 degrees of freedom</td></tr>
<tr><td colspan="3">Multiple R-squared: 0.6572</td><td colspan="2">Adjusted R-squared: 0.6435</td></tr>
<tr><td colspan="3">F-statistic: 47.94 on 1 and 25 DF</td><td colspan="2">p-value: 2.945e-07</td></tr>
<tr><td colspan="5">Simple Linear Regression (GDP~ENG)</td></tr>
<tr><td colspan="5">Coefficients:</td></tr>
<tr><td></td><td>Estimate</td><td>Std. Error</td><td>t value</td><td>Pr(>|t|)</td></tr>
<tr><td>(Intercept)</td><td>1.64677</td><td>0.08822</td><td>18.67</td><td>8.52e-16 ***</td></tr>
<tr><td>ENG</td><td>0.80681</td><td>0.06910</td><td>11.68</td><td>2.20e-11 ***</td></tr>
<tr><td colspan="5">Residual standard error: 0.2237 on 24 degrees of freedom</td></tr>
<tr><td colspan="3">Multiple R-squared: 0.8503</td><td colspan="2">Adjusted R-squared: 0.8441</td></tr>
<tr><td colspan="3">F-statistic: 136.3 on 1 and 24 DF</td><td colspan="2">p-value: 2.198e-11</td></tr>
</table>

(*Source:* author`s calculation)

In table 3, we summarized the statistical results obtained from the linear regression calculations, broken down by the two methods used, multiple and simple. Tables 1, 2 and 3 provide the complete statistical picture of the research based on which we have drawn the conclusions regarding the relationship between growth, total emissions, emissions from sources of generation and, implicitly, the conclusions regarding the need to apply the principles of the degrowth type economy, the basis of which is sustainability in all its forms.

3.1. About research opportunities and limits

The analysis of simple and multiple linear regression having as a central point the European states in the time horizon 1980-2016 reveals the manifestation of a long-term relationship between the economic growth, fundamental process for improving the quality of life, and the quantity of emissions, total and on sources. The results we reached reinforce the conclusions of other research on this topic. We have proposed as the starting point of the research two correct argumentative hypotheses. Following the empirical approach, we affirmed the first hypothesis and we rejected the second one. We have found that the methods and principles of classical and neoclassical economic growth, so important for all of us, no longer provide the appropriate framework for future growth. Economic, social and environmental sustainability will have to be based on perceptions of degrowth, which are more friendly with the environment. The results we have reached do not allow us to trace the European dichotomous space in the sense of dividing countries into a group of states that represents a model in terms of the relationship between growth and emissions and a group of states that takes over the model, the first group. We find that, within the perimeter of EU28, the main feature is heterogeneity. This characteristic requires economic policy measures adapted to the situation of each country.

Our analysis completes the specialized literature. The total emissions were detected in those from the processing of coal and coke, from natural gas and oil and derivatives, noting also the contribution of each category to the economic progress.

The limits of research derive from the lack of statistical data for some states and over a wider horizon. The analysis lends itself to continuity as the statistical data becomes accessible. Also, extending the time interval with updating data can alter the research results. The study is a stage of researching the relationship between growth and emissions. The results may also vary depending on the methodology used, the countries studied and their grouping on different criteria of differentiation. Therefore, the study of this subject is suitable to be carried out with other methods, other indicators, other subjects or temporary frames. Often the methodology differentiates the results. This offers different perspectives of the same reality reflected by the variety of conclusions.

The importance of the study also lies in the fact that we strengthen the conclusions of similar studies conducted in a different spatial-temporal and methodological context, namely the need to reduce emissions with harmful effect on the environment, especially those resulting from coal and coke processing. The time has come for the principles of growth to be brought to a higher level that supports the idea of economic, social and environmental sustainability. This level takes the form of degrowth, a particular mode of growth that requires the involvement of public administrations through efficient, high-quality measures, in order to achieve the economic, social and environmental objectives.

4. Conclusions

The analysis of the relationship between growth and the amount of emissions, total and by sources of provenance, shows that European economic progress, as we know it, is no longer the best solution in the future, hence we need to focus on another form of growth, namely degrowth. The classical and neoclassical growth mainly refers to the effort of macro-indicators quantitative expansion. For decades, this kind of growth has allowed the improvement of the people quality of life, but it has not been without consequences. The main effects whose manifestations we feel more and more acute are pollution and climate change. As a result, we asked whether growth can continue in the same way and whether pollutant emissions can be reduced under these conditions.

Starting from the European reality, through a regression analysis, we found that, theoretically, the economic growth can continue as before, validating the first research hypothesis but, as a result of a very high dependence of growth on polluting emissions, of over 95%, invalidates the second research hypothesis that the quantitative expansion of European economic activities will be done simultaneously with the emissions reduction. Growth is strongly and positively correlated with intensely polluting economic activities. European efforts to reduce emissions are particularly clear in the case of developed member countries. Other members have a more relaxed polluting activity which favors them from the amount of emissions reduction point of view. The conclusions of this study validate those of Bengochea et al (2001) because we note the heterogeneity of the growth-emissions ratio on the European territory. Even under these conditions, a change of paradigm and attitude appears necessary. In this context, changes are needed regarding the process of economic growth, whose dynamics of accomplishment lead to adopt the principles of degrowth, especially those of the conscience, the attitude and the population behavior and the economic agents that maintain a high quality of life at the same time, with significant environmental and ecosystem improvements.

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Annex 1

Table 1. European trends in the amount of carbon dioxide emissions

Country/ Region	**Period**	**Trend of ECO_2 quantity**	**Trend of ECC quantity**	**Trend of ENG quantity**	**Trend of EPL quantity**	**GDP growth group**
EU28	1980-2016	decrease	decrease	significant growth	slightly decrease	
Austria	1980-2016	growth	slightly decrease	growth	significant growth	G3
Belgium	1980-2016	decrease	significant decrease	growth	slightly decrease	G3
Bulgaria	1980-2016	decrease	decrease	decrease	decrese	G3
Croatia	1992-2016	slightly growth	growth	decrease	significant growth	G3
Cyprus	1980-2016	significant growth	negligible quantity	negligible quantity	significant growth	G3
Czech R.	1993-2016	decrease	decrease	growth	growth	G3
Denmark	1980-2016	decrease	decrease	growth	decrease	G3
Estonia	1992-2016	significant decrease	decrease	decrease	decrease	G2
Finlanda	1980-2016	decrease	decrease	growth	decrease	G3
France	1980-2016	decrease	decrease	growth	decerase	G3
Germany	1991-2016	decrease	decrease	growth	decrease	G3

Country/ Region	**Period**	**Trend of ECO_2 quantity**	**Trend of ECC quantity**	**Trend of ENG quantity**	**Trend of EPL quantity**	**GDP growth group**
Greece	1980-2016	growth	growth	growth	growth	G4
Hungary	1980-2016	decrease	decrease	growth	decrease	G3
Ireland	1980-2016	significant growth	growth	growth	growth	G1
Italy	1980-2016	decrease	growth	growth	decrease	G4
Latvia	1992-2016	decrease	decrease	decrease	decrease	G3
Lithuania	1992-2016	decrease	decrease	decrease	decrease	G3
Luxembourg	1980-2016	steady	significant growth	growth	significant growth	G1
Malta	1980-2016	growth	growth	growth	growth	G1
Netherlands	1980-2016	growth	growth	growth	growth	G3
Poland	1980-2016	decrease	decrease	decrease	decrease	G2
Portugal	1980-2016	significant growth	significant growth	significant growth	significant growth	G3
Romania	1980-2016	significant decrease	significant decrease	significant decrease	significant decrease	G3
Slovakia	1993-2016	significant decrease	significant decrease	significant decrease	significant decrease	G2
Slovenia	1992-2016	significant growth	decrease	growth	significant growth	G3
Spain	1980-2016	significant growth	significant growth	significant growth	significant growth	G2
Sweden	1980-2016	significant decrease	steady	significant growth	significant growth	G2
United Kingdom	1980-2016	decrease	decrease	significant growth	growth	G2

(*Source*: according to https://www.eia.gov/)