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THE IMPACT OF A COUNTRY'S LEVEL OF ECONOMIC DEVELOPMENT ON ENVIRONMENTAL SAFETY*

Ivanna Melnychuk[**1], **Oksana Savko**[1], **Serhii Pobihun**[1], **Nataliia Havadzyn**[2]

[1]*Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine*
[2]*King Danylo University, Ivano-Frankivsk, Ukraine*

Abstract

There has been established the relationship between the level of a country's economic development and its environmental safety based on identifying patterns of factors influence on the volume of harmful emissions into the air. The dynamics of CO_2 emissions in terms of purchasing power parity in European countries for 1990-2018 is presented. It is noted that there is a gradual and uniform decrease in this indicator in developed countries. With the help of the phenomenological method, there has been carried out the selection, justification and grouping of environmental, economic, social, scientific and intellectual factors influencing the emissions of CO_2, SO_2, NOx in France and Ukraine. Based on the correlation analysis, there has been determined the nature and degree of influence of the selected factors on the resulting indicators (volumes of harmful emissions). It has been substantiated that the factors with the correlation coefficient ≥ 0.8 are taken for the analysis; this gave grounds to assert a close relationship between the factors under study and emissions of harmful substances. It has been established that the number of such factors in France is significantly higher than in Ukraine, this is due to the political and economic situation in the country, the level of implementation of energy-efficient technologies and environmental modernization of enterprises.

Keywords: correlation analysis, emissions, environmental safety, level of development

1. Introduction

The modern priority of a country's development, which corresponds to the generally accepted UN doctrine of sustainable development, is the implementation of an effective policy in the environmental sphere. These are the environmental problems associated with climate change that require the use of priority measures to neutralize them. Therefore, the

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** Corresponding author: e-mail: iva99-84@ukr.net

search for theoretical and practical solutions in the field of interaction between the economic and ecological systems of countries, the choice of an option for their optimal development is of great importance. Taking this into account, the issues of determining the degree of influence of various groups of factors (economic, social, environmental) on harmful emissions, as well as studying the experience of advanced countries of the world in applying the directions of the "green" economy and their implementation for countries, become especially relevant for the developing countries.

It should be noted that articles on the issue of harmful emissions and their relationship with other phenomena and processes are published in scientific journals dedicated to various industries and spheres of human activity, that is, they are interdisciplinary (transport, energy policy, sustainable production and consumption, quality management of ecology, environmental policy, environmental and resource economics, etc.)

Recently, researchers have focused on identifying and establishing the nature of the relationship between various processes in society (e.g. economic growth, urbanization, increased use of various types of energy, scientific and innovative activities) and their impact on the environment. For example, (Balsalobre-Lorente et al., 2018) natural resources have been used as a control variable, examining the relationship between income and emissions in the EU-5 countries. (Danish et al., 2019) have used the AMG method to analyze the relationship between emissions, natural resources, revenues and renewable energy in BRICS. (Soytas et al., 2007) have studied the relationship between energy consumption, income and carbon emissions in the United States. (Sharma, 2011) have conducted researches on high-income countries, middle-income countries and low-income countries. The results have shown that energy consumption per capita is the main cause of carbon dioxide emissions. (Liu et al., 2018) have suggested that the rapid growth in cement production have led to a significant increase in carbon dioxide emissions. Studies of (Song et al., 2019; Gu et al., 2019) have shown that green innovation is the main factor affecting carbon emissions, and technological progress and green development systems prevent further environmental degradation.

It is obvious that there is a relationship between the level of economic development of countries and their environmental state. However, until now, studies have been carried out on the influence of only individual components of the state's level of development on harmful emissions into the atmospheric air. Therefore, it is necessary to conduct a systematic analysis of the existing relationships.

The aim of the study is to identify patterns of social, environmental, economic, scientific and intellectual factors influencing the volume of harmful substances emissions, such as carbon dioxide, sulfur dioxide and nitric oxide, to establish the relationship between the level of a country's economic development of and its environmental safety.

To achieve the goal, the following tasks have been set:

- to select and group the factors (social, economic, scientific and intellectual) that affect the emissions of harmful substances in Ukraine and France;
- to carry out a correlation analysis for assessing the closeness of relation and the nature of factors influencing the level of harmful emissions on the basis of the selected and grouped factors;
- to compare the selected factors with emissions of harmful substances for countries with developed economies and developing countries.
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2. Material and methods

The following research methods have been applied:

- the phenomenological method for determining and substantiating influence factors on harmful emissions;

- correlation analysis to determine the nature and degree of influence of social, economic, scientific and intellectual factors on the volume of harmful emissions, such as carbon dioxide, sulfur dioxide and nitrogen oxides.

The research is based on the coefficients of correlation and determination (approximation), linear and nonlinear (quadratic, logarithmic, inverse, power) functions. The values of the correlation and determination coefficients allow us to assess the degree of influence of the selected factors on the resulting indicators (amount of emissions). The type of function allows us to understand the nature of the impact: if it is a simple linear one, then the increase or decrease in the indicator occurs evenly. If it is nonlinear one, then we get an acceleration or deceleration of the indicator change depending on the factor change.

Statistical data of Enerdata, the World Bank, World Statistics, Eurostat, Index Mundi, OECD, Statista, International energy agency for 1999-2018 were used as materials for the study, namely, the level of harmful emissions into the atmospheric air: CO_2, SO_2, NOx, and parameters-factors, such as: energy intensity of GDP, investment level, rent payments, population density, energy consumption, etc.

The object of the research is France as a country with a high level of economic development and Ukraine as a country with a low level of economic development.

3. Results and discussion

One of the indicators that show a decrease in the burden on the environmental and social components in European countries is the intensity of CO_2 emissions, since it characterizes the efficiency of resource use and the level of emissions.

The CO_2 emissions intensity, according to the international consulting company Enerdata, is the indicator that shows the ratio of CO_2 emissions from fuel combustion to gross domestic product (GDP), which is measured in US dollars at purchasing power parity.

Fig. 1 shows the dynamics of this indicator by 2018 compared to 1990 in European countries and Ukraine. In general, there is a positive trend towards a decrease in the studied indicator. If before 2005 the indicator should have an abrupt trend in some countries (for example, the Czech Republic, Portugal, Norway, Sweden), then since 2005, as a result of the Kyoto Protocol (1997) and the Paris Agreement (2015), the indicator fell. In Ukraine, in addition to the enactment of the above international acts, a decrease in this indicator is associated with a decrease in industrial production and a global political and economic crisis in the state.

Since the object of our study is France and Ukraine, it seems appropriate to show the change in this indicator and compare it (Fig. 2).

3.1. Choice of factors

For a detailed analysis of the level of such emissions as carbon dioxide, sulfur dioxide and nitric oxide into the environment we select from the groups of social, environmental and economic indicators, which, in our opinion, have a great influence on the level of harmful emissions, and determine the main reasons that influence them and the possibility of their change. It should be noted that for developing countries, the number of factors is much greater, since there is more indirect factors that can ultimately affect emissions. They are, for example, a low level of investment attractiveness, political instability, military conflict, shaky economic situation, corruption, ineffective fiscal policy, and the like. Therefore, first, let us select and consider the factors, which, in our opinion, can have a direct or indirect impact on emissions in highly developed countries.

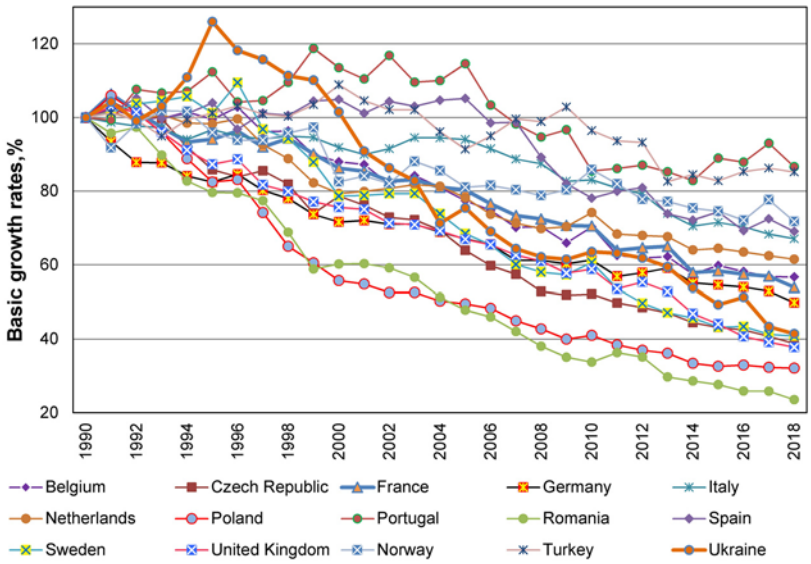

Fig. 1. Dynamics of the intensity of CO_2 emissions at purchasing power parity in European countries for 1990-2018 Compiled by the authors based on Enerdata statistics

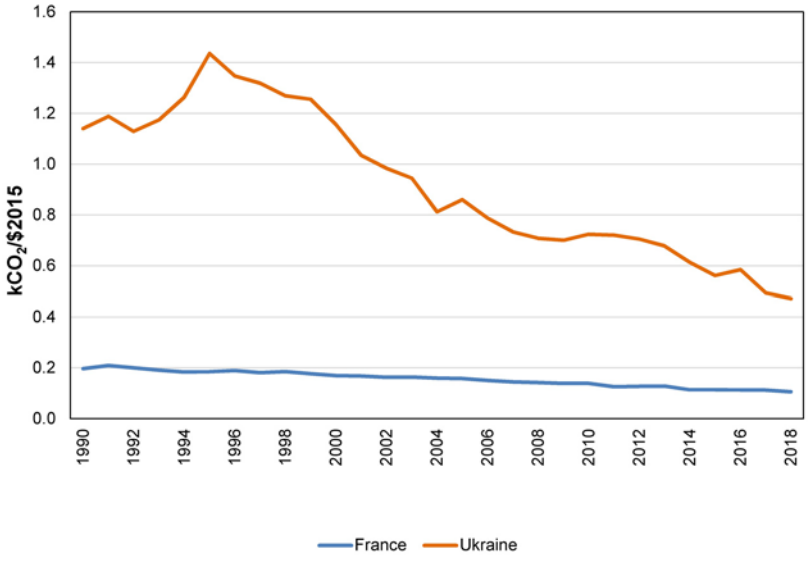

Fig.2. Comparison of the indicator for CO_2 emission intensity in France and Ukraine during 1990-2018

X1 – The Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development: a long and healthy life, being knowledgeable and have a decent standard of living. The HDI is the geometric mean of normalized indices for each of the three dimensions.

X2 – Energy intensity level of primary energy is the ratio between energy supply and gross domestic product measured at purchasing power parity. Energy intensity is

an indication of how much energy is used to produce one unit of economic output. Lower ratio indicates that less energy is used to produce one unit of output.

X3 – The share of renewable electricity is the ratio between the electricity produced from renewable energy sources and gross (national) electricity consumption, expressed as a percentage. It measures the contribution of electricity produced from renewable energy sources to the national gross electricity consumption.

X4 – Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.

X5 – Manufacturing, value added. Manufacturing refers to industries belonging to *International Standard Industrial Classification of All Economic Activities* divisions 15-37. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources.

X6 – Foreign direct investment, net inflows (BoP, current US$) refers to direct investment equity flows in the reporting economy. It is the sum of equity capital, reinvestment of earnings, and other capital. Direct investment is a category of cross-border investment associated with a resident in one economy having control or a significant degree of influence on the management of an enterprise that is resident in another economy. Ownership of 10 percent or more of the ordinary shares of voting stock is the criterion for determining the existence of a direct investment relationship. Data are in current U.S. dollars.

X7 – Population density is a measurement of population per unit area, or exceptionally unit volume. In simple terms, population density refers to the number of people living in an area per square kilometers.

X8 – Domestic coal and lignite consumption (Mt) – volumes of coal and lignite consumption by various sectors of the economy.

X9 – Cereal yield (kg per hectare), measured as kilograms per hectare of harvested land, includes wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains.

X10 – Total energy consumption is made up of production plus imports, minus exports, minus international marine bunkers plus/minus stock changes. It is also called Total primary energy supply or Gross inland energy consumption and represents the quantity of all energy necessary to satisfy inland consumption.

X11 – Transport services (% of commercial service exports) covers all transport services (sea, air, land, internal waterway, space, and pipeline) performed by residents of one economy for those of another and involving the carriage of passengers, movement of goods (freight), rental of carriers with crew, and related support and auxiliary services.

X12 – Transport services (% of commercial service imports) covers all transport services (sea, air, land, internal waterway, space, and pipeline) performed by residents of one economy for those of another and involving the carriage of passengers, movement of goods (freight), rental of carriers with crew, and related support and auxiliary services.

X13 – Unemployment, total (% of total labor force) (modeled ILO estimate). Unemployment refers to the share of the labor force that is without work but available for and seeking employment.

X14 – Ores and metals exports (% of merchandise exports). Ores and metals comprise the commodities in SITC sections 27 (crude fertilizer, minerals nes); 28 (metalliferous ores, scrap); and 68 (non-ferrous metals).

X15 – Charges for the use of intellectual property, payments (BoP, current US$). Charges for the use of intellectual property are payments and receipts between residents and nonresidents for the authorized use of proprietary rights (such as patents, trademarks, copyrights, industrial processes and designs including trade secrets, and franchises) and for the use, through licensing agreements, of produced originals or prototypes (such as copyrights on books and manuscripts, computer software, cinematographic works, and sound recordings) and related rights (such as for live performances and television, cable, or satellite broadcast). Data are in current U.S. doll.

X16 – Gross domestic expenditures on research and development (R&D).They include both capital and current expenditures in the four main sectors: Business enterprise, Government, Higher education and Private non-profit. R&D covers basic research, applied research, and experimental development.

X17 – Patent applications are worldwide patent applications filed through the Patent Cooperation Treaty procedure or with a national patent office for exclusive rights for an invention a product or process that provides a new way of doing something or offers a new technical solution to a problem. A patent provides protection for the invention to the owner of the patent for a limited period, generally 20 years.

3.2. Establishing relationships

Among the selected factors there may be erroneous, therefore, they must be checked for adequacy. For this, there is estimated the magnitude of the correlation coefficients. The closer the absolute value of the correlation coefficient is to 1, the more the relationship between the parameters is confirmed. Factors with a low value of the correlation coefficient can be excluded from the analysis. For example, consider the relationship of a group of environmental factors, namely: X2 – the energy intensity of GDP at constant purchasing power parity (koe/$2015), X3 – the share of renewable energy sources in electricity production (%), X8 – the domestic consumption of coal and lignite (Mt) with the value of CO_2 emissions for France (Fig. 3).

It should be noted that the values of X2 (energy intensity of GDP) and X8 (domestic consumption of coal and lignite) factors and CO_2 emissions show a similar trend, but the value of X3 factor (the share of renewable energy sources in electricity production) shows a wide scatter of the data. The absolute values of the correlation coefficients for X2 and X8 are 0.96-0.97, while for X3 they are less than 0.798. Thus, CO_2 emissions can be considered to have a close relationship with X2 and X8, and the relationship of X3 factor is rather doubtful.

Based on the analysis of the factors adequacy, we select the threshold of the absolute value of the correlation coefficient equal to 0.8 in the first approximate: all dependencies with correlation coefficients ≥ 0.8 are taken to be established, and dependences with a correlation coefficient below 0.8 are not established.

3.3. Comparative analysis of the impact of a country's economic development on harmful emissions.

In the study, there have been processed statistical data on harmful emissions into the atmospheric air in terms of CO_2, SO_2, NOx in France and Ukraine and the correlation coefficients have been determined using X1-X17 factors described above. The results of the study are shown in Figs. 4-6. The factors are divided into groups - environmental, economic, social, scientific and intellectual.

The obtained results of the study (Fig. 4-6) show that the number of correlation factors, selected for analysis with a high level of closeness of connection (absolute values of correlation coefficients higher than 0.8) and their impact on emissions of pollutants in France is significantly higher than in Ukraine, namely in France for CO_2 – 7, and in Ukraine only 3; in France for CO_2 – 8, and in Ukraine – 2; in France for NOx – 8, and in Ukraine – 2.

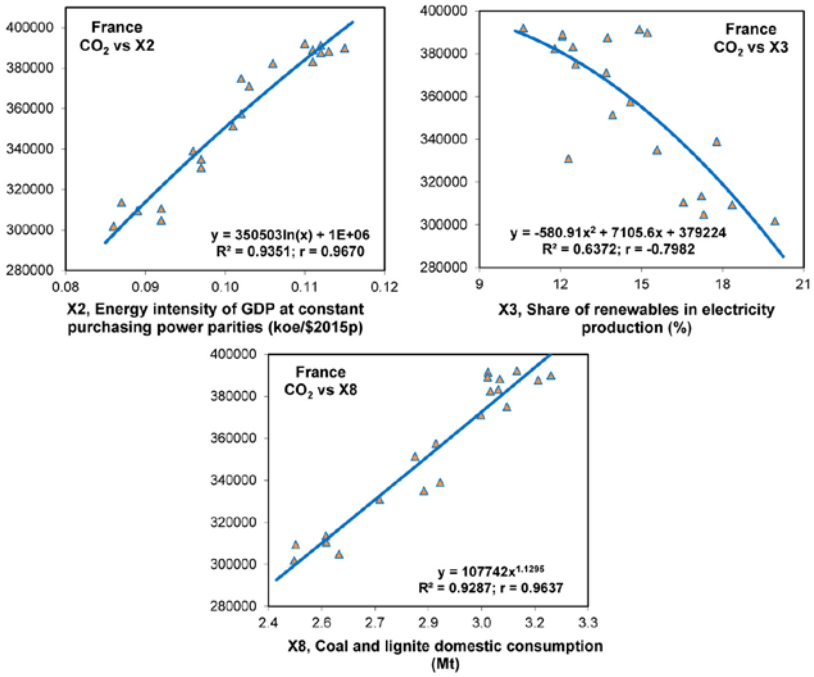

Fig. 3. Relationship between parameter factors and CO_2 emissions using the example of a group of environmental factors in France

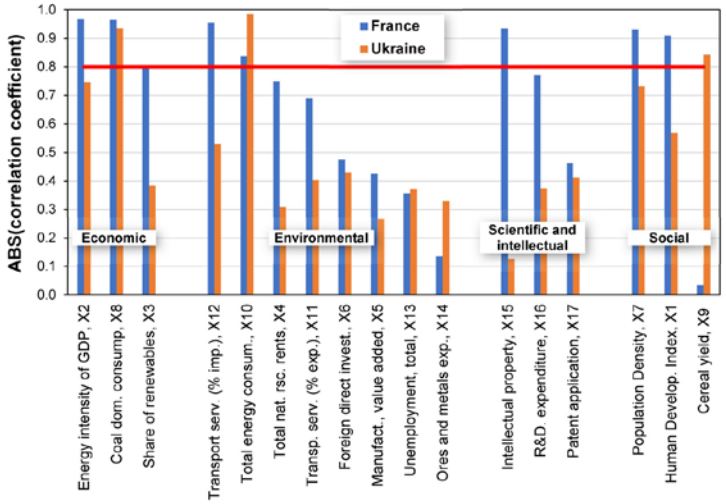

Fig. 4. The values of the correlation coefficients of the factors influencing the level of CO_2 emissions in France and Ukraine

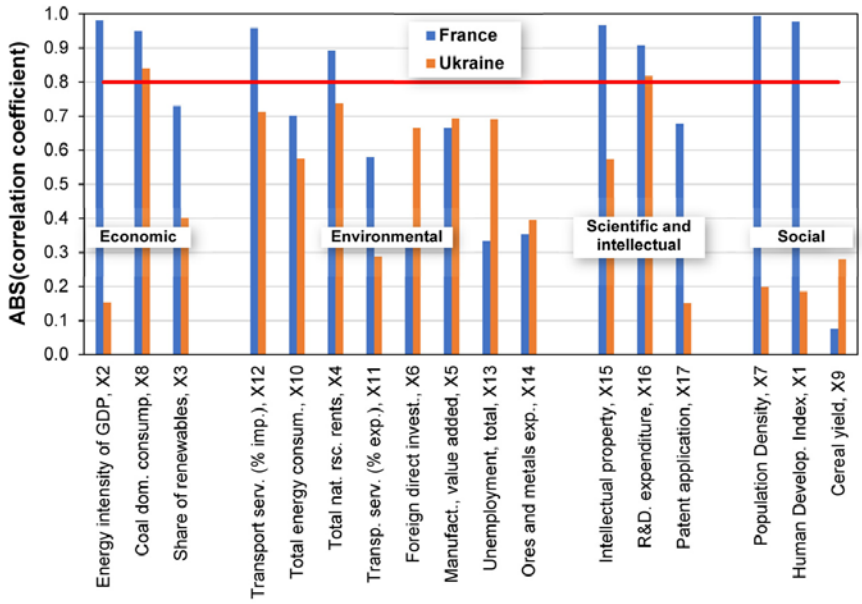

Fig. 5. The values of the correlation coefficients of the factors influencing the level of SO_2 emissions in France and Ukraine

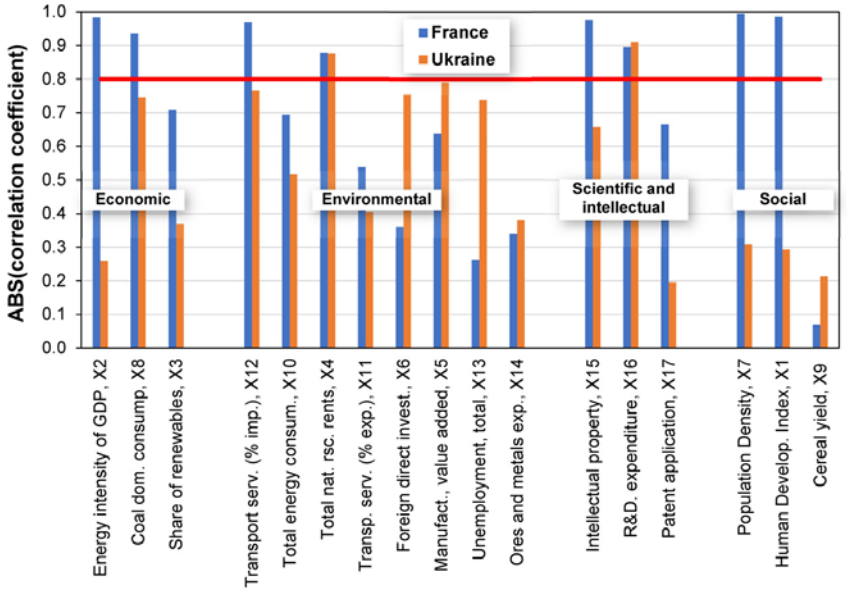

Fig. 6. The values of the correlation coefficients of the factors influencing the level of NOx emissions in France and Ukraine

3.4. Comparison of research results in countries and their analysis

In the context of groups of factors (environmental, economic, scientific and intellectual, social), the following results have been obtained.

3.4.1. Environmental group of factors

For France, X2 factor (Energy intensity of GDP) (Fig. 5 and 6) and X8 factor (Domestic consumption of coal and lignite) for CO_2 (Fig. 4), in Ukraine – only X8 have the greatest influence on CO_2, NOx and SO_2 emissions in the group of environmental factors. In France, the increase in the number of pollutants is influenced by the increase in production capacity in the country and the increase in domestic consumption of coal (and other fossil fuels). For Ukraine, this dependence is due to the fact that the main domestic consumers (90%) of thermal coal are power generating companies of CHP and TPP, which can operate not only on coal, but also on gas or fuel oil. But due to the high prices for gas, Ukrainian thermal power plants have been using it in recent years for heating boilers, and not as fuel. In addition, since the coal industry of Ukraine consists of the private and public sectors and the largest representative of the private sector is the energy holding company DTEK (45%), which in its turn, is also the main generator and distributor of electricity, it is not interested in reducing coal production.

3.4.2. The economic group of factors

For France, X12 factor (% of commercial services import) for CO_2, NOx and SO_2 has the greatest influence on all types of emissions in the group of economic factors. The share of transport services in France is quite high and accounts for about 20% of all imported services. Since transport is one of the largest sources of environmental pollution, the direct dependence is logical. X4 factor (rent for the use of natural resources) also influences NOx. In France this factor increases and emissions decrease. This is because the resource rent in France is a powerful tool and its high rate encourages businesses to reduce emissions in line with EU legislation.

For Ukraine, among economic factors, X4 factor (rent for the use of natural resources) has the greatest influence on NOx emissions, and X10 factor (total energy consumption) - on CO_2. The reason for this is that a wide range of fiscal instruments are used to extract natural rent in Ukraine, but their effectiveness is lower compared to the corresponding instruments used by developed countries, which is due to the transformational state of the taxation system in Ukraine and the unsatisfactory level of development of the main institutions (low tax culture of taxpayers, largely rent-oriented behavior of subsoil users, limited flexibility of approaches to cooperation with large taxpayers on the part of the tax authorities, low level of environmental taxes, especially for CO_2 emissions) (Savko et al., 2019). Despite the fact that Ukraine is included in the list of countries with the largest volumes of proven reserves of iron, manganese, titanium, uranium, zirconium ores and significant volumes of mining, receipts from the main types of payments for their extraction, which should withdraw natural rent into the consolidated budget, remain insignificant. Regarding the impact of total energy consumption on the level of CO_2 emissions, the intensification of the introduction of alternative renewable energy sources can be considered a positive change. Renewable energies help solve sustainable development challenges by reducing air, water, soil pollution (Mandryk et al., 2016) and CO_2 emissions.

3.4.3. Scientific and intellectual group of factors

For France, X15 factor (payment for the use of intellectual property) has the greatest influence on all types of emissions in the group of scientific and intellectual factors. Also, the level of NOx and SO_2 emissions is influenced by X16 factor (research and development costs) both in France and in Ukraine. As R&D costs increase in France, emissions decrease. This gives grounds to assert that intelligent developments are being introduced sufficiently at enterprises that ensure emission reductions in France. In Ukraine, the reason for this trend is the deformed structure of research and development funding, including by funding sources:

state funding remains the main source for development of domestic science and the level of private sector involvement in funding scientific and technical activities is low compared to developed countries.

3.4.4. Social group of factors

For France, there should be noted the influence of X1 (human development index) and X7 (population density) factors from the group of social factors on all types of emissions, since the value of the correlation coefficient is greater than 0.9. This can be explained by a number of reasons: for example, with an increase in population density, emissions can decrease in France owing to government support for startups that allow replacing a car's internal combustion engine with an electric motor, in addition, the population is forced to switch to the use of electric vehicles due to the fact that a number of car brands are banned in the EU countries because of a high level of emissions into the environment, high financing of energy efficiency. Since 2018, the energy saving sectors that are eligible for white certificates have increased significantly. As a result, given the time in France there are more than 200 energy efficient measures: from the installation of condensing boilers to refrigerators with low energy consumption, collective solar water heating systems to encouraging cycling, etc. In addition, given the high population density in cities, municipalities provide financial or technical support to the development of renewable energy production in neighboring rural areas, thereby strengthening local economic development. In their turn, rural communities, which are already engaged in the "positive energy" approach, or, in French, "Territoire à énergie positive", develop relationships with cities, offering them access to their resources, while maintaining control over projects and obtaining local income. It should be noted that in the formation of the gross domestic product, which is included in the calculation of the human development index, the service sector continues to dominate in France, and receipts from foreign trade and tourism are also of great importance. Therefore, with an increase in GDP, which leads to an increase in the human potential index, CO_2 emissions do not increase.

In Ukraine among social factors, X9 factor (grain yield) has the greatest influence on CO_2 emissions. The reasons for this trend may be that the yield increases due to fertilizers, pesticides, chemicals, while the level of emissions decreases in Ukraine.

4. Conclusions

There have been analyzed indicators of the level of a country's economic development, and on its basis, 4 groups of factors have been formed: environmental, economic, social, scientific and intellectual, which most fully characterize the level of a country development and affect emissions of harmful substances. It has been found that it is necessary to consider a greater number of factors for developing countries, especially indirect factors, since they have a significant impact on the level of economic development of such a country and they are of particular importance for further development in general.

Correlation analysis has been carried out to search for relationships between the level of harmful emissions and the selected factors, on its basis there have been selected factors, which are closely connected with CO_2, NOx, SO_2 emissions into the atmosphere. It has been found that the number of such factors in France is significantly higher than in Ukraine, and it is associated with the internal political and economic situation in the country, the level of energy-efficient technologies implementation and the modernization of enterprises, incl. environmentally friendly.

There are compared the selected factors and relationships with harmful emissions for countries with developed economies and developing countries. The differences in the research results have been shown and their reasons have been justified.

The research results allow us in the future to build multivariate econometric models for assessing the complex influence of such factors on emissions and to formulate recommendations for improving social, environmental and economic policies aimed at reducing harmful emissions.

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