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THE IMPACT OF THE CIRCULAR ECONOMY ON MITIGATING THE CONSEQUENCES OF CLIMATE CHANGE IN THE REGIONS OF UKRAINE

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ABSTRACT

Climate change and its impact on the economic and social welfare is a vitally important problem explored everywhere in the modern world. The objective of this research is to determine a correlation between the amount of carbon dioxide emissions in Ukrainian regions and their economic and demographic indicators: gross regional product, turnover of business entities and population density. The study is focused on CO_2 emissions from stationary pollution source. The article provides evidence-based arguments that circular economy is the model integrating two central objectives: economic growth and mitigation of effects from climate change. The study revealed a strong correlation between the implementation of circular economy practices and objectives of Sustained Development Goas, in particular with respect to minimization of CO_2 emissions. A statistical analysis of the relationship between CO_2 emissions and gross regional product (GRP), turnover of business entities and population density at the level of Ukrainian regions was made. It was revealed that all the Ukrainian regions with high rates of per capita GRP growth there is no tendency to increase CO_2 emissions. This complies with circular economy priorities: minimization of resource extraction through processing and re-production. The regions with a higher population density were revealed to have lower CO_2 emissions, which can be attributed to the fact that a higher population density often entails a more compact urban habitat. The regions with the largest turnover of business entities include regions with their highest population density. Economically developed regions often push technological innovations with breakthrough effects for energy technologies, transport and industrial processes, which help reduce CO_2 emissions.

Keywords: *climate change, circular economy, greenhouse gas emissions, CO_2 emissions, gross regional product, turnover of business entities, population density*

1. INTRODUCTION

Humanity of today has been facing many challenges, with climate change being the most pernicious as it poses threat to clean air, safe drinking water, adequate nutrition and safe housing. Climate change is expected to have a grave impact between 2030 and 2050, with the estimated effect of annual growth in mortality by nearly 250,000 persons, caused mainly by malnutrition, malaria, diarrhea and heat stress (World Heath Organizations, 2021).

Global efforts on harmonization of the Sustained Development Goals (SDGs) aim to improve the awareness of the relationship between carbon dioxide (CO_2)emission and circular economy (CE). Pasqualotto C., Callegaro-De-Menezes D., & Schutte C. S. L. (2023) argue that CE can be considered in this context as a way to achieve specific SDGs, e.g. the encouragement of institutions to adopting more responsible and resilient practices (SDG12).

The mass production has accelerated economic growth, improved social welfare and increased population size, resulting in the boosting output and even higher rates of waste generation and CO_2 emission (Degirmenci B., 2022). Industrial pollution closely related with economic development pushes companies to adopt environmental management practices, to reduce environmentally hazardous wastes on the global scale. Crucially important is developing the models designed for environmental protection, preservation of biodiversity and showing respect to nature on the way to sustainable development, without endangering living standards of individuals. CE is one of these models. Designed to reduce environmental pollution and greenhouse emissions, minimize resource exploitation for economic growth and create new jobs, this economic model makes it possible for future generations to inherit a more livable world. CE's goal is to create a system where materials are constantly recycled or repurposed rather than sent to wastes. By keeping materials in circulation and extracting the maximal value from them, CE seeks to reduce the depletion of resources and their environmental impact along with promoting sustainable economic growth (Taelman S. E., Tonini D., Wandl A., &Dewulf J., 2018).

The implementation of CE in parallel with economic modernization allows the Ukrainian society to have a dual benefit. First, the recycling of already consumed resources enables to gain an essential benefit in terms of saving costs for their purchase and reducing costs for waste utilization. Second, it decreases the environmental burden and solves the problems of waste utilization, with positive implications for the country's ecosystem (Podlevska O. & Podlevskyi A., 2023).

Studies by Belmonte-Ureña L.J. et al. (2021), Rodríguez-Antón J.M. et al. (2022) confirmed a high correlation between the implementation of CE practices and the objectives of SDGs. Also, climate change and its impact on economic growth or recession is a challenge to the contemporary world (Khan B., 2023). It is, therefore, very important to analyze a correlation between CO_2 emissions and economic growth in Ukrainian regions.

The objective of this research is to determine a correlation between the amount of carbon dioxide emissions in Ukrainian regions and their economic and demographic indicators: gross regional product, turnover of business entities and population density.

2. METODOLOGY

The documents for this research were selected using online sources MDPI, IEEE, Sciendo, Scopus та Science Direct. The selection was based on the criteria of novelty technological knowledge base and high potential of research.

The study was conducted for Ukraine as a whole and the Ukrainian regions over 2010–2021. To make an analysis more comprehensive, we used statistical information extracted from administrative data of the Ministry for Environmental Protection and Nature Resources of Ukraine and the State Statistics Service of Ukraine. The data produced from official statistical observations over 2010−2021 is given without inclusion of the temporary occupied territory of Autonomous Republic of Crimea, the city of Sevastopol; the data over 2014−2021 −without inclusion of a part of the temporary occupied territories of Donetsk and Luhansk regions; the data for

2022 – without inclusion of the territories temporary occupied by the Russian Federation and parts of the territories on which the warfare was (is) going on. Statistical data for Kyiv region are given with counting the data on the city of Kyiv, although in administrative terms Kyiv is not included in Kyiv region. The decision to avoid a separate data entry for Kyiv and Kyiv region was taken for purposes of a comparative analysis by Ukrainian region, because, following the official data reporting format, the other regional centers are included in a regional indicator.

This study of greenhouse gas emissions in Ukraine uses the definition of greenhouse gases as the ones trapping infrared radiation of the Earth surface, entailing the global warming of the planet. The main greenhouse gases in this study are carbon dioxide (CO_2), methane (CH_4), oxide of nitrogen (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Also, this study of CO_2 emissions at national level included the emission from mobile pollution sources, with a mobile pollution source referred to as a transport vehicle which movement generates emission of pollutants into the ambient air, whereas a stationery pollution source is referred to as an immovable object of pollution that preserves its spatial coordinates over time and generates emissions of pollutants into the ambient air.

In an analysis by Ukrainian region, gross regional product (GRP), turnover of business entities and population density were compared with CO_2 emissions, because the implementation of CE model can offer the double benefit to the Ukrainian society: production modernization and clean environment.

At regional level, GRP is a general indicator measuring the region's economic performance. GRP per capita was used for comparison purposes, to determine most productive regions of Ukraine and compare them with amounts of CO_2 emissions. A comparison of CO_2 emissions with economic activity of the business sector was made by turnover of business entities measuring the value of products shipped and paid by buyers.

3. RESULTS

3. 1. STATISTICAL INDICATORS FOR ANALYSIS OF CORRELATION BETWEEN CO2 EMISSIONS AND CIRCULAR ECONOMY

Global efforts on fighting against climate change and adopting more resilient economic practices are focused on understanding the complex relationship between CO_2 emissions and CE. Reports of the European Commission confirm the EU Action Plan on the achievement of sustainable development, with emphasizing the cyclic nature of production and consumption process (European Commission, 2016). In view of this, EU assigned the priority status to the transition from linear economy to CE, striving to achieve the majority of 17 SDGs.

Circular economy is a holistic approach to the sustainable development, aiming to minimize waste and maximize utilization of resources (Ramos A., 2024). It includes product, process and system development with emphasis on all the strategies enabling for recycling of materials into new production cycles or flows, in order to take benefit of their maximal value and maximal number of cycles (Foundation E.M., 2021).

Basically, CE development aims to maintain the maximal value and utility of materials, components and products over time by encompassing both technical and biological cycles (Ellen McArthur Foundation, 2015). CE can encourage innovations specific to industry (e.g. stable and effective use of resources); sustainable production and consumption (e.g. the implementation of resilient practices by companies, including integration of information on sustainable development in their reporting cycles, sustainable and effective utilization of nature resources, awareness of the life cycle and reduction of waste generation through recycling and reuse); actions aimed at fighting against climate change (e.g. sustainable management and use of forests and related resources) (Husgafvel R., 2024).

Also, CE redefines the manner of production, management, consumption of products and materials, creation of higher value in parallel with environmental advantages (The Circularity Gap Report 2023). At national level, it aims to form a carbon-neutral society; the promotion of CE is expected to have impact on solutions of problems pertaining to climate change, loss of biodiversity and excessive use of nature resources. Besides that, it was assumed that CE could stop and even partially reverse the loss of biodiversity across the world through, e.g., intervention of business in forestry industry, forestry management and construction (Tackling Root Causes, 2022).

The global economy is cyclic only on 7.2%, and the situation does not become better due to the increasing extraction and utilization of materials (The Circularity Gap Report 2023).But CE can satisfy human needs with an essentially reduced utilization of materials with keeping the planet within the safety limits. The main current areas of activities cover, for example, the companies' capacity to assess their impact, CE solutions for various sectors and systemic shifts for companies (World Circular Economy Forum 2023).CE solutions can mitigate effects of climate change, reduce the losses of biodiversity and overuse of nature resources; they include new business models designed to prolong the life cycle of products and to sustain the circulation of materials over the maximal period of time.

The key approaches to CE promotion are as follows:

1. reducing the extraction of primary raw materials (through lower scales of their utilization);
2. prolonged and better use of existing materials (through their longer use);
3. extended use of secondary materials (reuse);
4. replacing fossil fuel with renewable energy sources, and toxic materials with regenerative ones (making them clean).

Also, these approaches are closely associated with product design and functional use, and phases of products' completion of service (The Circularity Gap Report 2023).

Research demonstrates the existence of a correlation between dioxide carbon emissions and GDP. A complex relationship between dioxide carbon emissions and GDP is on the spotlight of environmental economics and research devoted to climate change. The relationship reflects a complex interplay between economic development and environmental effects (Nguyen H. T. et al., 2022). A rapid economic growth is conventionally associated with increasing CO_2 emissions due to intensified industrial activities and increased energy use (Nguyen H. T. et al., 2022).

Farhani and Rejeb (2012) revealed a correlation between GDP, energy consumption and CO_2 emissions by analyzing these indicators for 16 countries of Middle East and North Africa (MENA) in the long-run. Although Cho et al. (2014) estimated the correlation between GDP, energy consumption and CO_2 emissions over 1971–2000 in OECD area, they proved the importance of fossil fuel in explaining greenhouse gas emissions. Elfaki K. E. et al. (2022) demonstrated that energy consumption and financial development caused damage to the quality of environment in selected countries due to increased CO_2 emissions in the space, whereas economic growth and industrialization reduced environmental pollution due smaller CO_2 emissions.

Recent studies elaborating on global economic change and impact of international trade made this correlation more complex with emphasizing the need for multifaceted analysis with involving various economic entities (Wang Q., Zhang F. 2021).

Uzair Ali M. Et al. (2022) analyzed the impact of economic development, consumption of fossil fuel and population density on CO_2 emissions and revealed the existence of short-term causalities between economic development and CO_2 emissions, population density and CO_2 emissions, and consumption of fossil fuel and CO_2 emissions. They demonstrated that CO_2 emissions had adverse effects for economic development, whereas the impact of fossil fuel, foreign direct investment and total exports on economic development was positive in the long- run. Besides that, while CO_2 emissions have adverse effects for population density, economic development has positive impact on population density in the long-run.

A study of the correlation between CO_2 emissions and population density involves analysis of various complex factors with impact on CO_2 emissions (emissions in densely population areas). In regions with a denser population, higher energy needs, industrial activities and transport needs may increase CO_2 emissions (Wang S., Liu X., Zhou C., Hu J., Ou J., 2017). But these relationships are multidimensional, because highly populated areas, territorial communities or settlements may stand out for a higher efficiency, technological innovations and a propensity to sustainable urban practices.

Research demonstrates that the increasing economic activity and consumption trigger a higher demand for raw materials, resulting in a heavy greenhouse gas emission in the ambient air, which provokes radical climate change and jeopardize the environmental performance and bio-diversity.

The activities related with extraction, production and use of materials often make a significant contribution in CO_2 emissions resulting from their energy-consuming nature. Large scopes of raw materials extracted and used by a country are usually associated with the increasing energy consumption and greenhouse gas emissions, with an essential impact on climate change (Ekins P. et al., 2016). By contrast, a decrease in material consumption and an increase in the efficiency of resource use can potentially reduce CO_2 emissions. Striking the balance between economic development and resource sustainability has crucial importance for facing interrelated challenges of climate change and resource depletion, with special emphasis on the importance of a relationship between CO_2 emissions and extraction, production and use of raw materials (Ekins P. et al., 2016). Striking the balance between economic development and resource sustainability has crucial importance for facing interrelated challenges of climate change and resource depletion, with special emphasis on the importance of a relationship between CO_2 emissions and extraction, production and use of raw materials. The transition to CE with its preference to processing, reuse and sustainable management of materials is a promising strategy capable to distinguish between economic growth and environmental degradation, and to reduce CO_2 emissions caused by use of materials.

Bherwani H., et al. (2022) demonstrated on the example of three sectors, construction, industry and transport, how CE strategies reduce CO_2 emissions and consumption of materials.

Understanding the correlation between CO_2 emissions and CE has critical importance for politicians, researchers and companies engaged in environmentally responsible strategies. CE is inextricably linked with climate change, because it provides stimuli for effective use and reuse of materials, thus reducing energy consumption and greenhouse gas emissions related with extraction of resources, transportation and production processes. Through resource saving CE helps mitigate effects of climate change. CE model reduces the waste to minimum due to strategies such as recycling, renewal and reconstruction. A prolonged service life of products and materials decreases the need in manufacturing new products from scratch. This entails a lower demand for raw materials and energy-consuming production processes, resulting in reduced emissions of greenhouse gases. Such refusal from fossil fuel helps decarbonize energy systems, which is an important factor mitigating effects from climate change. Besides that, by encompassing the whole life cycle of products and services CE seeks to optimize resource flows and minimize their adverse environmental effects. This system approach helps build a more resilient economy and society capable to deal with climate change problems (Sardianou E., Nikou V., Kostakis I., 2024).

Maldonado-Guzmán G., & Garza-Reyes J. A. (2023) argue that CE principles, assigning priority to recycling, reuse and waste reduction, are able to considerably decrease CO_2 emissions. As demonstrated by research, the implementation of effective methods for recycling and innovative methods for waste management in the CE framework can help reduce CO_2 emissions compared with conventional linear models of production and consumption (Triguero Á., Cuerva M. C., & Sáez-Martínez F. J., 2022).

Research shows that national efforts in recycling entail lower CO_2 emissions, whereas the increasing waste of materials corresponds with higher CO_2 emissions. The results are consistent with empirical studies conducted by Ekins P. et al., (2016), which emphasize that large quantities of materials are often correlate with higher CO_2 emissions. $_2$A negative correlation between the country's economic growth and the level of CO_2 emissions means that environmentally clean urban planning, circular use of materials and conscious consumption have become more evident in countries with higher incomes. These results are consistent with the conclusions of Balsalobre-Lorente D. et al., (2017), stressing that further economic growth can reduce CO_2 emissions as countries introduce cleaner technologies and implement environmental policies. This study affirms the crucial role of resilient urbanization methods in reducing per capita emission in densely populated areas. Resource extraction, product manufacturing and consumption are admittedly have a critical impact on the environmental performance. It should be noted that technological innovations and a propensity to resilient urban practices are important factors for a negative correlation between population density and per capita emissions. The implementation of CE practices is a strong driver of the reduction in CO_2 emissions on account of reasonable utilization of materials and waste reduction. These results are consistent with studies emphasizing that CE principles can essentially reduce CO_2 emissions.

In focus of this study is an analysis of short-term and long-term correlations between CO_2 emissions, gross regional product, population density, turnover of business entities in various regions of Ukraine in 2015, 2021–2022.

3. 2. AN ANALYSIS OF THE CORRELATION BETWEEN CO_2 EMISSIONS AND SELECTED ECONOMIC AND DEMOGRAPHIC INDICATORS OF UKRAINIAN REGIONS IN THE CONTEXT OF IMPLEMENTING THE CIRCULAR ECONOMY MODEL AS A STRATEGY FOR MITIGATING EFFECTS FROM CLIMATE CHANGE

It was in 2015 that Ukraine approved for the first time the Nationally Defined Nomenclature (NDN) of commitments on reduction of greenhouse gas emission. The document envisaged 60% reduction in CO_2 emissions compared with 1990.

Later Ukraine ratified the UN Framework Convention on Climate Change, Kyoto Protocol and Paris Agreement. A series of respective legislative acts and by-laws were approved by the Parliament and the Government, including the ones referring to the period till 2023:

Guidelines for the implementation of state policy on climate change.

Strategy of environmental safety and adaptation to climate change.

On June 30, 2021, Government approved the Updated Nationally Defined Contribution of Ukraine to the Paris Agreement (NDN2), laying out the goal of 35% reduction in the greenhouse gas emissions compared with 1990.

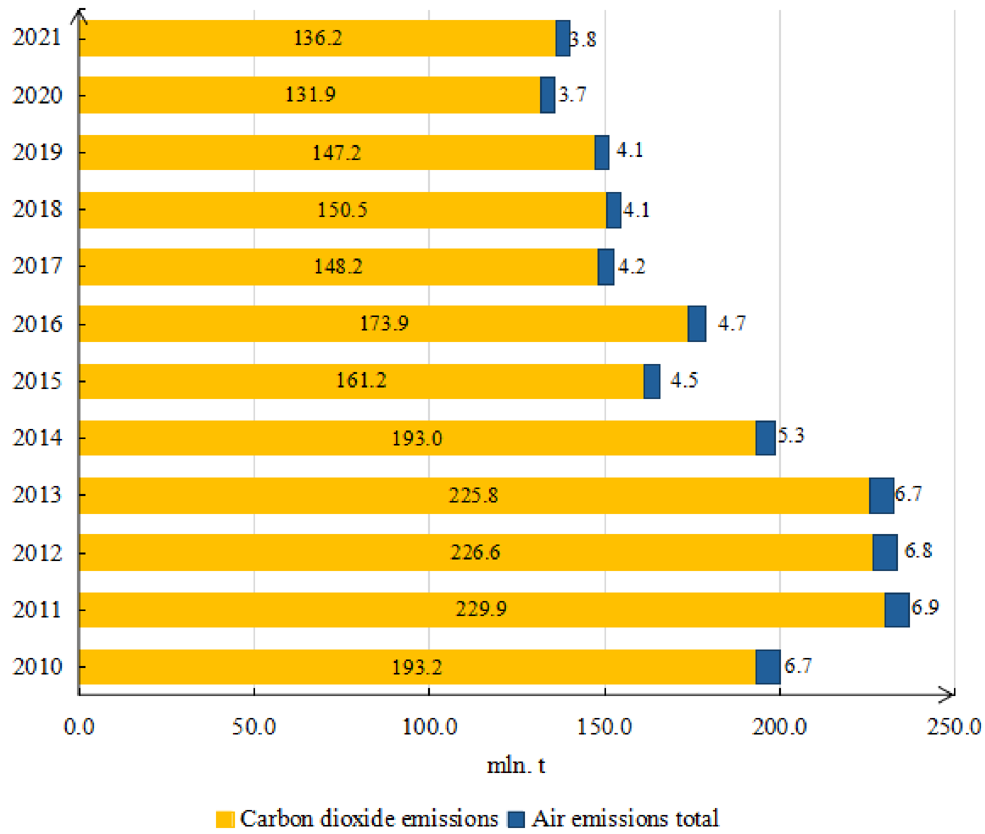
Also, the Cabinet of Ministers of Ukraine elaborated the sequence of actions in implementing the national system for trade in quotas for greenhouse gas emissions, a crucially important step in fulfilling Eurointegation commitments. However, in November 2023 the European Commission pointed out that the progress in this area was still inadequate for appreciation of Ukraine's efforts.

According to the World Meteorological Organization (WMO), the main greenhouse gases with the increasing concentration are carbon dioxide, methane, nitrogen oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and ozone in lower atmosphere (World Meteorological Organization).

The State Statistics Service of Ukraine includes the following substances to the greenhouse gas nomenclature: carbon dioxide, methane, nitrogen oxide, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) (State Statistics Service of Ukraine).

An analysis of greenhouse emissions in Ukraine in 2010–2021showed that in 2021 they amounted to 140 mln t and were only 4.4 mln t (by 3%) more than with 2020, but they fell by 15% compared with 2015 and by 30% compared with 2010. An analysis of air emissions in Ukraine in 2010–2021showed that in 2021 they amounted to 3.8 mln t, and were only by 3% less than with 2020, but they fell by 19% compared with 2015 and 1.8 times compared with 2010 (Fig. 1). Carbon dioxide emissions make up the largest part of all greenhouse gas emissions in Ukraine. CO_2 emissions in the ambient air were 136.2mln t in 2021, which is 4.3 mln t (3%) higher than in 2020, but 25 mln t (18%) less compared with 2015 and 30% less than in 2010 (Fig. 1).

Figure1. Dynamics of air emissions total and carbon dioxide emissions in Ukraine, 2010–2021, mln t



Source: developed by the author based on the data of the State Statistics Service of Ukraine

The dynamics of CO_2 emissions in the ambient air of Ukraine throughout 2010–2021 depended on various economic and social events taking place within the country and beyond it:

- A rapid decline in greenhouse emissions, including CO_2, from 1990 till the beginning of 2000s. It resulted from the shrinking industrial and agricultural production after collapse of the Soviet Union, with the falling fuel consumption in power industry, the restructuring of national economy and the expanding services sector.
- Early 2000s till 2008: a period of stabilization and growth in greenhouse emissions,

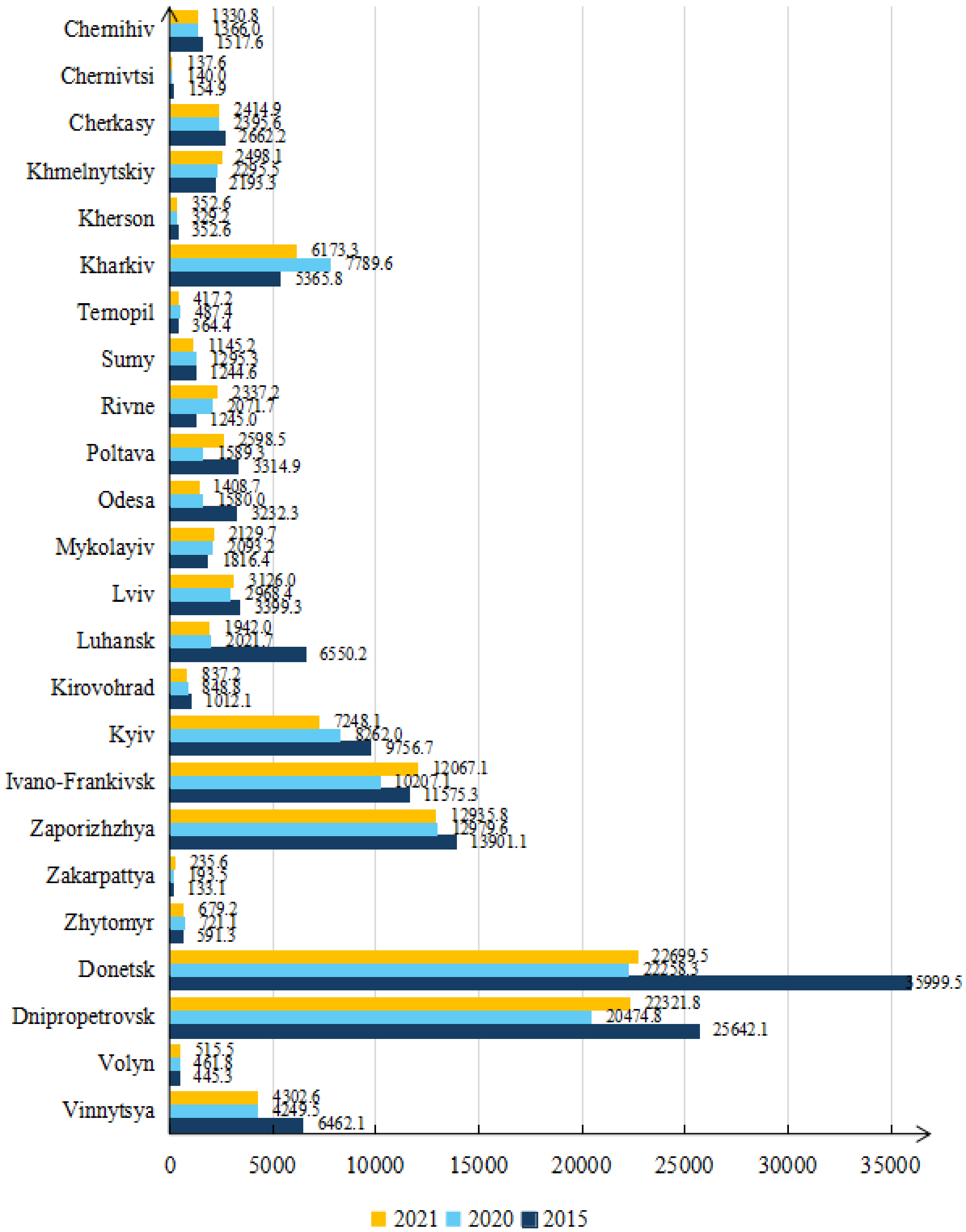
including CO_2. It was a consequence of the increasing output of minerals and basic metals, and of the macroeconomic growth. There was an upward tendency in the consumption of solid fossil fuel in the domestic power industry. But the industry launched a series of actions on modernization and energy saving, to reduce the consumption of natural gas due to the boosting gas price in 2006.

- CO_2 emissions fell by 12% in 2009 compared with 2008 due to effects of the global economic crisis of 2008, with the plummeting output of cement, ammonia and metals.
- The rising CO_2 emissions in 2010–2013 amidst the macroeconomic recovery from the consequences of global crisis in 2008. This period saw a higher consumption of solid fossil fuel in power industry as a result of the gas conflict of the Russian Federation;
- The plummeting CO_2 emissions caused by the economic recession due to the occupation of the Autonomous Republic of Crimea and the city of Sevastopol and the beginning of warfare in Donetsk and Luhansk regions.
- CO_2 emissions saw 6% increase in 2016 compared with the previous year.
- CO_2 emissions in 2017–2019 fluctuating between 147.2 and 150.5 mln t. This period was marked by the launch of a vigorous energy-saving policy (with the implementation of "Warm loans" program) and the gradual bringing the rates of electricity, hot water and heating into compliance with market-based principle of pricing.
- 2020 saw 12 percent reduction compared with 2019, caused by COVID-19 pandemic and measures taken to combat the virus.
- 2021 was marked by 3.2 percent increase in CO_2 emissions compared with 2020.

The analysis showed that the largest CO_2 emissions in the ambient air were generated by stationary pollution sources. The emissions were record high in Donetsk, Dnipropetrovsk, Zaporizhzhia, Ivano-Frankivsk and Kyiv regions both in 2015 and 2015. The lowest emissions were recorded over the analyzed period in Chernihiv, Zakarpattya, Kherson, Ternopil and Volyn regions (Figure 2).

Given that the general indicator measuring the economic performance of a region is gross regional product (GRP), an analysis of per capita GRP was made, to identify the most productive Ukrainian regions (Figure 3).

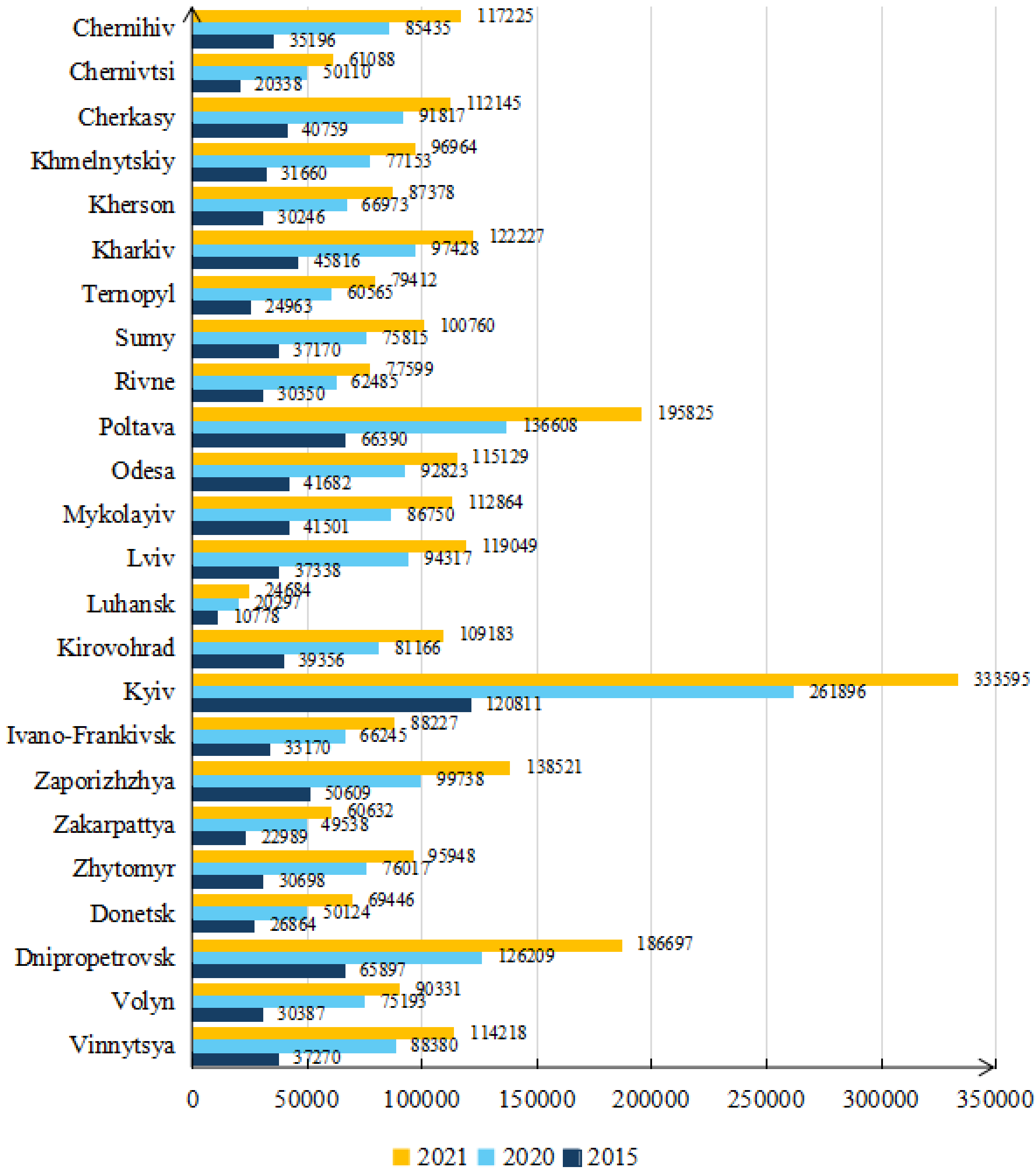
Figure 2. Air emissions of carbon dioxide from stationary pollution sources in Ukrainian regions,



Source: developed by the author based on Environment of Ukraine 2022. State Statistics Service of Ukraine

As shown in Figure 3, Kyiv region was the uncontested leaderin 2021 with GRP per capita of 333.6 thsd UAH, followed, with a large gap, by Poltava region (195.8 thsd UAH), Dnipropetrovsk region (186.7 thsdUAH), Zaporizhzhia region (138.5 thsd. UAH), and Kharkiv region (122.7 thsd UAH).

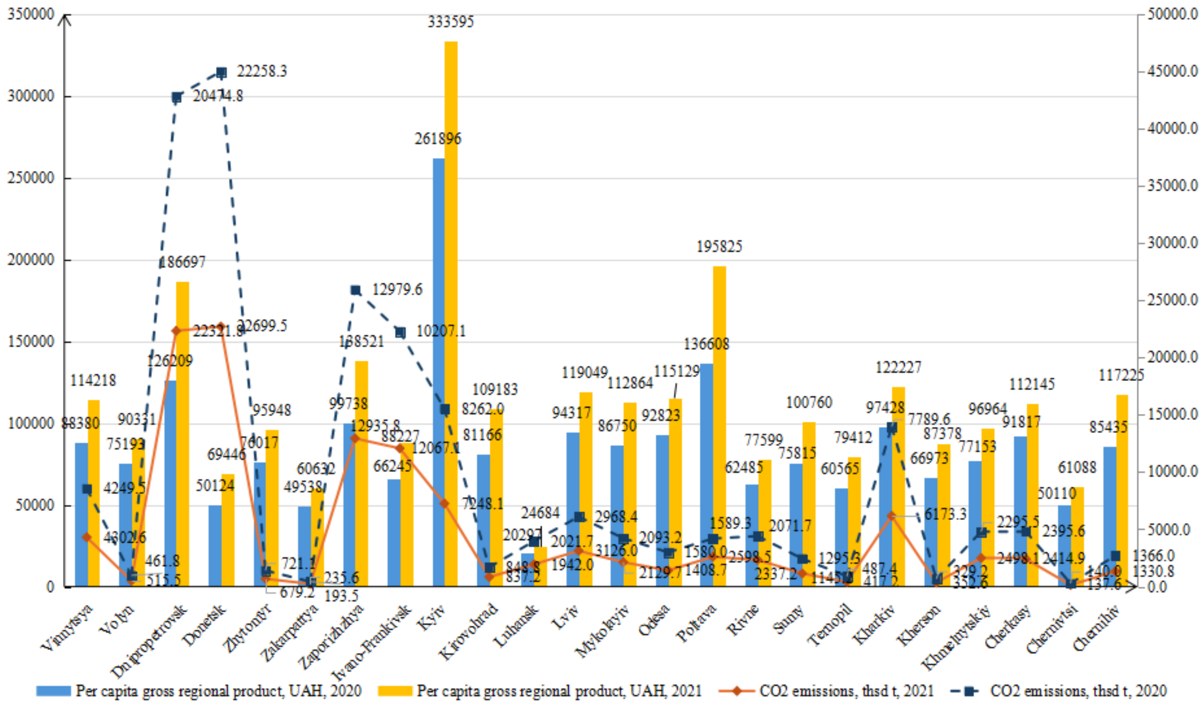
Figure 3. Per capita gross regional product of Ukraine, 2015, 2020–2021, UAH



Source: developed by the author based on the data of the State Statistics Service of Ukraine

It is worth to be noted that the record high economic performance of Kyiv region is attributed to the development of Kyiv city. When the economic performance in the regions in 2021 is compared with 2015, the ranking would be the same, with Kyiv region on the top (120.8 thsd UAH), followed by Poltava region (66.4 thsd UAH), Dnipropetrovsk region (65.9 thsd UAH), Zaporizhzhia region (50.6 thsd UAH), Kharkiv region (45.8 thsd UAH). The only difference is in essentially higher performance figures in 2021. Also, the study showed that a significant growth in per capita GRP in 2021 across Ukrainian regions relative to 2020 did not trigger higher CO_2 emissions (Fig. 4).

Figure 4. Comparison of per capita gross regional product and in CO_2 emissions by regions of Ukraine, 2020–2021

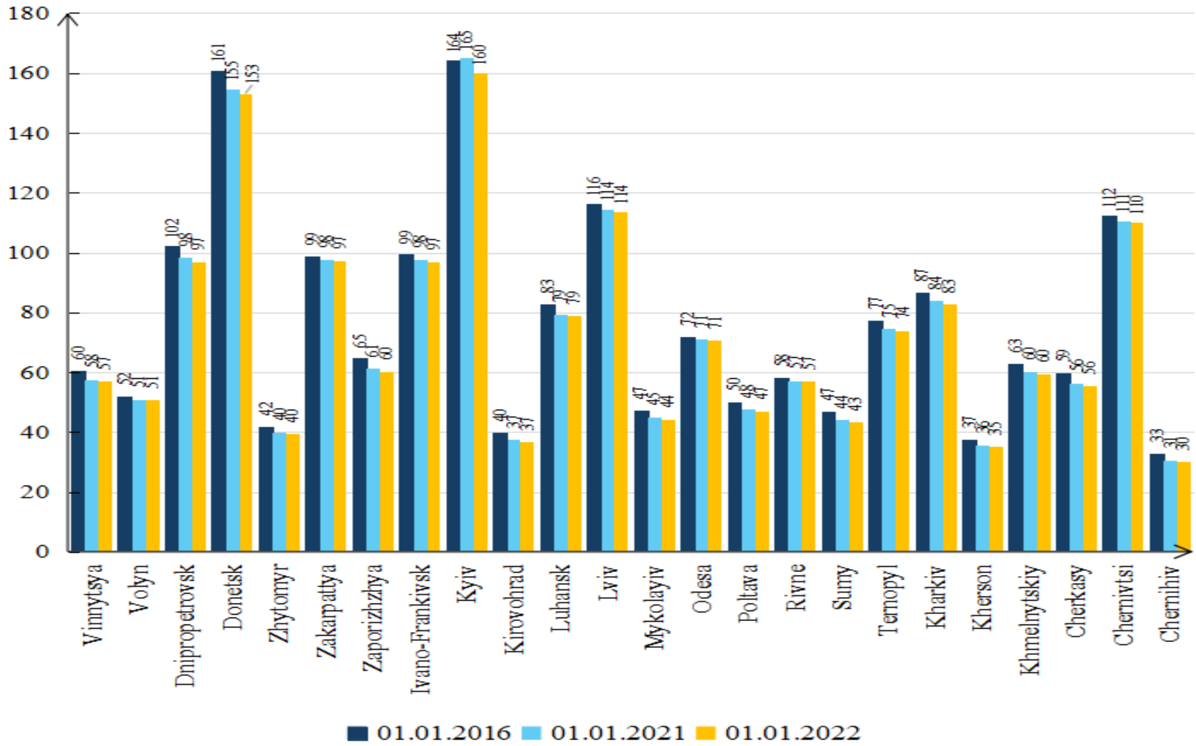


A strong correlation between the two indicators could be found only in Dnipropetrovsk, Ivano-Frankivsk, Donetsk, Poltava and Lviv regions. In other Ukrainian regions (Kharkiv, Sumy, Odesa or Kyiv), a not able growth in per capita GRP in 2021 relative to 2020 resulted in either unchanged or even reduced CO_2 emissions.

Consider the correlation between CO_2 emissions and population density by Ukrainian region. The regions with the highest population density in the analyzed period include Kyiv, Donetsk, Lviv, and Chernivtsi (Fig. 5).

While densely populated regions like Kyiv, Donetsk or Dnipropetrovsk feature increased needs in energy, with industrial activities and transportation needs being contributive and explanative factors for the increasing CO_2 emissions (Fig. 2), Chernivtsi region ranking fourth among the most densely populated regions has long continued to be among the regions with the lowest CO_2 emissions. The situation is the same in Zakarpattya region, which can be attributed to the fact that a high population density tends to form compact urban habitats with higher potentials for effective land use, a lesser extent of territorial sprawls and shorter distances for commuting to work. Another possible explanation is that these regions are more inclined to invest in the creation and maintenance of reliable public transport systems. Besides that, a high population density can be an energy saving factor due to economy-of-scale effects in infrastructure developments, e.g. energy-saving buildings, centralized heat supply and waste management systems. Another interesting fact is that the regions with the lowest population density, like Chernivtsi or Kherson, feature the lowest figures for CO_2 emissions.

Figure5. Population density in Ukraine in 2015, 2020–2021, persons/km²

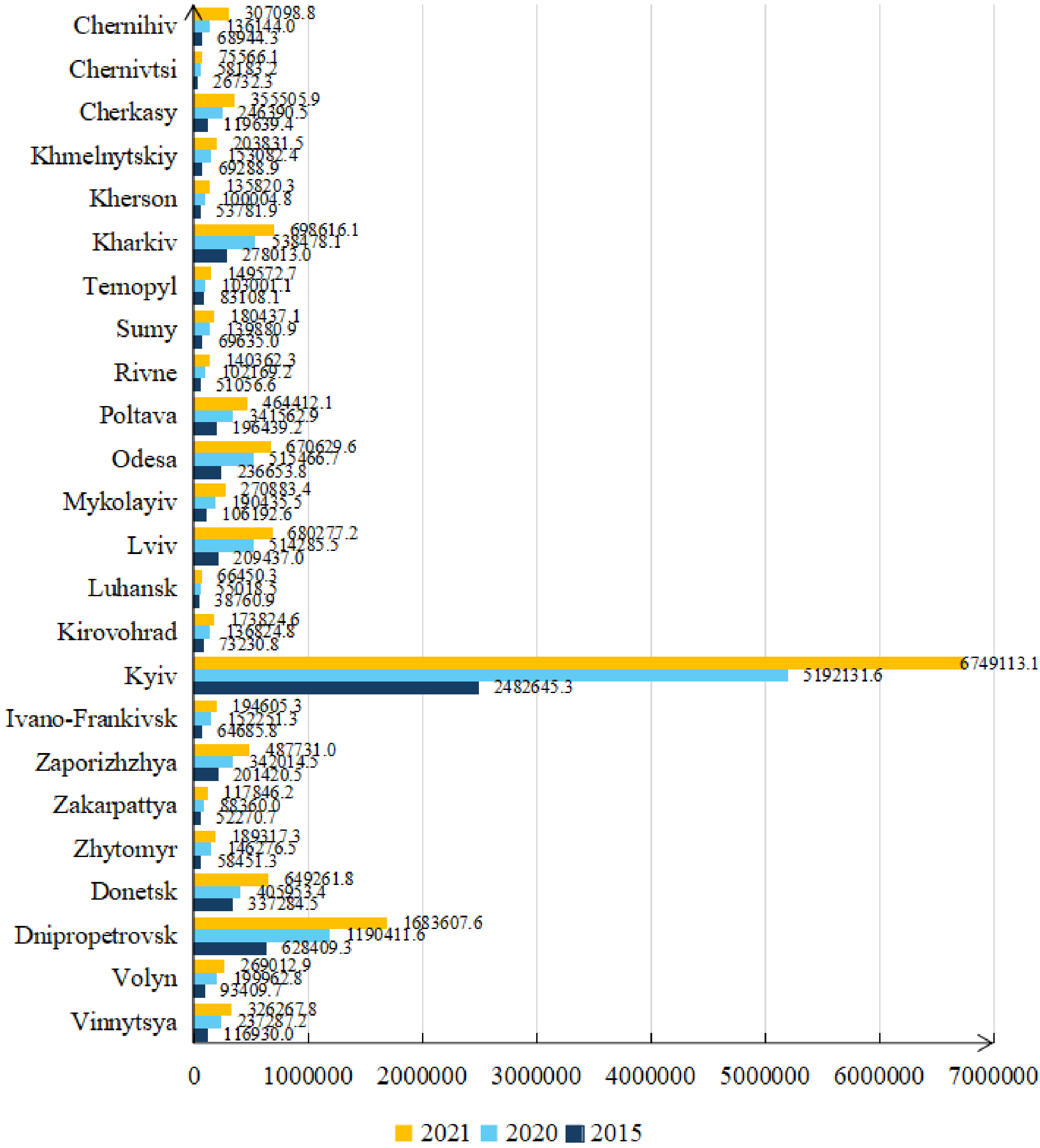


Source: developed by the author based on the data of the State Statistics Service of Ukraine

As mentioned above, the activities related with extraction, manufacturing and use of materials often make a large contribution in CO_2 emissions as a result of high energy consumption. An analysis of turnover of business entities was made to find its correlation with CO_2 emissions. The analysis showed that Kyiv region once and gain ranked top by turnover of business entities, with a heavy contribution by the city of Kyiv: in 2021, the city of Kyiv accounted for 86.2% of the region's turnover of business entities (Fig.6).

The regions with the largest turnover of business entities include Dnipropetrovsk. Kharkiv, Lviv, and Odessa. It is not surprising given their highest population density.

Figure 6. Turnover of business entities by Ukrainian region in 2015, 2021–2022, mln UAH



Source: developed by the author based on the data of the State Statistics Service of Ukraine

4. DISCUSSION

The results show that high indicators of regional performance in the short-run are often related with increasing CO_2 emissions. A negative correlation between economic growth in a region and increasing CO_2 emissions therein implies that environmentally clean urban planning, circular use of materials and conscious consumption have become even more evident in the regions with high per capita GRP. These results are consistent with Balsalobre-Lorente D. et al., (2017) emphasizing that the subsequent economic growth can reduce CO_2 emissions, because regions introduce cleaner technologies and implement environmentally friendly policies.

A correlation between regional economic performance and CO_2 emissions demonstrates that when regions achieve a higher economic growth, there will occur risk that expected advantages of environmentally clean methods may lead to a sentiment of satisfaction that can be a potential trigger for mitigating strict environmental norms. An adverse effect may occur when advantages of economic growth amidst higher incomes will force individuals to ignore the initially set environmental priorities. A region that has achieved a higher pace of economic development can give preference to industries with a higher carbon dioxide emission due to imaginative economic benefits, thus provoking an increased emission in spite of earlier effort on the implementation of environmentally friendly practices. Yet, our analysis could not reveal implications of high growth rates in per capita GRP for an increase in CO_2emissions in the overwhelming majority of Ukrainian regions.

5. CONCLUSIONS

The relationship between climate policy, sustainable development and circular economy has primary importance in present-day technological, economic and environmental transformations.

The article presents an analysis of the short-term and long-term correlation between CO_2emissions, per capita GRP, population density and turnover of business entities. The study is focused on CO_2emissions from stationary pollution sources. A close correlation between per capita GRP and CO_2 emissions was found for only Dnipropetrovsk, Ivano-Frankivsk, Donetsk, and Lviv regions, whereas in the other Ukrainian regions a growth in per capita GRP can even result in a decline in CO_2 emissions. This trend conforms to CE priorities, i.e. minimization of the resource extraction by encouraging their reuse, recycling and re-production. The need in resource extraction provoking higher CO_2 emissions can be decreased by prolonging the life cycle of products and materials. CE practices, recycling in particular, usually require lesser energy than extraction or processing of primary materials, which helps save energy and reduce CO_2 emissions. Using recycled materials in manufacturing allows for lower emissions compared with products made of raw materials. But the effectiveness of this practice depends on supporting policies including tax preferences, extended producer responsibility programs, and rules promoting sustainable production and consumption. Besides that, a negative correlation between GRP and CO_2 emissions may indicate that CO_2 emissions reduce as the region's development continues. Economic growth is also related with change in consumption models, e.g. in the economy based on services and featuring a lower carbon intensity than the industry, especially heavy industry sectors. Economically developed regions often push technological innovations with breakthrough effects for energy technologies, transport and industrial processes, which help reduce CO_2 emissions.

Public administration bodies need to implement emission reduction strategies focused on investment in cleaner technologies, which would help make energy more cost-effective and comply with industry standards of emissions. Also, politicians can encourage R&D on "green" technologies to face emission-specific challenges in times of economic growth. The enhancement of environmental law along with strict compliance with it acquires critical importance at the phases of rapid economic growth. Normative acts need to target industries with high CO_2 emissions and push the implementation of best practices aimed at limited use of extracted raw materials. The implementation of schemes for pricing of carbon emission, e.g. taxes on carbon emissions or schemes designed to control carbon emission and trade in carbon emission quotas, can push companies to reduce their environmental impact and help internalize environmental costs on CO_2 emissions.

The conclusion that regions with higher population density demonstrate low CO_2 emissions can be explained by the fact that a higher population density often entails a more compact urban habitat. This helps improve the effectiveness of land use and shorten distance of work trips. By creating better conditions for public transport, pedestrians and cyclists, compact planning considerably reduces carbon emissions generated by transport vehicles. Regions with higher population density are more inclined to invest in the creation and maintenance of reliable public transport systems. Well-established public transport networks are able to decrease the dependence of residents on individual automobile trips, thus reducing per capita emissions. Besides that, a higher population density can enhance economy of scale in infrastructures, e.g. energy saving buildings, centralized heating and waste utilization system, thus helping reduce per capita energy consumption and emissions.

Although this study provides valuable information, it is important to admit its limitations and outline the feasibility for future research. This study deals with economic (GRP, turnover of business entities) and demographic (population density) indicators as independent variables determining the carbon emissions. Yet, factors like political setup, technological advancement or cultural background may have impact on the relationship between CE practices and carbon emissions. An analysis of these supplementary factors can ensure a better understanding of the carbon emission behavior in various regions. Future research can be devoted to grouping of regions by key economic activity and by activity analysis of CO_2 emissions within created clusters.

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