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The impact of Digitalization (of society) on environmental awareness

Bachelor’s thesis

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ABSTRACT

The aim of this bachelor's thesis is to study the relationship between the development of society in the field of digitalization and the volume of environmental pollution. The work is based on the "ecological" hypothesis of the Kuznets curve, which assumes the existence of a relationship between the level of society's well-being and environmental pollutions. This thesis contains modeling and analysis of data collected from a sample of European Union countries and European countries. In total, 35 countries are analysed. To process the data, two types of panel data models are created: the fixed effect model and the random effect model.

Three hypotheses are put forward in the chosen topic. The first hypothesis explores the relationship between the digitalization of society and environmental awareness. Then next hypothesis put forward about the concurrent increase in the CO2 emissions and the level of GDP. The third hypothesis suggests a positive impact of human capital growth on reducing CO2 emissions. Upon completion of the data analysis a positive relationship is found between the considered variables, thereby confirming all the hypotheses proposed. The results are consistent with previous research.

Keywords: CO2 emission, economic growth, environmental Kuznets curve, human capital, digitalization, environmental awareness.

INTRODUCTION

Throughout the years there has been a growing focus on the state of the environment. It becomes highly important not only to assess the level of pollution and finance programs to protect and restore the environment, but also to educate the society to a greater extent about existing and possible environmental problems. A significant number of researches are devoted to the study of various types of pollution. The priority remains the study of gas emissions on the economies of Europe countries, although no small attention should be paid to emissions that do not have global attention, such as solids and some gases (Bai *et al*., 1992; Grossman, Krueger, 1995).

Modern web resources allow you to track the necessary information regarding current environmental issues. The demand for information based on environmental topics reflects the interest of the public. This interested part of the population is active in communities of social networks, where the exchange of information becomes easier, faster and has a wide coverage. Monitoring the group activity online can provide more accurate data for research than collecting research groups individually. The research question of this study is going to be focused on the question that contains factors of modern society that can affect the volume of CO_2 emissions.

The main focus of this research is to analyze the contribution to active groups of social networks on the environment awareness of individual regions, as well as to review the share of responsibility and the willingness of society to participate in solving the environmental problems that have arisen.

The goal of the thesis is to analyze the relationship between CO_2 emissions per capita, GDP per capita, broadband connection quality, percentage of individual Internet users, manufacturing value added, energy consumption per capita, and indicator of the freedom of the press over the two time periods 2008-2018 and 2010-2018. Such time periods were taken in order to analyze the impact of the global economic crisis on the underlying relationships between the variables of interest.

The research question was asked as follows: What is the impact of digitalization of the society on the environmental awareness?

In this regard, the author puts forward the following hypotheses:

H1. The digitalization indicator impacts positively environmental awareness measure.

H2. An increase of GDP per capita impacts positive CO_2 emissons.

H3. An increase in level of human capital leads to lower CO_2 emissions.

The work is divided into three parts. First, an overview of the early theoretical and empirical research is provided, on the basis of which all further work has been done. The second part is devoted to a review of the data used, a description of methods for collecting and analyzing data. The third part covers data modeling, its assessment and subsequent analysis.

Data used in the study is taken from publicly available Eurostat databases, the World Bank datasets, OECD database and Freedom house database. Further data preparation was carried out in Excel, and the empirical analysis was performed in the Gretl econometric modeling software package.

1. THEORETICAL FRAMEWORK

1.1. Main theory

With the development of the industrial revolution has also changed human preferences and needs. The prompt economic growth among countries and human activity in mining of fossil fuels only continues to increase in speed and cover large volumes of resource consumption. However, the consumption of that myriad of resources does not go unnoticed. The use of fossil fuels undoubtedly led to lower carbon levels in the atmosphere and at the same time, an increase in atmospheric temperature entails a number of problems with global warming and climate change. Based on the Intergovernmental Panel on Climate Changes (IPCC) report of 2007, a general relationship between Green House Gases (GHG) emissions and global average temperature was found (IPCC 2007). Only in the last couple of decades the GHG emissions have increased about 1.6% per year with carbon dioxide (CO_2) emissions from the use of fossil fuels about 1.9% per year. Besides, the IPCC estimated the average global temperature rise between 1.1 and 6.4 Celsius degrees in the next 100 years (IPCC 2020). Taking into account the existence of a number of other gases and pollutants that also actively affect the degradation of the environment, it is carbon dioxide that remains the main indicator for many studies and statistical analyses (Grossman, Krueger 1995).

For the most part, all studies in this area have been tied to testing the effect of inequality on the environment. The EKC (Environmental Kuznets Curve) is a hypothesis describing the change in environmental quality as a country economic growth develops. This is expressed as a turning point in income - the level of per capita income at which emissions begin to decline rather than increase (Grossman, Krueger 1995). Superficially, the essence is that the more money is circulated within the state and the more the population has the funds to cover all the necessary needs with interest, the more the public begins to pay attention to the intangible aspects of general standards and try to correct them. Roughly speaking, if a person is able to cover all the necessary costs and has money left, then he/she may think about breathing clean air and drinking clean water.

In modern economic literature, a special place is given to the problem of uneven distribution of personal income. To estimate inequality, Kuznets (1955) uses the TDM (total disparity method) method to study the relationship between income differentiation with the socio-demographic structure of society and the main macroeconomic indicators. This is what formed the basis of Kuznets' hypothesis, which established the dependence of the Gini coefficient on GDP per capita. This relationship is visualized on the Environmental Kuznets curve. Most of the theoretical models of the relationship between CO_2 emissions can be attributed to one of two directions. The first revolves around the Kuznets curve and examines the question of how carbon dioxide emissions evolves in the process of economic development. The second considers the opposite case - the impact of the level of development on economic growth. Precisely this manifestation of division can be traced in applied studies: some look for data by visualizing the Kuznets curve, the second part is devoted to assessing how pollutions affect the rate of economic growth, if there are any. That is, despite the fact that the empirical literature on CO_2 emissions and growth pursues the presence of a correlation that can carry data about the nature of the causal relationship, most works investigate only one of its sides.

The appearance in 2005 of the concept of "web 2.0" marked the beginning of the transition from an integrative approach to a social one, therefore the concept of "social network" firmly joined the list of the most widespread and used Internet terms. The basic principles of ICT (information and telecommunication technologies) Web 2.0 are named as interactivity, syndication and socialization (O'Reilly 2007). They can be briefly described as follows:

- *Interactivity* - Web 2.0 is a technology for filling a site with content, when it gets better the more people use it - visitors actively form the site, filling and repeatedly editing its content. And if, when using Web 1.0 technologies, a significant part of the site's content was determined by developers, not users, then Web 2.0 technological platforms act, in O'Reilly's words, only as intermediaries between users in the exchange of their life experience.
- *Syndication* - full or partial use of other Internet services (for example, the so-called RSS (Rich Site Summary) feeds as sources of information, due to which the user is provided with new opportunities for work. A service can also become a source of information for other services, thereby creating a network of interconnected, integrated services.
- *Socialization* - use of technology that allows you to create a networked community. This concept usually includes the possibility of individual site settings and the creation of a personal zone for the user in order to realize its uniqueness, and technologies that allow the

community to self-regulate and give users additional goals of presence on the site (competitive element, reputation system, etc.).

The Internet is becoming an effective mediator between information and people. Everyone has the ability to generate information that anyone can see, and a separate uniqueness remains that representatives of the mass media cannot correct it.

Recently, the phenomenon of active participation in social networks and online activism in general has acquired the term "Greta Thunberg effect", which clearly refers to the young Swedish environmental activist Greta Thunberg. This definition was derived from a 2019 survey of social media and user behavior by a UK media regulator Ofcom (2019). More than 3,500 children and their parents participated in the study of the impact of digital platforms on children's online activity. The study was conducted in comparison with the results of 2018. As it turned out, children are more likely to be online. This became especially noticeable in supporting organizations by sharing their posts or commenting on them. In addition, children aged 12-15 began to use social networks to support their peers who found themselves in difficult situations (Ofcome 2019).

A set of scientific, research and design works that serve to obtain new knowledge or create new technologies combined into a Research and Development (R&D) sector. This is an absolute must for any economy or company wishing to remain competitive. However, not everyone is in a hurry to invest in research and development, and as a result, the share of internal costs for R&D is several times behind the volume of investments in new technologies and products (Cole 2007). This takes a long time and is associated with significant financial risks: the quantitative economic effect of an innovation, as a rule, is visible (or not visible) only after it has already been introduced. Small companies cannot afford such costs, and large companies, especially state-owned companies, do not want to take risks, since the risks associated with start-ups are not included in their budgets (Chu and Cozzi 2016).

In most countries, the corporate sector bears the main burden of spending on new developments. It makes no sense to calculate the average percentage of investments in R&D in business, in each industry the need for innovations and the cost of their serial production are different (Cole *et al.* 2008). The quality of life does not always directly depend on material well-being. The same story with investments in R&D. Might devote in new developments as much as you like, but there can not be a 100% guarantee that research spending will bring instant profits. In theory, innovation is critical to a high-margin business, but there is no reliable correlation between R&D costs and a company's commercial success. Costs must be rational. Innovation is the product of perfecting a good idea, not purely financial costs. Much here depends on the competence of the performers, intangible resources, time and competent accounting of R&D costs (Gerlagh 2007). Thus, with the right approach, the formulation of "innovative" tasks should be entrusted to specialists in the industry - either directly to the business (if they have competencies) or to individual consulting / engineering structures, versed in both economics and science.

Economic growth - a stable increase in production and consumption from year to year - in the countries - leaders of world development has turned out to be one of the most stable phenomena of the last centuries and the subject of constant interest of economists (Jones 2016). Romer, the founder of the endogenous growth theory, wondered how to make the main source of growth - technical progress - endogenous. After all, it is the result of decisions and actions of optimizing players and can be explicitly modeled and analyzed. Just as firms make capital investment decisions, they make engineering investment decisions to maximize long-term returns (Romer 1990). It was not by chance that classical models introduced the level of technology as an exogenous parameter. Technologies, unlike capital, have an important property - non-competitiveness: they can be used simultaneously by many firms, they are the same for the entire economy. The role of one firm in the formation of these technologies is negligible, which gives rise to the classic free-rider problem - the firm will not spend its money on participation in research development, knowing that the result will then be used by many firms at once and will prefer to use the inventions of others.

Romer's main idea was to make them temporarily excluded in the model. A firm investing in a new technological development temporarily obtains a monopoly on its use. This monopoly is guaranteed, for example, by secrecy, that is, no one can adopt the technology for a certain period. Or it is guaranteed by formal patent law, which legally prohibits other firms from copying the development of that firm. But over time, this development becomes public domain, raising the overall technological level in the economy.

Each period, firms make decisions about production and investment in physical capital and research, taking into account the current level of technology common to the entire economy. Capital investment simply gives this firm greater production opportunities in the future, but it is also limited by a diminishing marginal product. Investments in research also provide additional opportunities for this firm, but they also have a positive external effect - they increase the total level of technology in the economy for the next period. In the next period, the cycle repeats, firms again make decisions about investment and research development, but taking into account the great technological capabilities. And this general level of technology no longer has the property of a diminishing marginal product, so we get sustainable economic growth (Romer 1990).

By producing a new intermediate product ("capital factor"), the firm not only earns a profit for itself, but also promotes technological progress - after all, as a result, the more factors, the more production. Hence, despite temporary monopoly power, in Romer's and other models of endogenous growth, technology and organizational innovation ultimately remain a public good. Even if an invention is protected by a patent, often the very fact of a new product emerges contains important information for competitors.

Along with Romer's theory, Robert Lucas (2015) is another founder of the theory of endogenous growth, focusing on human capital. Human capital has become a key element of long-term growth that Lucas has focused on in his research. In his models, the knowledge, skills, social skills, and health of workers are as important to the production of goods and services as machines, computers, or buildings. Like physical capital, human capital grows through investment - the time spent on education, maintaining and strengthening health. But unlike physical capital, the return on human capital does not decrease following its increase, which makes its accumulation a source of sustainable long-term growth. It is the different levels of human capital that Lucas explains why poor countries remain poor and the rich get richer.

The idea of the impact of human capital on long-term economic growth is equally important during the COVID-19 pandemic. Like other disasters, it destroy human capital, hurt people's health and take lives. At the same time, such catastrophe negatively affect the prospects for long-term growth of the world economy. That is why public investments in health care and medicine are so important today, therefore, temporary losses of GDP are also largely justified from an economic point of view in order to save as many lives as possible and preserve human capital so important for future growth.

Technological progress and human capital are an obvious, but not the only factors in economic growth. The 2018 Nobel laureate Nordhaus studies the impact of climate on the economy, in fact, also creating a theory of endogenous economic growth. In his proposed "Integrated Assessment

Model" (IAM), he effectively combined the climate change model and the economic growth model (Nordhaus 1997). The most important reason why the work of Romer and Nordhaus can be combined is that the mutual influence of climate and economic development, if at all, occurs only in the long term. It makes sense to study the consequences of industrial development for the environment and, conversely, changes in the environment for production, while it relied on a long-term development model.

Nordhaus introduced two new variables to the production function: natural resources and environmental damage. Natural resources are included in this function as one of the factors of production, along with labor and capital capacities. Thus, environmental damage is included in the production function in the same way as general factor productivity, only the latter increases with technological progress, while environmental damage, on the contrary, decreases output as the environment is polluted.

Like Romer's model, Nordhaus's model generates an external effect that causes the inefficiency of an unregulated economy. Only if Romer's external effect was positive (research developments of one firm raise the overall technological level), then Nordhaus's external effect is negative. Every firm (and every country) that uses natural resources in production does not take into account the greenhouse effect it produces, since the contribution of one individual firm to global warming is very small. However, since all firms do this, then together they have a stronger impact on the environment, increasing the air temperature and ultimately harming themselves, since the total productivity of production factors decreases due to environmental damage. As a result, the economy is growing more slowly than it could.

The main attention of researchers is preferably given to the analysis of the relationship between the development of the economical welfare and IT innovations on changes in environmental quality, taking into account carbon dioxide emissions as the main variable. From a sustainable development viewpoint there has been a growing concern that the economic expansion of the world economy will cause irreparable damage to our planet. Especially when it comes to local pollution factors, a correlation was found on the bell-shaped curve linking per capita pollution to per capita GDP (Galeotti, Marzio 2007).

1.2. Previous research

The topics of the impact of the human capital on the modern activities of the state and public life have begun to acquire relevance lately, along with how quickly that sector is developing. Recently, research has been carried out on the significant relationship of schooling and tertiary education and its impact on CO_2 emissions in adjacent regions. The results of the study showed a considerable effect of an additional year of higher education on the reduction of carbon dioxide emissions by approximately 55-65% among the studied countries (Yao *et al.* 2020). The author concluded that investing in human capital remains the most easily accessible alternative way to achieve a solution to the problems of climate change and environmental protection.

From a household point of view, consumers with tertiary education are 25 percent more likely to be eco-friendly and have a preference for recycling, regardless of their income level (ESRC 2011). Households with higher human capital are more likely to choose appliances that use less energy or higher proportion of renewable energies (Ahmed and Wang 2019). In the production sector, firms with more human capital focus on sustainable development, which guarantees long-term run (Lan and Munro 2013). These industrial companies are responsible for enforcing environmental standards and taking into account strict pollution control. Communities with higher levels of human capital fight more effectively against pollution organizers. In a community survey in Indonesia, it was found that better educated communities negotiated more effectively with polluter firms (Pargal and Wheeler 1996). Lan and Munro (2013) found, using the example of China, that cities with a large volume of human capital have a greater influence on manufacturing firms that generate a significant source of CO_2 emissions and forcing them towards a more sustainable type of production.

Considering the impact of institutional governance on the regulation of CO_2 emissions, most of the early research focused on studying the type of political systems and the level of emissions. According to the results of the study, Lv (2017) showed that democracy reduces the level of CO_2 emissions only when a certain level of income within the country is reached, supporting numerous theories of endogenous economic growth. The opposite effect is observed in more corrupt states. Due to unregulated activities, there is a distortion of the actual data on atmospheric pollution at a similar value (Goel *et al.* 2013). Concealment or underreporting of the facts in some cases may suggest a predominance of indirect effects of pollutants over direct ones (Cole 2007). The fact of the open activity of the economy and government institutions makes it possible to fully assess the omissions in environmental protection and introduce the necessary measures. In some cases, the fear of introducing a new policy may lead to a decrease in production output and a deterioration in the economy. Industrial growth leads to an increase in resource consumption, and at the same time, policies aimed at reducing CO_2 emissions will not affect the volume or quality of products, but will only stimulate the use of cleaner and alternative technologies to replace natural resources (Abokyi *et al.* 2019). One of the directions of this approach is already considered to be the transition to the consumption of nuclear energy (Saidi 2020). The use of alternative energy was recorded in the territories of the OECD countries and significantly reduced carbon dioxide emissions. The author of the article argues that the combined use of nuclear energy and renewable energy has the potential, over the long term, to significantly reduce CO_2 emissions (*Ibid.,* 13).

Problems with unregulated compliance with the rules and lack of awareness of pressing problems are observed not only in air pollution. Wildlife protection occupies a separate category. The main difficulty lies not in the creation and implementation of projects for the protection of wild animals, but for the most part, delivering information to the public in an accessible manner. According to the results of the study, it was concluded that the main channels for the popularization of wildlife conservation are the mass media (Сергеева 2014). The conclusions made suggest the need to point out to society about the existing problem, inform them about the methods of conservation of wildlife and inform about the negative impact of humans. In the early stages, printed newspapers and magazines were especially effective in conveying information. With the development of progress, new technologies for transmitting information appear. Only a few years ago, the leadership was behind TV and radio, but now the most effective is the use of social networks and Internet platforms. The implementation of projects to protect the environment, including endangered species of animals and air pollution, by popularizing them through social networks, can provide positive outreach among society and lead the majority to action (Guodong *et al.* 2012).

Increasing the productivity of the enterprise is one of the key factors in the implementation of the Internet, thereby simplifying communication, speeding up the exchange of data, automating complex business processes. 45% of organizations have improved the efficiency of interaction with business partners thanks to the Internet and for 35% of organizations has reorganized and unified a range of business processes (Сергеева, 2014). A significant profit from the use of the Internet was felt by 29% of enterprises (*Ibid.,10*). It should be assumed that by introducing new Internet tools, increasing communication coverage and improving streaming connections, the economy will be able to receive new inflows of funds that can cover the costs of additional needs.

The expansion of the global Internet economy implies an increase in network investment, the creation of new jobs and, as a result, increased competition with the traditional economy.

Several studies have confirmed the positive impact of growing internet speed on the economy. The ITU (International Telecommunications Union) also noted the contribution of broadband Internet to job creation - building a broadband network requires communication technicians, builders and manufacturers of the necessary equipment (ITU 2012). The union's research also showed that in the countries of the Organization for Economic Cooperation and Development (OECD), an increase in broadband Internet penetration by 1% increased business productivity by 0.13% (Katz 2012), which is not so much, but in this the union includes the most economically developed countries, and additional profits can be up to $ 10 million. A study by the ITU found that a 10% increase in Internet coverage increases GDP per capita from 0.27% to 1.38% (Katz 2012). This is because high-speed Internet, being a key driver of increasing the efficiency of production and business processes, creating jobs and improving interaction between people, helps to develop new financial flows of the economic process.

The latest research finds a connection between the development of IT areas and the economy. Amid the COVID-19 pandemic, there has been an increase in broadband and internet usage. In 2019 alone, the increase in broadband coverage reached 32.1%, while the average annual value is considered to be 14.5% (Zhang 2021). The level of growth is primarily associated with the urgent need to "stay at home" and social networks and Internet sites remained the only way to contact others. The author of the study compares the results of GDP growth in the first months of 2019 and the first months of 2020 during a pandemic in China. For a 10% increase in the introduction of broadband connection, GDP growth amounted to 1.3%, exceeding the result of 2019 by 2 times (0.82% in 2019). In addition to the above, there is also a positive trend in the development of the bandwidth of connections. An increase in throughput speed by 1 Mbit/sec (which is taken as one unit) showed an increase in regional GDP by 0.18%. Moreover, the benefit was calculated in terms of the ratio of broadband subsidy programs to revenue generated. The benefit was about 50% of the cost (Briglauer *et al.* 2020).

Although the Kuznets' curve describes time dependence, early studies of state welfare mixed all available data into a cross-section sample and applied simple estimation techniques. With the passage of time and thanks to the advent of the Deininger and Squire database (Deininger 1996), more advanced assessment methods began to be used.

The main problems associated with the identification of the Kuznets curve were noted in the first studies on this issue. For example, M. Ahluwalia (1976) distinguishes between two types of relationship - long-term and short-term. The author emphasizes that Kuznets' work deals precisely with the long-term relationship generated by qualitative changes in the structure of the economy. On the other hand, the short-term relationship was considered separately. For example, in the 1970s, the example of Brazil in the 1960s was discussed, when high rates of economic growth, as many believed, led to a noticeable increase in inequality. Ahluwalia writes that although this effect can be easily explained in terms of EKC hypothesis (in the early stages of development, economic growth, which means economic development, leads to growing pollutions), such reasoning is not entirely valid: there are forces that have a short-term effect on CO_2 emissions. Almost all researchers agree that to fully test Kuznets's hypothesis, much longer periods of time are needed than those for which there is at least some data.

The question of the importance of the length of time intervals is also relevant for modern research. For example, Chambers (2007) distinguishes between the analysis of the impact of the current rate of economic development on the current level of inequality and the analysis of the impact of the rate of economic development in the past on the current level of inequality. He notes that many researchers used very significant periods of time in their works as the observation period (for example, Ahluwalia (1976) uses 25-year intervals, and R. Barro (2000) uses 10-year intervals). Assuming that the Kuznets curve reflects the relationship between current levels of development and CO_2 emissions, it is not necessary to use such gaps. For instance, Forbes notes that when using panel analysis methods, when the typical observation period is 5 years ($t = 5$), the estimates of the coefficients reflect the short-term effect, which does not necessarily contradict the long-term dependence, which possibly tracked using spatial sampling (Forbes K., 2000). That is, Chambers points out that the choice of the breakdown periods for the considered period of time directly depends on the hypothesis that the researcher is going to test.

This issue is very important in the context of the problem of the bilateral causal relationship between carbon dioxide emissions and economic growth. Thus, if we assume that the Kuznets curve is a long-term phenomenon and that inequality affects growth with a much smaller lag, the technical problems associated with evaluating both sides of the relationship are mitigated.

In most works, confirmation is found in the classical shape of the Kuznets hypothesis curve in the form of an inverted letter U, but the position of the breaking point differs. So, as a result of the threshold regression modeling, it became known that the position of the inflection point can depend on the size of the country's population and the openness of the economy (Chen 2007). However, of particular interest is study of List and Gallet (1999) that looks beyond the Kuznets curve and asks what happens outside the curve. The modern theory of Kuznets studies the formation of the economy through the development of technologies and the introduction of technical innovations, thereby representing in the long term the cyclical movement of inequality in the course of economic development. In their article, the List and Gallet propose to take into account the presence of the third segment of the blacksmith's curve, when the level of inequality rises again after the level of development increases. In some studies evaluating regression, in which control variables are included (for example, indices of democracy, economic openness, level of human capital, etc.), they note the fact that even the presence of the Kuznets curve explains only a very small part of the variance.

That is, there are many more factors that explain the dispersion in the income of the population, such as the state economic policy, which is responsible for the redistribution of income, regulation of financial markets, support for entrepreneurship, education. In addition, the main problem for accurately determining the Environmental Kuznets curve is the existence of a two-way causal relationship between CO_2 emissions and economic growth. It is also noted that ignoring individual effects complicates the measurement process that is so important for the variable Gini coefficient, which is a statistical indicator of the stratification of society along the studied attribute (Barro 2000).

In another article, the authors propose a theoretical justification for nonlinear dependence in two models: semi-parametric and nonparametric (Banerjee *et al.* 2003). In the empirical part, both methods can provide a more reliable estimate than an incorrectly specified parametric model. An estimate of a partially linear semi-parametric model indicates a nonlinearity of the relationship (in the form of an inverted parabola) between the rate of economic growth and the lagged rate of growth of the Gini coefficient. In addition, the authors substantiate the need to include both the level of inequality and the rate of growth of the level of inequality in the number of regressors (*Ibid.*, 2003). Based on these results, Banerjee and Duflo (2003) explain the inconsistencies of previous studies by incorrect model specification, which does not take into account the presence of nonlinear effects associated with the growth rate of inequality, and in the case of panel regression leads to a positive coefficient before the measure of inequality.

Considering the above, an interesting development of empirical research could be the assessment of the threshold regression model, where the threshold would reflect the level of development of the country. This view of research could serve as an empirical test of a number of theories that claim CO_2 emissions are beneficial in the early stages of development and negative in the later stages (Fishman 2002). The threshold can be not only the level of a country's development, but also any criterion that is natural for a given econometric model. For example, within the framework of the panel regression model, it turns out that in countries with a socially oriented ideology, inequality negatively affects the growth rate of the economy, but at the same time, countries with a liberal ideology have positive shifts (Bjornskov 2008). The authors note that when evaluating such structural models, the mandatory use of factors that determine the level of pollutions and the rate of growth. This requires the use of more complex econometric methods, but this approach is the most promising and complete, since it tries to take into account those relationships between economic indicators that are usually ignored when using traditional models.

In support of Romer's theory of endogenous growth, research results were identified using the example of production monopoly and economic growth rates (Etro 2019). The author argues that control over market activity is necessary in order to stimulate the R&D sector, which is a fundamental factor in endogenous growth in the long term. He is of the opinion that a strong monopoly could slow development, thereby offsetting long-term growth. Another study based on Romer's growth theory argues for the importance of capital investment in the scientific sector. The study is based on the example of China and specifically shows that an innovative approach to knowledge management and developing human capital leads to an increase in economic wealth (Chu et al., 2016).

The study of other countries also showed the dependence of human capital on economic growth. In Pakistan and Sri Lanka, human capital was expressed in terms of enrolment rates (Abbas 2001). Examining each level of education and the number of enrolments, a pattern was revealed that residents of the selected countries with higher education were easier to find employment and were much more economically significant. The author acknowledged that the results of the study support the theory of endogenous growth by Lucas and Romer, and concludes that human capital requires constant involution and coordination.

When it comes to the population's earnings and GDP indicators, it can be assumed that there are links between the values of the state of the environment and the well-being of the country. But at the same time, a large amount of literature studying the environment argues that the relationship between the quality of economic development and environmental safety depends on the supply and demand for environmental care around (Antle 1995). Especially, if there remains a substantial demand for environmental amenities relative to income, the demand for environmental quality management is likely to grow with GDP per capita. If the income elasticity condition is met over time, a more careful approach to environmental care is more likely to be observed as per capita income increases. Also, in the course of research, it turned out that the more a country's economy depends on natural resources, the less and weaker the per capita GDP develops (Neustroev 2013). This is due to the limited nature of those very natural resources, deposits of which, in addition, require a huge contribution to care. In addition, the need was identified for the development of human capital to work with such kind of resources in order to maintain a stable economy. Other study also emphasize the need to stimulate long-run growth of economic growth by investing in human capital and effective labor environment thus supporting Lucas's theory of economic growth (Gomez 2017).

The openness of news channels and media remains almost the main link between society and the state. Often the distortion of facts about the environment affects the actions taken in the future, which can not fully correct the existing problems. Due to the large amount of data and third-party factors, it is difficult to fully and the main thing is to correctly calculate an indicator that can reflect the openness of the media in specific regions and conduct an analysis. This is what a non-governmental organization Freedom House (2020) that studies the state of political and civil liberties is doing. The objects of Freedom House's research are monitoring of democratic changes in the world, support for democracy and human rights in the world. One of the aspects of the development of the organization is to study the freedom of media and press in the world, display and create a rating (Freedom house 2020). It forms its ratings on the basis of a survey of experts in accordance with its own methodology, analyzing the legal, political, economic aspects of the state.

In addition, the speed of the provided connection is also a complex indicator of the development of the Internet. British researchers annually assess the quality of Internet connections around the world, as a result of which a list of countries with the fastest broadband Internet is compiled. To find out which countries have the fastest Internet, the authors of the rating tested 200 countries and regions for 12 months. This year, research leaders are Liechtenstein, Jersey, Andorra, Gibraltar and Luxembourg. With an Internet speed of 70.90 Mbps Estonia took 22nd place in the rating (Worldwide speed league, 2020). In 2020 alone, the world's average internet speed has more than doubled the average of the previous year. It is assumed that the current upward trend is in the background and continues to be around 20 percent annually. The rest of the growth and growth differences are due to the constant updating of platforms.

Today, the level of development of the Internet is an excellent indicator of the development of both economic and social development. This indicator can be used for research and identification of problems arising in politics, economics and tracking the progress of the development of Internet technologies. The Web Index is a comprehensive indicator, developed in 2012, and characterizing the level of influence of the Internet and assessing the contribution of Internet technologies to the social, economic and political development of the state. The Web Index consists of various parameters combined into four parameters: universal access, relevant content and use, freedom and openness, empowerment (Web Index 2020).

Universal access - an indicator that assesses the intensity of Internet use in the assessed country, including an assessment of the quality of telecommunication technologies and coverage. First place in 2020 is taken by South Korea (86,9 point out of 100). Estonia is in 6th place (82,6 points).
Relevant content and use - a parameter that is an assessment of the level of use and accessibility of local content for various groups of society in the local segment of the Internet through the available platforms and channels in the language spoken in that region. The leaders of the rating in 2020 are the United States (95,6 points), France (92,7 points) and Canada (92,2 points).
Freedom and openness - this parameter assesses the freedom of citizens to receive the desired information, the availability of data and openness in expressing personal opinions on the Internet, as well as the security and confidentiality of personal data. Estonia (94,5 points) is the second in the ranking, putting New Zealand (94,7 points) in first place.
Empowerment - evaluates social, political, economic and environmental indicators of the development of the state in the context of the influence of the Internet on themselves. Estonia (81,8 points) entered the top 5 countries in this category. Qatar (85,7 points) is the leader of the rating in 2020.

Modern web resources allow to track the necessary information regarding current environmental issues. The demand for information based on environmental topics reflects the interest of the public. This interested part of the population is active in social groups of social networks, where the exchange of information becomes easier, faster and has a wide coverage. Monitoring the group activity online can provide more accurate data for research than collecting research groups individually.

1.3. Hypotheses development

Mention of early researches exploring the Environmental Kuznets' curve showed that there is a relationship between economic growth and carbon dioxide emissions. It should be assumed that CO_2 emission can come not only from the use of fossil fuels, since many countries do not have enough resources and are obliged to use alternative sources of energy. This might be the fact about the good economic situation inside the country, which can allow not only the use of alternative energy, but also restore the environment.

More accessible in territorial and legislative terms, the Internet can provide an opportunity for reliable and quick exchange of information. It should be assumed that already now (Chen et al. 2019), one of the aspects of this approach may become easier access to environmental awareness. This can allow individuals to unite in solving problems in the environment.

The research question was asked as follows: How the progress of digitalization of society affects CO_2 emissions?

Process of self-organization in a digital society in the sphere of environmental protection creates an environmental awareness in an individual and in a society and enforce the authorities to address urgent tasks of sustainable manufacturing and waste management. Therefore, the foregoing leads to the first hypothesis.

H1. The digitalization indicator impacts positively environmental awareness measure.

As a fact of resource digitization and development of information technologies, a positive impact on the state of GDP indicator is possible. The reason for this may be a faster data exchange, a change in the structure of production through the introduction of software systems that will regulate the economical use of resources and reduce unfavorable emissions into the atmosphere. The foregoing leads to the second hypothesis:

H2. An increase of GDP per capita impacts positive CO_2 emissons.

Another factor which goes in connection with increased digitalization is human capital. As previous studies showed, developing human capital is fundamental to endogenous economic growth, the key factor of which is the creation of innovative technologies. The generalized process of courses, trainings and constant gaining of work experience adds up human capital, at the beginning of which is the acquisition of higher education. Education, as a foundational step, provides an opportunity to adapt to a constantly changing surroundings and to invest the skills in improving the environment. Hence, the foregoing leads to the third hypothesis:

H3. An increase in level of Human capital leads to lower CO_2 emissions.

The following parts are going to clarify whether to accept the hypotheses or reject them.

2. METHODOLOGY AND EMPIRICAL RESEARCH

2.1. Data collection process description

This subsection provides an overview of the data used in the work and description of the analysis.

The progress in this section can be divided into the following steps. The data used in compiling the work was taken from different databases. To begin with, a list of member countries of the European Union and other developed countries of the continent, actively participating in economic activities, was identified. In total, 35 countries were collected. In addition to all EU member states, the list also included non-EU countries: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Romania, Slovenia, Slovakia, Finland, Sweden, United Kingdom, Iceland, Norway, Switzerland, Montenegro, Macedonia, Serbia, Turkey. The time period 2008 - 2018 was selected. This period is taken for the reason that for these years the necessary data on the countries under study are available in open databases. In addition, a different time period was investigated, excluding the period of the World Economic Crisis 2008-2009. The second period covers 2010-2018 and allows to analyze the impact of the economic crisis on the selected variables. Then, based on the list of countries studied, data was collected for analysis. Economic growth is expressed in real GDP per capita in terms of ESA 2010, as reported by Eurostat, and expressed in thousands. Carbon dioxide emissions per capita are taken from the Global Carbon Project website (2020) and are expressed in tons. The model also includes the ratio of the students enrolled in tertiary education, manufacturing value added and energy consumption per capita in each country of the sample. The data of all the variables is taken from Eurostat. The indicator of the freedom of the press is taken from the Freedom House website (2020).

The digitization variable is the percentage of households in each of the surveyed country with access to a broadband Internet connection. Another variable that unites digitalization and population is the percentage of individual Internet use in the surveyed territories. The data for both variables is taken from Eurostat.

2.2. Data and descriptive statistics

First, a descriptive statistic of data is provided. Second, a Pearson correlation analysis of the previously described data is carried out. All descriptive statistics is obtained in the econometric software package Gretl.

Table 1. Descriptive statistics of data used

	Minimum value	Maximum value	Mean - average value	Standard deviation
CO2 emission per capita (1 ton)	2.7	27.5	9.39	3.92
GDP per capita (1000 eur)	3.35	83.47	25.43	18.32
Internet use by individuals (%)	32	98	76	15
Broadband and connectivity - households (%)	25	98	74	16
Ratio of students enrolled in tertiary education (%)	10	41	25	7,8
Freedom of the press	8	76	24.24	12.55
Percentage of manufacture value added of GDP	4	35	14	5.2
Energy consumption (100 tons p.c)	1.56	14.33	5.8	2.3

Source: Author’s calculations

Table 1 provides descriptive statistics for the data used in the model. Statistics shows that the smallest volume of pollutant emissions per capita was observed in Montenegro in 2009 at 2.7 tones. At the same time, the highest CO_2 emissions per capita were recorded in Luxembourg in 2008. The indicator was 27.5 tonnes, which was slightly more than 3 times higher comparing to the average for the entire sample. It is also worth noting that over the course of 10 years, this figure in Luxembourg has decreased by almost 8 tons, which, with population growth, may indicate a positive interest in environmental activity.

The given indicator of GDP per capita varies greatly between the minimum and maximum values. The lowest rate was recorded in Macedonia in 2009. Obviously, this indicator was the result of the global financial and economic crisis, the beginning of which is considered to be in 2007. Only at the turn of 2008-2009, a decrease in GDP per capita was noticeable in all countries in the given sample. Some on the list were able to return to the previous indicators that existed before the tipping point in a couple of years, and even increase those numbers. It took other countries several years to revive the economy.

The percentage of individual Internet users mainly depends on the quality of the connection provided and the coverage of the territory of the countries with the available Internet. The highest rate is recorded in Denmark and reaches 98%. This means that almost the entire population has free access to the Internet and leads a social life online. If to look at the figure in Denmark 10 years ago, in 2008 the share of individual Internet use was 85% of the total traffic, again one of the first digitalized countries, on par with Norway. In the same year, the lowest rate was recorded in Romania - 32%. In comparison with the leader of this chart, in 2018 Romania showed the lowest share of individual Internet users, which was 77 percent, thus reaching the average value of an indicator - 76%.

Another indicator is that the share of households with Internet access depends on factors such as the quality of available technologies and investment in the development of IT innovations. The minimum index of this variable was in Bulgaria in 2008 and amounted to 25%. In the same time period, the highest rate was in Netherlands - 86%. Netherlands has always remained the leader in terms of the share of Internet access among households, and in 2017 this indicator became 98%.

The highest percentage of people with higher education was found in Ireland in 2017 and accounted 41 percent of the total. The lowest figure released in Turkey in 2008 and was around 10 percent.

Another variable of manufacture value added (MVA) % in GDP scored the lowest percent of production in Luxembourg (0.04) in 2014 and the highest in Ireland (0.35) in 2015. The lowest energy consumption per capita was in Malta (156 tonnes) and the highest in Iceland (1433 tonnes) in 2018.

Table 2 shows the data of the statistical relationship between the given variables. Primary analysis showed a high correlation between values BC and IU (0.95), which suggests that the better the broadband connection is, the higher the number of individual internet users. In addition, a strong positive correlation or 0.62 was found between the people with high education and GDP per capita. This may indicates that people with higher education are more economically active.

Table 2. Correlation coefficient

CO2	GDP	IU	BC	TE	FoP	MVA	EC	
1.0000	0.5800	0.3737	0.3442	0.4432	-0.5559	-0.0835	0.6334	CO2
	1.0000	0.6631	0.6425	0.6188	-0.6680	-0.1706	0.6521	GDP
		1.0000	0.9533	0.6892	-0.5956	-0.1422	0.6366	IU
			1.0000	0.6335	-0.4925	-0.1023	0.5523	BC
				1.0000	-0.5994	-0.2014	0.4941	TE
					1.0000	0.0419	-0.6392	FoP
						1.0000	-0.0276	MVA
							1.0000	EC

Source: Author's calculations in Gretl software

where:

CO2 – carbon dioxide emissions per capita;

GDP – real GDP per capita;

IU – percentage of individual Internet users;

BC – percentage of households with internet access;

TE – ratio of students enrolled in tertiary education;

FoP – index freedom of the press;

MAV – percentage of manufacture value added of GDP;

EC – energy consumption (100 tons per capita);

The correlation coefficient between the variables GDP and CO2 shows a moderate positive linear relationship (0,58). This indicates, first of all, that the growth of GDP per capita entails an increase in CO_2 emissions. And vice versa, since the level of CO_2 emissions indicates the work of the industry, the level of GDP grows accordingly. In addition, a moderate positive correlation may also indicate an improvement in industry and a decrease in CO_2 emissions, since there is also a strong correlation between the variables of GDP per capita and tertiary education.

The correlation coefficient of the "FoP" variable in the overwhelming majority of cases indicated a moderate negative relationship. The most interesting correlation coefficients in this case belong to the CO2 emission variable (-0,56). It can be assumed that the growth of a free press helps to inform society about the problems of pollution of the environment and leads to decreased CO_2.

In addition, the correlation analysis showed a positive relationship between the GDP per capita indicator and two other digitalization variables. The correlation between GDP per capita and the share of individual Internet users is 0,66. In the case of the share of households with broadband connection - 0.64. Both relationships are positive and relatively strong.

2.3. Econometric model

This bachelor's thesis applies econometric analysis of panel data that combines time series and cross-sectional data together. The use of two objects and time identifiers allow for a more thorough analysis and identification of the task framework.

To work with the independent and dependent variables, two econometric models were used and over two time series. In both cases, two similar models were constructed - the fixed effects model and the random effects model. The dependent variable of the model was CO2 emissions, measured in tons per capita. The independent variables were the ratio students enrolled in tertiary education, GDP per capita, internet use by individuals and broadband connections by households. Freedom of the press, manufacturing value added and energy consumption are reported as control variables in the model.

Econometric model:

$$CO2 = \beta_1 + \beta_2\, TE + \beta_3\, GDP + \beta_4\, IU + \beta_5\, BC + \beta_2\, FoP + \beta_3\, MAV + \beta_4\, EC + u \quad (1)$$

where:
CO2 – carbon dioxide emissions per capita;
GDP – real GDP per capita;
IU – percentage of individual Internet users;
BC – percentage of households with internet access;
TE – ratio of students enrolled in tertiary education;
FoP – index freedom of the press;
MAV – percentage of manufacture value added of GDP;
EC – energy consumption (100 tons per capita);
u – random component or error term;

The suitability of the model as a whole was assessed using the following indicators: Hausman test, test for differing group intercepts, coefficient of determination (Unadjusted R^2 and Adjusted R^2), standard error of regression (Standard error of residuals).

An F-test is performed to test the statistical significance of the model. White's test is used to test for heteroscedasticity. The null hypothesis is the absence of heteroscedasticity, the variance of errors is constant. The Hausman test is used to analyze models with fixed and random effects. Getting the null hypothesis involves using the random-effect model instead of the fixed-effect. Test for differing group intercepts puts forward a null hypothesis about the absence of individual effects, upon rejection of which chooses in favor of an alternative hypothesis or random-effect model.

3. RESULTS AND ANALYSIS

3.1. Econometric analysis

This section of the bachelor's thesis presents the results of regression analysis of data through the Gretl econometric package. The total number of observations is 385. The time period is 2008-2018. The acceptance rate of the alternative hypothesis is 0.05 to have a more meaningful p-value effect.

First, a *fixed-effects* model was built, reflecting the dependence of the variable CO2 on the variables GDP, TE, IU, BC, FoP, MVA, EC. Considering the values of the model parameters for this sample, it can be noted that the dependence of the CO2 variable on variables MVA (strong positive relation 7.65), EC (strong positive relation 8.2) and BC (positive relation 3.1) are significant, the remaining coefficients have a value close to 0 and do not significantly affect the dependent variables. The standard errors of the variables were identified and are indicated in parentheses in the formula below each of the values. The mathematical equation based on the model is as follows:

$$\underset{(1.06)}{CO2 = 6.80} - \underset{(2.34)}{11.2 \cdot TE} + \underset{(0.0282)}{0.0455 \cdot GDP} - \underset{(1.89)}{5.33 \cdot IU} + \underset{(1.55)}{3.10 \cdot BC} + \underset{(0.0150)}{0.0147 \cdot FoP} \quad (2)$$

$$+ \underset{(3.25)}{7.65 \cdot MVA} + \underset{(1.03)}{8.20 \cdot EC}$$

where:

CO2 – carbon dioxide emissions per capita;

GDP – real GDP per capita;

IU – percentage of individual Internet users;

BC – percentage of households with internet access;
TE – ratio of students enrolled in tertiary education;
FoP – index freedom of the press;
MAV – percentage of manufacture value added of GDP;
EC – energy consumption (100 tons per capita);

The resulting regression model is presented in Appendix 1. On closer inspection, it turns out that the probability of the F-test was p = 3.3e-212. Since the p-value is less than the selected level of significance (p = 5%), a decision is made to accept an alternative hypothesis, i.e. on the adequacy of the model as a whole. However, the descriptive ability of the model was 97.3%, which indicates a high level of explanation of the actual data by the model, as well, according to the F-test, it can be considered quite significant. The within R-squared determination coefficient is 46.4%.

At the next stage, the *random-effects* model was constructed and evaluated. The variable FoP showed a value exceeding the statistically acceptable level and was excluded from the model. Data is given in the appendix 2. All of these variables were found to be statistically significant. The general coefficient of determination of the model is 92%. The *Joint test on named regressors* showed a low probability, corresponding to acceptable numbers no more than 0.05. With this result, it can be assumed that at least one of the regressors is statistically significant. The *Hausman test* showed that estimates are consistent, which suggests that the null hypothesis is accepted and the fixed effect model is rejected. Further analysis will be carried out on the resulting model.

At the second stage of modeling, the time window was changed, excluding the years of the strongest impact of the economic crisis on the studied countries. The new time window covers the period 2010-2018. The number of observations - 315. The variables have not changed and remain the same. Evaluation of the *fixed-effects* model gave the result of R-squared coefficient equal to 97.9%. The model is also statistically significant, since the F-test score did not exceed the value of 0.05. The rest of the data obey the normal distribution. The resulting regression model is presented in Appendix 3.

Next the *random-effects* model was constructed and evaluated. Variable of FoP is excluded being not statistically significant. Other variables are statistically significant. Data is given in the appendix 4. The general coefficient of determination of the model was 92,7%. The *Joint test on* *named regressors* showed a low probability, corresponding to acceptable numbers less than 0.05. With this result, it can be assumed that at least one of the regressors is statistically significant. The *Hausman test* showed that estimates are consistent. Thus, confirming the null hypothesis and accepting the estimates obtained in the *fixed-effects* model as untenable. Further analysis will use data from model 4.

3.2. Results and discussions

To confirm the previously put forward three hypotheses, 4 regression analyses were carried out evaluating the relationship of the CO_2 emission variable with the other independent variables in a pooled sample of 35 countries of the European Union and non-EU states over two time periods. The first time window covered the period 2010-2018. The next time window ruled out a couple of years of the global economic crisis and covered the period 2010-2018.

Models include a dependent variable expressed as integer values of CO2 emissions per capita in tons. The independent variables in all models were the variables of GDP per capita, the percentage of individual Internet users and households with internet access in each country in the sample. In addition, all models include control variables for the freedom of press, manufacturing value added, and energy consumption per capita across the sample countries.

Three hypothesis have been put forward to determine the effect of digitalization on public environmental awareness that was expressed as CO2 emissions per capita. Each of them must be supported by the estimated models.

The best model was chosen for the first time period. Its mathematical equation (Model 2) looks like this:

$$\underset{}{CO2} = \underset{(1.05)}{6.05} - \underset{(2.24)}{10.8}*TE + \underset{(0.0209)}{0.0767}*GDP - \underset{(1.87)}{5.43}*IU + \underset{(1.48)}{3.34}*BC + \underset{(2.82)}{5.58}*MVA + \underset{(0.941)}{8.67}*EC \quad (3)$$

where:

CO2 – carbon dioxide emissions per capita;

GDP – real GDP per capita;

IU – percentage of individual Internet users;

BC – percentage of households with internet access;

TE – ratio of students enrolled in tertiary education;

MAV – percentage of manufacture value added of GDP;

EC – energy consumption (100 tons per capita);

According to the data expressed, there is a negative relationship between CO_2 emissions and individual Internet users. In other words, an increase in the share of individual users by 1 unit leads to a reduction in carbon dioxide emissions by 5.43 unit points. The existing correlation is significant. In this way, the expressed data support the first hypothesis.

In the same model, the GDP variable is highly statistically significant. The p-value of that variable is less than 0,001, which is lower than given acceptable rate. Further analysis of the second time period will make it thoroughly to analyze the effect of the influence of changes in the level of GDP on the shift in the change in the indicator of CO_2 emissions.

The third hypothesis involves finding the relationship between the variable of human capital expressed as tertiary education and variable of CO_2 emission per capita. The same model (formula 3) is used. The coefficient is positive and says that an increase in variable of tertiary education leads to decrease of carbon dioxide emissions by 10.8 units. To rephrase it, as more the prevalence of human capital with higher education significantly reduces CO_2 emissions per capita, since knowledge and skills allow to improve technologies and change consumed resources to more environmentally friendly ones. Therefore, the third hypothesis raised in the work is confirmed. This result is consistent with the relevant research in this area.

In addition, an equation with a modified time period is provided, which excludes two years of the global economic crisis. Accordingly, the period is 2010 - 2018. This is done for the purpose of assessing possible changes in the relationship of variables. The mathematical equation (Model 4) looks like this:

$$CO2 = 5.68 - 0.34*GDP - 6.08*IU + 4.49*BC - 5.4*TE + 6.84*MVA + 9.16*EC \quad (4)$$

$$(1.08) \quad (0.0312) \quad (2.21) \quad (1.86) \quad (2.125) \quad (2.59) \quad (0.91)$$

where:

$CO2$ – carbon dioxide emissions in tons;

GDP – real GDP per capita;

IU – percentage of individual Internet users;

BC – percentage of households with internet access;

TE – tertiary education;

MAV – manufacturing value added;

EC – energy consumption;

Through this equation, it became clear that the global economic crisis was able to directly affect the changes in the correlation between the variables. The correlation of the variables has become slightly more negative compared to the period covering the two years of the global economic crisis. Internet accessibility for individual users showed a more negative correlation with CO_2 emissions per capita. The impact was -6.08 points.

In addition, the variable GDP has acquired a negative value in the new time period. The growth of the value of GDP per capita of 1 unit now reduces CO2 variable by 0.34 unit points. Such a ratio may be due to the fact that the model does not include the first couple years of the great economic crisis.

A detailed analysis of two time intervals allows us to examine in detail the bias of results in coefficients, thereby assessing the impact of the economic crisis that began in 2008. This comparative analysis of the data in formulas 3 and 4 allowed to find the change in correlation over time and events. The dependent variable was the CO_2 emission per capita variable and the independent variable was the GDP per capita variable. Comparing the structure of the two models, it is worth to mention that the impact of these two variables changed, and the CO_2 per capita ratio became negative and equal to −0.34 in the shorter period. In other words, society gets richer and some members of it start thinking about the state of the environment in which they live. In this way the third hypothesis was confirmed and in the same way supports the ecological part of Kuznets hypothesis in specific way.

CONCLUSION

This bachelor thesis explores the impact of society's digitalization on CO_2 emissions. The aim of the work was to analyze how digitalization of society can reduce the volume of CO_2 emissions into the environment and direct society's attention to existing problems. The research was conducted over two time periods: 2008-2018 and 2010-2018. This decision was made to analyze the impact of the global economic crisis on the selected time period.

To achieve the goal of the thesis, three theories were put forward:

H1. The digitalization indicator impacts positively environmental awareness measure.
H2. An increase of GDP per capita impacts positive CO_2 emissions.
H3. An increase in level of Human capital leads to lower CO_2 emissions.

A sample of 35 countries from the European Union and adjacent territories was taken. For this sample, data was collected on the state of real GDP per capita, CO_2 emissions per capita, quality of broadband connection, share of individual Internet use, manufacturing value added, energy consumption per capita, and indicator of the freedom of the press. All data was used to build regression models and further analysis.

In the first chapter, the author presented an overview of economic theories and earlier studies. The ecological hypothesis of the Kuznets' curve was presented, which formed the basis for the development of the entire thesis. According to that hypothesis, there is a breaking point at the stages of economic development, until which the state of the environment will only deteriorate. The growth of environmental pollution is accompanied by an increase in economic well-being. Only after reaching the turning point on EKC, the society living in an economically stable country begins to participate in the restoration of the ecological situation and the curve goes down. In addition to the fundamental variables of income and the environment, it is also important to participate in progress and the development of IT technologies which become more closely part of society. For this reason, it is important to consider the new members of the regression in assessing the state of the environment and to predict further scenarios.

The second chapter reviewed the data used to create the models. Descriptive statistics and models' specifications were carried out. 4 models were collected. All are presented in the appendix. In the third chapter, an empirical analysis and interpretation of the results was carried out.

Over the past decade society and government have changed markedly, and with it the attitude towards the environment has changed. The data analysis carried out in this work showed that despite the global crisis, most states were able to reanimate their economies and even improve their living standards. At the same time, they reduced the amount of energy consumed, invested in the R&D and human capital. The development and implementation of innovative technologies for information exchange of data in society over the past decade has become more global in nature. The fact that it has become a part of life and has an impact on decision-making gives a greater sheer weight. This should be the key as a catalyst for solving the problem of excess CO2 emissions. There is still a lot of work to be done to achieve the desired goal of creating a stable environment. The main focus should be on educating the public and providing an opportunity to learn about existing air pollution problems.

Relying on the results of the data obtained by analyzing the models, it can be stated that all the hypotheses proposed remain true. It is worth noting the validity of the Environmental Kuznets' curve hypothesis. After analyzing and comparing the data for the period covered, a clear change in the attitude of the government and society to the problem of CO_2 pollution was revealed. Based on the data received it can be considered that right now many countries are passing the turning point leading to an improvement in the state of the environment.

The goal set by the author has been achieved. The answer to the research question has been received. In the following research, more variables can be added or a wider time period can be used.

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APPENDICES

Appendix 1. Model 1.

Model Fixed-effects, using 385 observations
Included 33 cross-sectional units
Time-series length: minimum 3, maximum 11
Dependent variable: CO2

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	6.80192	1.05503	6.447	<0.0001	***
TE	−11.1813	2.34166	−4.775	<0.0001	***
GDP	0.0455343	0.0282499	1.612	0.1080	
IU	−5.32968	1.89310	−2.815	0.0052	***
BC	3.09830	1.54854	2.001	0.0463	**
FoP	0.0147492	0.0150395	0.9807	0.3275	
MVA	7.65175	3.24573	2.357	0.0190	**
EC	8.19721	1.03108	7.950	<0.0001	***

Mean dependent var	9.676471	S.D. dependent var	3.921784
Sum squared resid	140.1647	S.E. of regression	0.683532
LSDV R-squared	0.973117	Within R-squared	0.464416
LSDV F(39, 300)	278.4519	P-value(F)	3.3e-212
Log-likelihood	−331.7974	Akaike criterion	743.5948
Schwarz criterion	896.7527	Hannan-Quinn	804.6217
rho	0.601075	Durbin-Watson	0.651845

Joint test on named regressors -
Test statistic: F(7, 300) = 37.1623
with p-value = P(F(7, 300) > 37.1623) = 2.69751e-037

Test for differing group intercepts -
Null hypothesis: The groups have a common intercept
Test statistic: F(32, 300) = 154.306
with p-value = P(F(32, 300) > 154.306) = 1.49764e-166

Distribution free Wald test for heteroskedasticity -
Null hypothesis: the units have a common error variance
Asymptotic test statistic: Chi-square(33) = 17346.9
with p-value = 0

Test for normality of residual -
Null hypothesis: error is normally distributed
Test statistic: Chi-square(2) = 96.7489
with p-value = 9.8002e-022

Appendix 2. Model 2.

Model Random-effects, using 385 observations
Included 33 cross-sectional units
Time-series length: minimum 3, maximum 11
Dependent variable: CO2

	Coefficient	*Std. Error*	*z*	*p-value*	
const	6.04939	1.04566	5.785	<0.0001	***
TE	−10.8149	2.23902	−4.830	<0.0001	***
GDP	0.0767210	0.0208601	3.678	0.0002	***
IU	−5.43029	1.86864	−2.906	0.0037	***
BC	3.33564	1.47767	2.257	0.0240	**
MVA	5.57852	2.82473	1.975	0.0483	**
EC	8.66833	0.941265	9.209	<0.0001	***

Mean dependent var	9.676471	S.D. dependent var	3.921784
Sum squared resid	3186.945	S.E. of regression	3.088973
Log-likelihood	−862.8774	Akaike criterion	1739.755
Schwarz criterion	1766.557	Hannan-Quinn	1750.435
rho	0.593525	Durbin-Watson	0.658137

'Between' variance = 8.33744
'Within' variance = 0.467156
mean theta = 0.924113

Joint test on named regressors -
Asymptotic test statistic: Chi-square(6) = 279.126
with p-value = 2.41708e-057

Breusch-Pagan test -
Null hypothesis: Variance of the unit-specific error = 0
Asymptotic test statistic: Chi-square(1) = 1412.1
with p-value = 4.92567e-309

Hausman test -
Null hypothesis: GLS estimates are consistent
Asymptotic test statistic: Chi-square(6) = 11.1328
with p-value = 0.0843586

Appendix 3. Model 3.

Model Fixed-effects, using 315 observations
Included 33 cross-sectional units
Time-series length: minimum 3, maximum 9
Dependent variable: CO2

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	6.80799	1.06360	6.401	<0.0001	***
GDP	−0.336727	0.0298678	−1.127	0.0021	***
IU	−6.45853	2.21699	−2.913	0.0039	***
BC	4.94734	1.92703	2.567	0.0109	**
TE	−5.98263	2.43736	−2.455	0.0148	**
FoP	0.000602393	0.0151887	0.03966	0.9684	
MVA	9.80799	3.42969	2.860	0.0046	***
EC	8.42446	1.01645	8.288	<0.0001	***

Mean dependent var	9.483154	S.D. dependent var	3.796975
Sum squared resid	85.39639	S.E. of regression	0.597752
LSDV R-squared	0.978693	Within R-squared	0.395578
LSDV F(39, 239)	281.4884	P-value(F)	5.0e-178
Log-likelihood	−230.7287	Akaike criterion	541.4574
Schwarz criterion	686.7059	Hannan-Quinn	599.7234
rho	0.563805	Durbin-Watson	0.677568

Joint test on named regressors -
Test statistic: F(7, 239) = 22.3456
with p-value = P(F(7, 239) > 22.3456) = 3.66975e-023

Test for differing group intercepts -
Null hypothesis: The groups have a common intercept
Test statistic: F(32, 239) = 161.86
with p-value = P(F(32, 239) > 161.86) = 1.55201e-143

Distribution free Wald test for heteroskedasticity -
Null hypothesis: the units have a common error variance
Asymptotic test statistic: Chi-square(33) = 5335.65
with p-value = 0

Test for normality of residual -
Null hypothesis: error is normally distributed
Test statistic: Chi-square(2) = 154.27
with p-value = 3.16695e-034

Appendix 4. Model 4.

Model Random-effects, using 315 observations
Included 33 cross-sectional units
Time-series length: minimum 3, maximum 9
Dependent variable: CO2

	Coefficient	*Std. Error*	*z*	*p-value*	
Const	5.68901	1.08956	5.221	<0.0001	***
GDP	-0.34025	0.03124	-1.312	0.0048	***
IU	−6.08013	2.21203	−2.749	0.0060	***
BC	4.49196	1.86778	2.405	0.0162	**
TE	−5.40096	2.12591	−2.541	0.0111	**
MVA	6.84605	2.59666	2.636	0.0084	***
EC	9.15799	0.914544	10.01	<0.0001	***

Mean dependent var	9.483154	S.D. dependent var	3.796975
Sum squared resid	3051.056	S.E. of regression	3.336951
Log-likelihood	−729.5722	Akaike criterion	1471.144
Schwarz criterion	1492.932	Hannan-Quinn	1479.884
rho	0.572282	Durbin-Watson	0.667030

'Between' variance = 8.4589
'Within' variance = 0.356343
mean theta = 0.927887
Joint test on named regressors -
Asymptotic test statistic: Chi-square(5) = 164.065
with p-value = 1.34591e-033

Breusch-Pagan test -
Null hypothesis: Variance of the unit-specific error = 0
Asymptotic test statistic: Chi-square(1) = 918.353
with p-value = 1.00474e-201

Hausman test -
Null hypothesis: GLS estimates are consistent
Asymptotic test statistic: Chi-square(5) = 15.9694
with p-value = 0.06932

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