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Green innovative economy remodeling based on economic complexity

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ABSTRACT

In this article, we propose a model of innovative economy remodeling, which aims to increase economic complexity by developing and investing in the green economy. We create this model for example of a transitional economy, which is the economy of Ukraine. For a comprehensive statistical analysis of the share of natural and energy resources in individual sectors of the economy, data on intermediate consumer costs from the first quadrant of the Input-Output table (Leontief model) were used for the first time. In this way, the most resource-intensive sectors of the economy and those that require investment in innovative technologies of green business are identified. The following sectors have the highest shares in the consumption of natural and water resources: C – Production; D – Electricity, gas, steam and air conditioning supply; E - Water supply; sewerage, waste management and remediation activities. In these sectors, first of all, implementing modern (knowledge-rich) green technologies should take place, which will reduce the consumption of natural and water resources. The proposed model can serve as a justification for the choice of investment directions in the remodeling of other economies in the transition period.

1. Introduction

The study of instruments of economic complexity is gaining more and more popularity among scientists, economists, politicians and ecologists every year (Erkan and Ceylan, 2021). During the last decade, new directions have been updated in studying economic complexity, including introducing innovative technologies into production processes capable of reducing the necessary resources for production. Economic complexity is also taken into account in the analysis of the effectiveness of solving environmental problems when creating mechanisms for the development of industry sectors and economic activity (EA), including mechanisms for environmentally safe storage, transport, processing and disposal of manufactured products (Lybbert and Xu, 2022; Soprun et al., 2020; Gala et al., 2018; Laverde-Rojas and Correa, 2019; Sciarra et al., 2020; Caous and Huarng, 2021; Antonelli, 2016).

It should also be noted that in the last few decades, the world has faced very serious environmental problems in the last few decades. Initiatives undertaken by global organizations are the answer to these problems. Since the 1992 United Nations Conference on Environment and Development (the Rio Earth Summit), environmental and climate goals have been at the center of policy debates on economic development. The concept of "green growth" has been recognized as an alternative perspective on how to increase global prosperity in the long term with explicit recognition of environmental constraints (Bowen and Hepburn, 2014).

There are many interpretations of the term “green economy”. As stated in the UN document “Green Economy Initiative”, published in November 2011 (Green Economy Initiative, 2011), it is a policy that promotes improving people’s well-being by reducing environmental pollution and rational use of natural resources.

As Mealy and Teytelboym (2022) show, there is no defined, specific and beneficial green industry policy. It is possible to indicate where the next competitive green opportunities are likely to emerge, but the extent to which growth in these areas requires industrial policy intervention or regulatory reform needs to be determined on a country-by-country basis. An important indicator of the green economy is the Environmental Performance Index (EPI), which is a comprehensive indicator of the assessment of the state’s environmental policy and its subjects conducted by Yale University (Scotland). Economies in transition fare much worse than developing countries in these rankings (The 2022 Environmental Performance Index (EPI) Results, 2022).

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Moreover, as Erkan and Ceylan (2021) show, countries need to increase their level of economic complexity to increase their competitiveness. The authors examine 22 economies in transition in terms of the causal relationships between the Economic Complexity Index (ECI) and Economic Growth Rate (GR), Economic Freedom Index (EFI), Human Development Index (HDI), and Foreign Direct Investment (FDI). These studies show, among other things, that in the case of Ukraine, Hungary, Kazakhstan, Slovakia, and Georgia there is a one-way relationship "ECI is the Granger cause of FDI". This means that the low level of economic complexity affects the low level of ownership interests of companies of these countries in foreign companies and projects. The influx of FDI into economies in transition is also discussed by Johnson (2006). Autor divides the European transition economies into two subgroups; the Central and Eastern Europe (CEE) economies and the Commonwealth of Independent States (CIS) economies, including Ukraine. His analysis shows that the CEE economies were much more effective in attracting FDI inflows than the CIS economies (average cumulative per capita inflows are more than five times higher for the CEE group than for the CIS group). However, the economies of Eastern Europe are an opportunity for business development in other developed European and non-European countries, but they also need an influx of capital and technology (Mihai, 2012). It is essential that economies in transition strive for economic growth while maintaining a clean environment (Adedoyin et al., 2020) including improving the efficiency of energy policy in the environmental area (Jonek-Kowalska, 2022). As Huang (2023) emphasizes, in the context of the study of sustainable development of Central and Eastern European (CEE) countries, this is a region of great geopolitical importance, which has not yet received sufficient attention.

The above-mentioned articles show the problems and directions of change of countries in transition in Central and Eastern Europe. Taking into account these guidelines to change, in this article we propose a model of innovative remodeling of the economy in the transition period. By innovative remodeling of the economy, we mean reconstruction that takes into account the increase in economic complexity based on the concept of a green economy, because, as shown earlier, environmental issues are so important. We propose the example of a transitional economy, which is the economy of Ukraine, a model of innovative remodeling of the economy based on the Input-Output table. We use the Input-Output table because the Leontief model is a good method of studying the behavior of the economy. In this type of research, the second quadrant of the Input-Output table, the so-called final demand matrix is most often used. For example, Jarwal (2022) used the final demand matrix to study the behavior of the economy in the formal and informal sectors. He showed, among other things, that the success of an enterprise along with economic development leads to the transformation of informal sector units into formal ones, and that both sectors are interrelated, interdependent and mutually complementary. Harada (2016) developed a theoretical model for input-output innovation matrix. His research revealed that the links between innovations are sometimes negative, but quite a few sectors show positive and significant innovation linkage effects. On the other hand, García Álvarez-Coque et al. (2012) used the Leontief model (second quadrant) to study the intensity of innovation and linkages in the agri-food sector. A novelty in our research is the use of the first quarter of the input-output table, the so-called production consumption matrix.

The following research questions were formulated in order to build a model of innovative remodeling of the economy:

- How the development of a green economy in each type of economic activity will affect the economy in general and which types of economic activities are advanced (as green drivers)?
- What is the share of natural resources in individual sectors of the economy?

In connection with the first research question, an analysis of statistical data on the volume of production of goods and services and production costs for intermediate consumption was performed. Particularly interesting in the context of the proposed approach is the share of natural resources in individual sectors of the economy. For a comprehensive statistical analysis of the share of natural resources in individual sectors of the economy and the share of water consumption and disposal costs in the same industry sectors, data on costs for intermediate consumption from the first quadrant of the Input-Output table were used. The analysis makes it possible to identify the most resource-intensive sectors of the economy and those that require investment in innovative technologies. The results obtained for all sectors of the economy according to the Leontief model are presented in the expanded diagram of the resource-capacity matrix. Then, to build a model of innovative remodeling of the economy, these investments in high technologies were calculated, which will make it possible to reduce resource consumption due to a decrease in the consumption of natural resources and the consumption of water resources.

The conducted analyzes allow proposing a model of remodeling the Ukrainian economy, in the transitional period. Our research procedure can be used in other countries (especially countries in transition) to remodel their economy in an innovative way. The proposed investment model in green business, particularly in the field of critical infrastructure, can justify the choice of investment directions in the period of innovative remodeling of the other economies.

The article is organized as follows: in the introduction, we justify the choice of the research subject and carry out literature studies on our research. Section 3 presents the methodology (materials and methods). Section 4 presents the research results, and Section 5 contains a discussion of the results obtained. We end the article with a summary in the "Conclusions" section.

2. Related literature

2.1. Economic Complexity

The concept of economic complexity appeared in the context of assessing the development potential of the world economy and its components (Dieppe, 2021; Le Moigne, 1995; Jackson, 1999; Bublyk et al., 2021a,2021b,2021c), in the case of income distribution to bridge the gap between wealth and poverty (Rothschild and Sen, 2006; Holling, 2001), in the context of assessing highly intellectual components in the production of goods and services (Drucker, 1969; Romer, 2014;), as well as in the case of determining the spread of exported products and their diversity (Rivera-Batiz and Romer, 1991; Lee and Vu, 2020; Tacchella et al., 2013). A breakthrough in recognizing economic complexity as an important tool for assessing the share of knowledge and intellectual work in the final effect - gross production of goods and services was the Atlas of Economic Complexity (2022), developed in 2011 by professors of the Harvard University C. A. Hausmann et al. (2013). For the first time, the key role of economic complexity in shaping a country's income was described by Hidalgo and Hausmann (2009). They defined the concept of economic complexity as a measure of society's knowledge contained in manufactured goods and services. In subsequent studies, in the calculations of economic complexity, characteristics of exports such as the diversity and universality of goods and services were taken into account (Hidalgo, 2021). In addition, many researchers emphasize that achieving a variety of goods and services cannot be without the use of high technologies with a high share of intellectual work and the introduction of unique know-how for producing products with a significant concentration of knowledge (Chukhray et al., 2019; Cristelli et al., 2015; Bublyk et al., 2021a,2021b,2021c; Ferrarini and Scaramozzino, 2016; Mariani et al., 2015). Economic complexity is also taken into account in the analysis of the effectiveness of solving environmental problems when creating mechanisms for the development of industry and EA, including mechanisms for environmentally safe storage, transport, processing and disposal of manufactured products (Lybbert and Xu, 2022; Soprun

et al., 2020; Gala et al., 2018; Laverde-Rojas and Correa, 2019; Sciarra et al., 2020; Caous and Huarng, 2021; Bublyk et al., 2021a,2021b,2021c; Antonelli, 2016).

2.2. Open Innovation

The environmental friendliness of business is directly related to green investments in resource-saving and knowledge-intensive technologies, where open innovation plays a key role (Yun et al., 2016). The concept of open innovation assumes a two-way approach to knowledge exchange, i.e. acquiring knowledge from other entities (inbound activities) and making knowledge available to beneficiaries (outbound activities) (Yun and Liu, 2019). Incoming activities include consumer co-creation, information networking, contracting with external R&D providers and crowdsourcing. Outbound innovation, on the other hand, refers to the extraction of knowledge from the company through the sale of market-ready products, undertaking corporate ventures, licensing intellectual property and selling patents, and spinoffs. As shown by Yun et al. (2019), open innovation is also a strategy that can be a useful policy program for governments to solve the problem of creating new jobs and developing new industries. This aspect should be noted in the context of our research towards a model for rebuilding the economy in the transition period. In addition, culture should be considered a key driver of innovation (Yun et al., 2020). Creating a culture for open innovation is of key importance not only for industry but also for cities and societies as well as for public organizations that, in addition to legal barriers, also have to overcome cultural barriers.

In the context of open innovation, green innovations are discussed extensively by, among others, Tjahjadi et al. (2020). The authors believe that green innovations provide an opportunity to compete in green markets through open innovations that reduce the negative impact on the environment and satisfy customer needs for environmentally friendly goods and services. Chin et al. (2022) consider revolutionary blockchain technologies responsible for the formation of the green innovation ecosystem and provide recommendations for their organization. Loučanová et al. (2022) substantiates the role, examples and implications of open business models of eco-innovation for sustainable development in Slovakia, focusing on the dynamic impact of open innovation.

Most authors (Tjahjadi et al., 2020; Chin et al., 2022; Loučanová et al., 2022) consider open innovation from the point of view of the process of developing new products, services, and technologies in cooperation with various companies, government institutions, and consumers. Given the complexity of Ukraine's economy before the war, it is important to find new ways to restore it and achieve sustainable development after the war. Therefore, open innovation should become a key tool for achieving these goals. According to Allal-Chérif et al. (2023), the peculiarity of open innovation at the micro level is the ability to combine knowledge and resources of various origins, involving in the creation of new goods and services both the knowledge and experience of highly qualified specialists and the technologies of the world's leading companies.

In the analyzed case, at the macro level of Ukraine's economy, open innovation should be understood as an approach to creative activity, which involves attracting external sources of knowledge and resources to create new ecological goods and services. approach to innovative activity, which consists in attracting external sources of knowledge and resources to create new ecological goods and services. Among the methods of introducing open green innovations into the economy of Ukraine is an increase in investment in low-carbon technologies, and low-energy resources with a high intellectual share, aimed at the development of green business. An important role is also played by the creation of an effective system of cooperation and interaction between various economic entities and power structures for the development of green products, services and technologies (Bublyk et al., 2021a,2021b,2021c). In our opinion, the openness of green innovation means cooperation with external partners, which include, first of all, universities, research organizations, high-tech companies and leading research groups of innovators and startups. Furthermore, to restore the complexity of the economy, and develop new sectors of the economy and business models for Ukraine, it is important to use the experience of the world's leading countries (for example, the EU and the USA) where the green economy is successfully developing. Allal-Chérif et al. (2023) researching the successes of the Patagonia company highlight revolutionary management strategies for sustainable entrepreneurship, among which open ecological product innovation and business digitalization play an important role.

Therefore, open innovations in green business are an important element of the model of innovative remodeling of the economy based on the complexity of the economy.

2.3. Green economy implementation

Many scientists have laid theoretical and methodological foundations for "greening" the relationship between man and nature, aimed at survival in both the present and future environment. The term "green economy" dates back to 1989 when it was first used in the Report of the British Government "Concept of Green Economy" by a group of scientists: Pearce, Markandia and Barbier (Pearce, 1989). Ecological economics was initiated at the Millennium Summit of the United Nations in 1992 in Rio de Janeiro, when the "Agenda for the 21st century" was adopted (Agenda 21, 1992). This program document approved the implementation of "green" measures in the national economies of the countries within the framework of the sustainable development strategy. Based on the results of this document, the UN Framework Convention on Climate Change was signed (United Nations Framework Convention on Climate Change, 1992). All this contributed to the fact that sustainable development was recognized as one of the most important tasks of humanity.

In 2008, in the context of the global financial crisis and a possible global recession, the Organization for Economic Cooperation and Development (OECD) advocated the idea of stimulating the national economies of the world by introducing "green" production (Allen and Clouth, 2012) and redirecting public and private capital to finance green activities (Borel-Saladin and Turok, 2013). Consequently, such stimulation was to help improve the economy, increase the employment level of the population, and contribute to the fight against climate change, negative environment and poverty. In October of the same year, the UN Environmental Program (UNEP) announced the transition to a "green" economy and launched an initiative to analyze its development. In its documents, UNEP calls for maximum attention to be paid to the five most important areas (UNEP, 2011):

- The energy efficiency of construction;
- Transition to alternative energy sources, such as wind, solar, geothermal and biomass energy;
- Sustainable development of transport;
- The ecological condition of fresh waters, forests, soils and coral reefs;
- Development of sustainable agriculture, including organic production

UNEP and other international organizations that have supported the green initiative suggest investing up to 2% of global GDP in greening economies. First, investments should be directed to agriculture because no other economic sector is associated with so many aspects of the green economy. This sector is the main source of income for most of the world's population, provides it with food and occupies about 40% of the territory. In addition, 70% of drinking water is used specifically for agriculture and is one of the largest sources of greenhouse gas emissions.

The green economy is a purposeful state policy and strategic direction aimed at saving resources, protecting the environment and

improving the general well-being of the population. It is the fundamental factor that forms the ecological component of the country's positive image, which directly affects the creation of its investment attractiveness to the global business community.

The green economy is a type of sustainable development economy (Pop et al., 2011) that aims to achieve harmony between man and nature (Collins et al., 2010). As pointed out by Wang et al. (2011) it is important to achieve benefits for all situations between the human economy and the natural environment. In addition to promoting low-carbon energy, green economy advocates harnessing the ecological processes that occur in natural systems without compromising the sustainability of these ecosystems (D'Amato and Korhonen, 2021). The green economy is also related to elements of the circular economy, such as reducing material and energy inputs in the production process, recycling and reuse, and greener supply chains (Loiseau et al., 2016; Lorek and Spangenberg, 2014).

The green economy is a concept that is constantly evolving, from the stage oriented towards the goal of the ecosystem (1989–2006) through the stage oriented towards the economic-ecosystem goal (2007–2010) to the stage oriented towards the economic-ecological-social goal (2010–present) (Ren and Sun, 2020, Zhang, 2022).

As pointed out by Houssam et al. (2023) and Licastro and Sergi (2021), there is no one-size-fits-all green economy model, therefore the social and economic situation of each country should be taken into account in the transition of countries to a green economy.

As mentioned earlier, an important indicator of the green economy is the Environmental Performance Index (EPI), which is a comprehensive indicator of the assessment of the state's environmental policy and its subjects conducted by Yale University (Scotland). Economies in transition fare much worse than developing countries in these rankings (The 2022 Environmental Performance Index (EPI) Results, 2022). For example, in 2018, Ukraine took 109th place among 180 countries in the world with an EPI indicator of 52.87 points (which is significantly lower than in 2016, when Ukraine was rated 44th with an environmental productivity index value of 79.62 points), Georgia took 104th place and Kazakhstan took 101st place. Switzerland leads the rating with an environmental productivity index value of 87.42 points, significantly ahead of France with an EPI = 83.95 points.

The concept of green economy is closely related to the term green business (Hasan et al., 2019). In order to implement the principles of a green economy, it is necessary to develop green business. There are many definitions of green business. For example, Gilbert (2007) considers it to be any human activity carried out in such a way as to minimize the negative impact on the environment or that can bring benefits to the environment. Another definition says that these are environmentally oriented enterprises or activities, i.e. the use of ecological or natural products, actions against emissions and development of renewable sources (Friend, 2009). Brown and Ratledge (2011) believe, that these are simply companies that produce green production. Whereas Čekanavičius et al. (2014) suggest that "a green business is an organization that respects the principles of sustainable development of the environment in its activities, strives to use renewable resources and tries to minimize the negative impact of its activities on the environment". In this sense, it is part of a long-term strategy to strive for sustainability, i.e. activities that do not pose economic, social and environmental risks, which is also emphasized by Mioara and Mihai (2014).

Despite numerous publications by the UN non-governmental organization and many scientific studies that spread the principles of the "green" economy, today green business is not included in the priority strategic directions for the development of the economies in transition, including Ukraine. Therefore, as a result of research into innovative ways of developing the economy of nature use and environmental protection, a priority was set for the development of green business in relation to other types of economic activity, which is also the implementation of the green economy concept.

3. Materials and methods

3.1. The economic complexity analysis

The Economic Complexity Index (ECI) assesses economic complexity. In ECI calculations, a key role is played by the volume of the country's exports and the level of its diversification. Hausmann et al. (2013) substantiate that the level of export diversification is precisely the key driver of the country's projected income. The level of economic complexity indicates not so much the income growth itself but its speed, which characterizes the curvature (speed or slope) of the country's economic growth. Therefore, the Economic Complexity Index (ECI), can be used to define a measure of economic development. The advantages of the new index are also discussed by Cristelli et al. (2013). They suggest using the ECI index to assess the level of competitiveness of countries since the production of complex (science-intensive) goods and their considerable diversity are drivers of the modern world economy. The positive impact of economic complexity in reducing poverty and increasing the equity of income distribution is also noted (Hartmann et al., 2017). Zhu and Li (2017) analyzing almost all countries of the world economy (about 210), resort to the use of reflection methods to prove the positive impact of economic complexity on human capital development. Moreover, Ferraz et al. (2018) emphasize that the increase in the complexity of the economy leads to a rapid increase in human capital. Similar results were obtained by Lee and Vu (2020), who built several economic and mathematical models. Macro learning costs in national accounts have also been studied. It has been shown that they create intangible assets that should be included in GDP and investments, and not, as is customary, in intermediate consumption (Marrano et al., 2009).

3.2. Matrix methods and models of economic analysis (Input-Output Table)

Matrix methods and economic analysis models are used to systematically analyze system elements and determine the interaction between their components. Among the tools of matrix methods, the most famous are SWOT analysis, PEST analysis, BCG and McKinsey matrix, M. Porter's five forces matrix, Ansoff matrix, etc. These matrices are used to a greater extent for competitive analysis and determination of optimal market development strategies at the micro level, where the key players in the market are business entities - enterprises or companies.

At the macro level, matrix methods are used less frequently because of the large volumes of information and data that must be collected and analyzed. The Input-Output table is the most famous, based on the Leontief model.

We analyze the state and structure of national accounts in Ukraine, which the State Statistics Service of Ukraine conducts according to the matrix of the inter-industry balance developed by Leontief. In the State Statistics Service of Ukraine, this world-famous Leontief model has been called the Input-Output table. The Input-Output table in the last row reflects the entire volume of gross output of goods and services (GO) for each EA according to the structure of costs for certain types of goods and services used during production.

The expediency of using the Leontief model for analyzing the resource capacity of the Ukrainian economy was first substantiated in the work of Bublyk (2015), where the volume of production of goods and services was studied for each EA according to indicators of direct resource consumption.

Data for the research were obtained from open sources of statistical institutions in Ukraine and the USA. We use the matrix method of analysis to present and visualize the data obtained from the first quadrant of the Input-Output table (Leontief model), where the volumes of intermediate consumer spending in the currency of the country are given. For a comprehensive statistical analysis of the shares of natural and energy resources in each sector of the economy of Ukraine and the USA, the following ratios were used:

- The share of all intermediate consumption of each industry sector (EA) in the total output of the economy;
- The share of intermediate consumption of natural resources in the total output of each industry sector (EA);
- The share of intermediate consumption of water resources, sewage and waste management in the total output of each industry sector (EA);

Based on the values of these shares, it is determined which sectors of the economy are the most resource-intensive and requires investments in innovative technologies.

Taking into account these recommendations (Bublyk, 2015), in our study, when calculating the impact of investments on the development of a green economy, we used the well-known Leontief model, which is described by formula (1):

$$x_i = \sum_{j=1}^{n} x_{ij} + y_i, \tag{1}$$

In formula (1), the sector of final consumption (households) is added to all types of economic activity ($i = 1; n$), where x_i is the output of goods and services of the i-th type of economic activity from all n-types of economic activity, y_i is the number of products of the i-th type of economic activity supplied to the final consumer (households); x_{ij} - current costs of products of the i-th type of economic activity for the production of the j-th type of economic activity, then the production of goods and services of the i-th type of economic activity.

Assuming a linear relationship between costs and production volume, we can determine the coefficient, which is called the coefficient of direct costs of the i-th product in the j-th EA, and is expressed by the formula (2):

$$a_{ij} = \frac{x_{ij}}{x_j} \tag{2}$$

where coefficient a_{ij} is positive ($a_{ij} \geq 0$).

This made it possible to construct a square matrix of the order n, where $1 \leq i \leq n$ and $1 \leq j \leq n$ $(i,j = 1,\ldots,n)$ called the technological matrix, represented by the formula (3):

$$A = a_{ij}. \tag{3}$$

Substituting (2) into (1), we obtain the Leontief model (4) in vector-matrix form (that is, the consumption-output table):

$$X = AX + Y \tag{4}$$

which is written (5):

$$(I - A) \times X = Y, \tag{5}$$

where $X = (x_i)$ is a column vector of gross outputs; $Y = (y_i)$ - column vector of final products; I is the unit matrix.

The static system of inter-industry connections is described by formula (6):

$$X = (I - A)^{-1} \times Y = BY, \tag{6}$$

where B is a matrix multiplier described by formula (7):

$$B = (I - A)^{-1} \tag{7}$$

Implementing innovative, environmentally friendly technologies leads to increased investments in the green economy. The description of the influence of the green economy on the model of the inter-industry balance is reflected by formula (8), which is proposed by Shabranska (2015):

$$X_i^{(t+1)} = \sum_{j=1}^{n} (a_{ij} + b_{ij_i}) X_j^{(t)} - \sum_{j=1}^{n} b_{ij} X_j^{(t-1)} + Z_i^t \tag{8}$$

where $X_j^{(t+1)}$ is the forecast volume of production of goods and services for the i-th green EA; $X_j^{(t-1)}$ the actual volume of production of goods and services under the i-th green EA in the previous year; a_{ij} is the coefficient of direct material costs of products of the i-th green EA, which is spent on the production of a unit of products of the j-th green EA; b_{ij} is the capital capacity coefficient, which shows how many units of investment products of the i-th (investment) EA are used for one unit of increase in production of the j -th green EA; z_i^t is the forecast volume of final products of the i-th green foreign exchange, which contains all elements of the final use of GDP, except for the gross accumulation of fixed capital.

Over the past three years, many authors have turned their attention to the undiscovered possibilities of the Input-Output table. Thus, Mascaretti et al. (2022), Galychyn et al. (2022) and Long et al. (2020) believe that the study of the level of the carbon footprint of economic activity, and cost-benefit analysis should be used. In the case of successful investments in high technologies, such an analysis will show the redistribution of these costs between specific sectors of the economy. Galychyn et al. (2022) believe that using the input-output table in the approach contributes to considering the hierarchy of sectors, their functional relationships, and all possible ways of ecological and socio-economic flows existing in a complex economic environment. In addition, Input-output tables, as proved by Mascaretti et al. (2022), contribute to the analysis and visualization of similarities and differences between the technological structures of countries.

4. Results

4.1. Analysis of the resource capacity according to the Input-Output table

The main source of problems in the Ukrainian economy is currently the war between Russia and Ukraine, which has led to the massive destruction of the country's economic infrastructure.

However, before the start of the war, economic activity had a destructive impact on the environment, economy and society due to its high dependence on resources (Bublyk et al., 2021a,2021b,2021c). The share of knowledge-intensive products in Ukraine's exports was less than 2%. The rapid development of the industrial revolution, the growth of the world's population, which led to a rapid demand for water and food products, and a geometrical increase in the amount of waste that accompanies human activity, only deepened the crisis in the state's economy.

It is natural that when production volumes increase, the need to use large volumes of renewable and non-renewable natural resources also increases. However, the key goal of doing business is to make a profit. However, is this achieved by any means without addressing social or environmental goals? No one denies that enterprises of various types of economic activities (EA) often increase the use of limited natural resources and pollute the environment, creating inevitable consequences of the results of their EA.

As shown by Bublyk (2015), the total consumption capacity in the Ukrainian economy is the largest in the processing industry (74 kopecks per 1 hryvnia of the cost of manufactured products). For the supply of electricity, gas, steam and air conditioning it is 62 kopecks for 1 hryvnia of the cost of the produced products, for water supply; sewerage, waste management - 65 kopecks for 1 hryvnia of the cost of manufactured products, for construction - 71 kopecks for 1 hryvnia of the cost of the produced products. This indicates a high share of costs in the total cost of the manufactured products and their low technology.

In addition, the costs of fuel and energy resources in water supply, sewerage and waste management are extremely high (18.8% of the output of goods in this type of EA), and the lowest are in financial and insurance activities (0.09% of the production of goods in this type of EA). The average cost of fuels and energy resources amounted to 4.4% of commercial production in the Ukrainian economy.

The high resource capacity of Ukrainian goods and services is several times higher than the corresponding indicators of the world's leading countries, which causes Ukraine's ratings to be lower every time

Table 1
Input-output table for the use of commodities by industries (sector) in consumer prices in a million UAH in the period 2019.

Com/Ind*	A* *	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
A	196769	296	194488	1262	18	246	246	2999	4677	7	0	553	244	331	2395	2924	704	58	73
B	3575	30023	487894	168223	577	21437	3927	41694	544	78	2	956	401	1591	2109	2789	992	248	271
C	212540	75612	876216	41774	12693	220598	99407	104198	11863	14785	4796	17512	24565	11241	32963	4762	37966	1632	5060
D	16229	41237	118956	32803	8035	3029	16466	33722	3820	4288	44	555	2855	4252	9365	15164	5147	2295	1720
E	853	701	4815	6429	3063	420	1194	1174	404	146	14	1717	143	1963	470	355	713	115	304
F	4021	2279	21018	2864	754	167157	12872	13078	1556	1208	235	17031	13626	3776	6607	406	880	220	726
G	116934	49544	674490	2150	2432	14659	130783	17762	563	7570	3250	5162	11853	2747	2141	5471	3862	951	522
H	42038	14879	172329	1359	2526	3358	67128	48408	306	773	207	646	5684	1979	5664	1019	699	516	357
I	233	159	1563	319	9	478	1666	682	795	554	27	86	1502	1497	1409	98	408	588	104
J	974	773	10265	2134	661	1376	24045	3602	1299	135109	3001	2097	17530	2451	5565	9276	4065	1022	1697
K	8371	4727	18202	6724	1336	2511	43932	10028	1634	4600	35950	7314	10657	2026	3282	3399	3993	843	1206
L	4475	2518	21469	2325	611	2604	40194	5273	1743	10883	5733	16318	32380	2068	277	1183	3573	625	722
M	14113	12027	43812	4089	2759	18830	44173	14755	2858	6935	12499	17535	21167	8624	9728	8627	3470	1348	2449
N	5865	5923	7717	688	2066	5473	5997	16662	2083	2402	2174	8995	656	16229	0	4050	2068	2106	2142
O	1334	1752	7934	5254	1187	846	4909	2419	529	265	350	1319	1402	509	1593	3833	1525	474	115
P	34	140	241	130	31	56	250	187	26	93	41	47	503	59	388	5948	298	8	7
Q	66	261	574	189	69	298	151	575	128	93	14	16	84	25	613	15	17178	68	14
R	34	41	510	61	19	8	289	217	213	1712	0	231	523	38	2132	252	270	2241	3643
S	178	164	455	335	203	165	2283	376	283	342	213	373	533	183	0	264	1417	160	438

* Notes: author's calculation based on Ukraine's Input, Output Table at Consumer Prices (2019) (https://ukrstat.gov.ua/operativ/operativ2006/vvp/vitr_vip/vitr_u/arh_vitr_u.html); 0 indicates that the specific consumption of the resource of sectors in each other industries is less than 1000 UAH; * * Letters indicate the corresponding ciphers of the following types of industries (sector): Com – Commodities; Ind – Industries; A – Agriculture, forestry and fishing; B – Mining and mining support service activities; C – Manufacture; D – Electricity, gas, steam and air conditioning supply; E - Water supply; sewerage, waste management and remediation activities; F – Construction; G – Wholesale and retail trade; repair of motor vehicles and motorcycles; H – Transport, warehousing, postal and courier activities; I – Accommodation and food service activities; J – Information service activities and telecommunications; K – Financial and insurance activities; L – Real estate activities; M – Professional, scientific R&D and technical activities; N – activities in the field of administrative and auxiliary services; O – Administrative and support service activities; P – Education; Q – Human health activities, residential care activities and social work activities without accommodation; R – Arts, entertainment and recreation; S – Other service activities.

compared to the leading countries of the world (Bublyk, 2015). At the same time, in the countries of the European Union, entrepreneurs are trying to optimize production by reducing their resource capacity (Cortez et al., 2022; On the Key Principles (Strategy) of the State Environmental Policy of Ukraine for the Period till 2030, 2019; The 'Sustainable Development Goals: Ukraine' national report, 2017), which complicates the European integration processes for Ukraine.

The same opinion is shared by Shabranska (2015), who proposes the use of the classic form of the consumption-production table to assess the impact of the development of the green economy on the national economy in general. However, she only theoretically models the impact of the development of green EA types on the country's economy to assess their possible merits as drivers, without providing any calculations for the evidence base.

In our opinion, it is important to establish how the development of a green economy in each type of economic activity will affect the economy in general and which types of EA are advanced (green drivers). The impact of high-tech green investments on the economy will be positive. In Ukraine, some types of EA, especially in the service sector, which practically do not cause any harm, are already green in their content. We believe it is important to establish which types of EA the state of affairs is catastrophic and which types of EA need the most investment flows in technologies with a high intellectual share.

For the calculation, data from the first quadrant of the Leontief model for 2019 in consumer prices in million UAH, which describes the processes of reproduction in the national economy, for each EA, according to KVED (KVED, 2010), were used. In the first quadrant of Ukraine's Input–Output Table at Consumer Prices, 2019, data on intermediate consumption in each EA are given for a different set of its subtypes, with a different number in each sector of the economy.

To indicate the sectors of industry, set W was introduced, which contains all the names of the sectors according to the relevant general (KVED, 2010).

$W \in \{A,\ B,\ C,\ D,\ E,\ F,\ G,\ H,\ I,\ J,\ K,\ L,\ M,\ N,\ O,\ P,\ Q,\ R,\ S\}$

For example, in sector B - Mining and mining support service activities the subtypes of the these EA is only 3, and for sector C - Manufacture these subtypes are already 17 ones. To calculate the total intermediate consumption in each sector of the economy, formula (9) was used:

$$x_{uv} = \sum_{k_{\min}}^{k_{\max}} \sum_{l_{\min}}^{l_{\max}} y_{u_k v_l}, \tag{9}$$

where x_{uv} - the cell in Table 1, which shows the current costs of production of the u-th type of economic activity for the production of the v-th type of economic activity, calculated in million UAH.

$y_{u_k v_l}$ – a cell in the input table Input–Output Table, where the current costs of products of the k-th subtype of the uth type of economic activity for the production of products of the l-th subtype of the vth type of economic activity, calculated in million UAH.

$k_{\min}$, $k_{\max}$ – the minimum and maximum value of the subtype number of the u-th type of economic activity;.

$l_{\min}$, $l_{\max}$ – the minimum and maximum value of the subtype number of the v-th type of economic activity;.

$u, v \in W$ – type of economic activity.

Table 1 shows the results of the calculation of current production costs for all 19 types of economic activity in the production of 19 types of economic activity carried out according to formula (9).

Table 1 shows the first quadrant of Leontief model for 2019 at consumer prices in a million UAH, which describes the processes of reproduction in the Ukrainian economy, for each EA, according to the Classification of economic activities (KVED, 2010).

The Input-Output table in the first quadrant (intermediate consumption) in the columns reflects the value composition of each EA's gross output of goods and services according to the structure of costs for

Table 2
Capacity composition of GDP of each industry by the structure of costs for resources used during production in 2019, UAH per UAH 1 of output.

Com/Ind	A**	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	Share
A*	0.197	0.000	0.195	0.001	0.000	0.000	0.000	0.003	0.005	0.000	0.000	0.001	0.000	0.000	0.002	0.003	0.001	0.000	0.000	0.441
B	0.004	0.030	0.489	0.169	0.001	0.022	0.004	0.042	0.001	0.000	0.000	0.001	0.000	0.002	0.002	0.003	0.001	0.000	0.000	0.533
C	0.213	0.076	0.879	0.042	0.013	0.221	0.100	0.105	0.012	0.015	0.005	0.018	0.025	0.011	0.033	0.005	0.038	0.002	0.005	1.816
D	0.016	0.041	0.119	0.033	0.008	0.003	0.017	0.034	0.004	0.004	0.000	0.001	0.003	0.004	0.009	0.015	0.005	0.002	0.002	0.321
E	0.001	0.001	0.005	0.006	0.003	0.000	0.001	0.001	0.000	0.000	0.000	0.002	0.000	0.002	0.000	0.000	0.001	0.000	0.000	0.025
F	0.004	0.002	0.021	0.003	0.001	0.168	0.013	0.013	0.002	0.001	0.000	0.017	0.014	0.004	0.007	0.000	0.001	0.000	0.001	0.271
G	0.117	0.050	0.677	0.002	0.002	0.015	0.131	0.018	0.001	0.008	0.003	0.005	0.012	0.003	0.002	0.005	0.004	0.001	0.001	1.056
H	0.042	0.015	0.173	0.001	0.003	0.003	0.067	0.049	0.000	0.001	0.000	0.001	0.006	0.002	0.006	0.001	0.001	0.001	0.000	0.402
I	0.000	0.000	0.002	0.000	0.000	0.000	0.002	0.001	0.001	0.001	0.000	0.000	0.002	0.002	0.001	0.000	0.000	0.001	0.000	0.012
J	0.001	0.001	0.010	0.002	0.001	0.001	0.024	0.004	0.001	0.136	0.003	0.002	0.018	0.002	0.006	0.009	0.004	0.001	0.002	0.228
K	0.008	0.005	0.018	0.007	0.001	0.003	0.044	0.010	0.002	0.005	0.036	0.007	0.011	0.002	0.003	0.003	0.004	0.001	0.001	0.171
L	0.004	0.003	0.022	0.002	0.001	0.003	0.040	0.005	0.002	0.011	0.006	0.016	0.032	0.002	0.000	0.001	0.004	0.001	0.001	0.155
M	0.014	0.012	0.044	0.004	0.003	0.019	0.044	0.015	0.003	0.007	0.013	0.018	0.021	0.009	0.010	0.009	0.003	0.001	0.002	0.251
N	0.006	0.006	0.008	0.001	0.002	0.005	0.006	0.017	0.002	0.002	0.002	0.009	0.001	0.016	0.000	0.004	0.002	0.002	0.002	0.094
O	0.001	0.002	0.008	0.005	0.001	0.001	0.005	0.002	0.001	0.000	0.000	0.001	0.001	0.001	0.002	0.004	0.002	0.000	0.000	0.038
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.006	0.000	0.000	0.000	0.009
Q	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.017	0.000	0.000	0.020
R	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.002	0.004	0.012
S	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.008

* Notes: own elaboration; * * - letters indicate the cyphers of industry (see the note in Table 1); Share – the share of all intermediate consumption of each industry in the total output; 0.000 indicates that the specific consumption of the resource per unit of the cost of the volume of output in this industry is less than 0.1 kopecks for 1 hryvnia.

certain types of goods and services used during production (Table 1).

In Table 1, the lines indicate the use of certain goods or services for intermediate consumption during production for each EA.

Table 2 shows the calculated capacity composition of the gross output of each EA according to the structure of resource costs (cost capacity) consumed during the production of goods and services.

The Table 2 shows the capacity composition of the gross output of each EA enterprise calculated by formula (10) according to the structure of resource costs (cost intensity) consumed during the production of goods and services.

$$w_{uv} = \frac{x_{uv}}{V_v}, \tag{10}$$

where w_{uv} – is the share of intermediate consumption of the u-th type of economic activity in the total production output of the v-th type of economic activity, calculated in relative units; x_{uv} – intermediate consumption of products of the u-th type of economic activity during the production of the v-th type of economic activity, calculated in million UAH.V_v – output of goods and services in each v-th type of economic activity, calculated in million hryvnias.

According to Ukraine's Input-Output Table at Consumer Prices (2019), intermediate consumption is estimated at basic prices and includes 1) the cost of goods and services used by an economic unit for a year; 2) conditional payment for services of financial intermediaries; 3) travel expenses except per diems; 4) purchase by manufacturers of low-value and fast-wearing items; 5) rent for buildings, structures, machines and equipment; 6) acquisition of weapons, uniforms, food for the armed forces; 7) trade and transport markups consumed as part of used goods; 8) taxes except for subsidies on products consumed as part of used goods and services. However, Tables 1 and 2 show only the value component of intermediate consumption without trade and transport markups and taxes on products consumed as part of used goods. It was possible to remove this from intermediate consumption because their values are given in separate lines in the Input-Output tables (Ukraine's Input, Output Table at Consumer Prices, 2019).

Figure 1 shows the percentage value $w_{uv}\%$ of intermediate consumption of natural resources in the total output of each type of economic activity, calculated according to formula (11).

$$w_{uv}\% = w_{uv} \times 100\%. \tag{11}$$

Graphically in Figure 1 presents the percentage value of the share of consumption of natural resources by each sector in 2019.

As can be seen in Figure 1, in 2019 we have the two largest consumers of natural resources, industry sector C - Manufacture and industry, and sector D - Electricity, gas, steam and air conditioning supply, for which high consumption of natural resources is observed (respectively 48.95% and 16.88% of all production of goods and services in each EA sector). Three sectors of industry B – Mining and mining support service activities; F – Construction and H – Transport have natural resource costs ranging from 2% to 5%. The rest of the industrial sectors form a group with low consumption of natural resources (less than 1%).

The same study was conducted to compare the share of costs for water consumption and water disposal in the same industry sectors. As shown in Figure 2, the highest shares of costs for water resources consumption and their sewage system belong to three sectors of industry D - Electricity, gas, steam and air conditioning supply (0.64%); C - Manufacture (0.48%) and E - Water supply (0.31%). Regarding the industrial sector E (Water supply), the share value of costs for the water resources consumption and their sewage system in 0.31% of the volume of the entire production of goods and services in this EA is due to the specifics of this industrial sector.

Four more sectors of industry G – Wholesale and retail trade; repair of motor vehicles and motorcycles; H – Transport, warehousing, postal and courier activities; L – Real estate activities; N – activities in the field of administrative and auxiliary services have costs for the consumption of water resources and their sewage system in the range from 0.1% to 0.3%. The rest of the industry sectors form a group with low consumption of water resources (less than 0.1%). There are only two industry sectors which have higher values of shares A – Agriculture, forestry and fishing and B – Mining and mining support service activities and are 0.09% and 0.07%, respectively. This is also not quite an unexpected phenomenon due to the specifics of production technologies in these EAs.

Figure 2 shows the percentage value $w_{uv}\%$ of the intermediate consumption of water resources and their drainage in the total output of

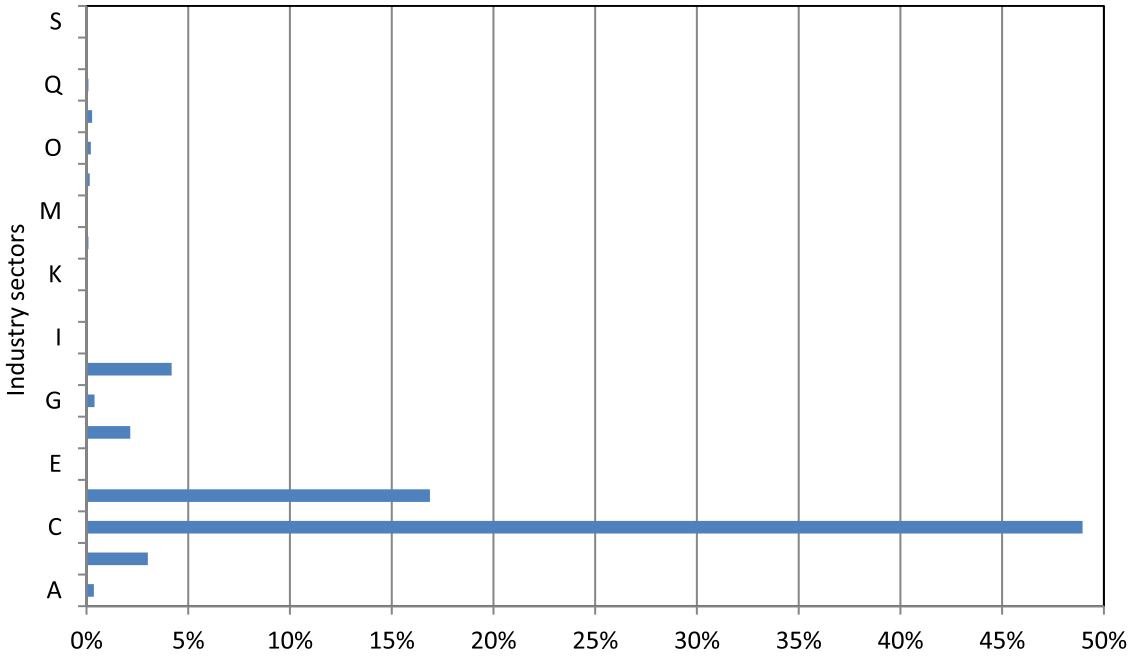

Fig. 1. The share of consumption of natural resources in 2019 by each industry sector. * Notes : own elaboration; * * The letters indicate the corresponding industry cyphers (see the note to Table 1).

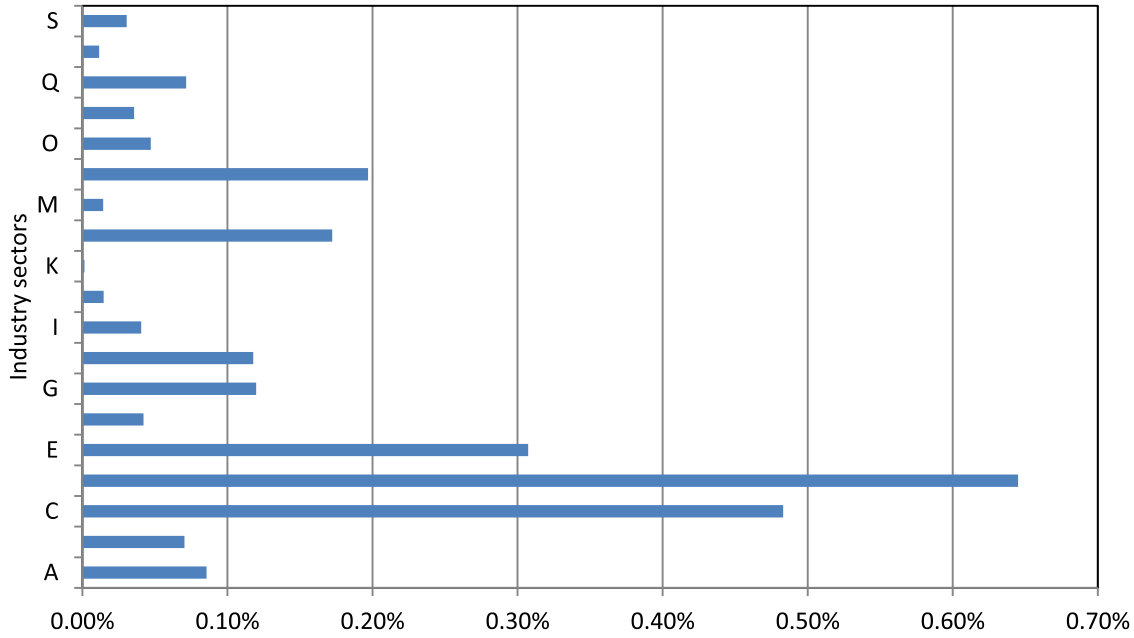

Fig. 2. The share of costs for the consumption of water resources and their sewerage in 2019 by each type of EA.* Notes : own elaboration; * * The letters indicate the corresponding EA cyphers (see the note to Table 1).

each type of economic activity, which is calculated according to the same formula (11).

For the calculation in Table 3, data from the first quadrant of the Leontief model for 2020 in consumer prices in million UAH were used. Calculations were made according to formula (9) for the input data given in Ukraine's Input–Output Table at Consumer Prices (2020). The industry sector C – Manufacture consumes the most natural resources. Expenditures on the consumption of natural resources in this sector reach 370,720 million UAH (Table 3). Industry sector D – Electricity, gas, steam and air conditioning supply consumes almost 3 times less natural resources. These costs amount to 139,148 million UAH (Table 3).

Table 4 shows the capacity composition of the gross output of each EA calculated by the formula (10) according to the structure of resource costs (cost capacity) consumed during the production of goods and services in 2020.

Figure 3 shows the percentage value w_{uv}% of intermediate consumption of natural resources in the total output of each type of economic activity, calculated according to formula (11).

As can be seen in Figure 3, in addition to the largest consumer of natural resources in the industry sector C - Manufacture, whose share in 2020 is 34.97% of its total output of goods and services, we have another industry sector D - Electricity, gas, steam and air conditioning supply, whose share is about 13% of its total output of goods and services (Table 4, Figure 3). The sector has a high consumption of natural resources, but it is 3 times less than the natural resources consumed by the industry sector C - Manufacture. Also, the same three sectors of industry B – Mining and mining support service activities (1.96%); F - Construction (1.84%) and H - Transport (2.93%), which in 2019, have natural resource costs ranging from 1% to 5%, but their values are somewhat lower. Also, the same 14 industrial sectors as in 2019 form a group with low consumption of natural resources (less than 1%) (Table 4, Figure 3).

Comparing the shares of costs for the consumption of water resources and their sewerage in various economic sectors in 2020, we see in Figure 4, that the highest shares of costs for the consumption of water resources and their sewage system occur in three economic activities C - Manufacture (0.52%); D – Electricity, gas, steam and air conditioning supply (0.43%); E - Water supply; sewerage, waste management and remediation activities (0.42%). Compared to 2019, their share also mostly decreased. In 2020, the group of industry sectors that have costs for the consumption of water resources and their sewage system in the range of 0.1–0.3% expanded to 6 members. The group includes A – Agriculture, forestry and fishing (0.12%); G – Wholesale and retail trade; repair of motor vehicles and motorcycles (0.12%); H – Transport, warehousing, postal and courier activities (0.11%); L – Real estate activities (0.17%); N – activities in the field of administrative and auxiliary services (0.22%); Q – Human health activities, residential care activities and social work activities without accommodation (0.12%).

The remaining 9 industrial sectors form a group with low consumption of water resources (less than 0.1%). Here, too, industry sector B – Mining and mining support service activities – leads the group, whose expenses for consumption of water resources and their drainage constitute 0.08% of its total output of goods and services.

Figure 4 shows the value of the share of intermediate consumption of water resources and their drainage in the total output of each type of economic activity, which is calculated according to the formula (11).

A thorough analysis of statistical data on the volume of production of goods and services and the costs of production for intermediate consumption, as well as the obtained shares of consumption of natural resources and shares of costs for the consumption of water resources and their sewerage by each industry sector, indicates an urgent need for innovative restructuring of the economy of Ukraine based on resource-saving technologies.

Therefore, we analyzed the state and structure of national accounts in Ukraine according to the matrix of the inter-industry balance. We have established that two types of economic activity: D (supply of electricity, gas, steam and air conditioning) and E (water supply; sewerage, waste management) are in the most critical condition according to the criteria of resource capacity year after year.

4.2. Model of the innovative remodeling of the Ukraine economy

After conducting a thorough analysis of statistical data on the production of goods and services and production costs with intermediate consumption according to the matrix of the inter-industry balance (Leontief model), the shares of consumption of natural resources and shares of costs for the consumption of water resources and their

Table 3
Input-output table for 2020 at consumer prices, I quadrant - intermediate consumption in a million UAH.

EA	A* *	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
A*	226922	253	238748	706	36	164	164	709	3980	3	0	165	401	595	2859	1744	446	26	17
B	2599	20732	370720	139148	270	19474	6292	31021	244	50	1	1426	277	943	821	834	646	131	163
C	189936	66394	853485	45602	13664	203052	104940	116760	7236	19409	1323	15151	22168	14537	35642	5844	45939	1495	4317
D	16407	44599	103119	48868	8952	2677	16958	37222	4285	4163	59	947	2741	4131	7776	6358	12295	2016	1410
E	1256	829	5526	4594	4430	338	1262	1202	357	72	19	1808	166	2365	599	379	1306	131	211
F	5232	5314	21155	3113	924	254049	10804	11234	1768	1042	175	35753	16093	6452	9927	821	6125	347	1229
G	110847	40525	726730	3632	4391	11142	199266	10878	2041	8078	3478	5496	5457	5391	2793	6764	8580	1981	3702
H	56894	10853	173781	2588	2581	7997	60032	72196	480	765	171	1409	6256	2103	7984	2658	1035	911	516
I	182	129	894	211	18	218	522	499	721	333	7	51	1156	360	1195	58	304	272	65
J	1109	726	8780	2776	705	1104	16618	4942	610	126982	6183	2219	19493	2526	5250	7797	5440	756	1053
K	12171	4456	25930	9476	1235	1834	38685	11912	1239	4579	46130	8824	10835	2087	2650	4211	5195	318	1144
L	6592	1023	15623	2512	354	2651	37731	4952	1660	10923	4304	14164	31939	1704	194	906	3323	307	489
M	9363	5339	64279	8856	2206	13213	46020	8729	1596	8999	6412	12418	18541	5397	4465	8775	7961	817	1154
N	8156	4092	17059	1701	2109	3902	6514	12676	1418	3216	1743	7405	3640	10005	0	2386	4136	1762	878
O	1343	1298	5863	5530	877	383	7427	5073	170	675	116	653	5069	228	1128	5072	2128	247	144
P	66	222	422	144	63	70	500	607	5	216	71	64	467	60	923	16320	353	11	4
Q	63	63	226	37	32	37	83	216	12	63	73	16	44	10	203	34	6558	34	23
R	15	18	246	16	3	6	191	111	211	1222	0	53	240	90	2194	2858	419	1495	2422
S	72	58	546	196	160	147	684	618	196	743	202	95	487	116	0	1134	906	34	574

* Notes: author's calculation based on Ukraine's Input, Output Table at Consumer Prices (2020) (https://ukrstat.gov.ua/operativ/operativ2006/vvp/vitr_vip/vitr_u/arh_vitr_u.html); * *- letters indicate the corresponding codes of the following economic sectors (see the note in Table 1).

Table 4
Capacity composition of GDP of each EA by the structure of costs for resources used during production in 2020, UAH per 1 UAH of output.

EA	A* *	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
A*	0.251	0.002	0.046	0.000	0.001	0.001	0.028	0.001	0.050	0.000	0.000	0.001	0.000	0.002	0.013	0.029	0.012	0.002	0.002
B	0.008	0.091	0.103	0.423	0.013	0.038	0.025	0.052	0.011	0.001	0.002	0.010	0.002	0.001	0.004	0.026	0.014	0.010	0.009
C	0.166	0.143	0.293	0.094	0.269	0.379	0.258	0.108	0.254	0.056	0.010	0.031	0.100	0.011	0.024	0.059	0.193	0.044	0.106
D	0.011	0.076	0.028	0.064	0.173	0.007	0.033	0.030	0.036	0.016	0.001	0.065	0.007	0.003	0.010	0.066	0.039	0.033	0.023
E	0.001	0.002	0.003	0.012	0.098	0.002	0.003	0.002	0.006	0.000	0.000	0.007	0.001	0.003	0.001	0.004	0.006	0.002	0.005
F	0.001	0.003	0.001	0.004	0.012	0.236	0.006	0.004	0.006	0.001	0.001	0.020	0.011	0.002	0.001	0.001	0.002	0.002	0.002
G	0.120	0.089	0.235	0.001	0.003	0.003	0.061	0.003	0.001	0.004	0.031	0.001	0.003	0.001	0.000	0.001	0.000	0.003	0.004
H	0.041	0.093	0.051	0.010	0.018	0.013	0.140	0.056	0.005	0.008	0.002	0.003	0.010	0.002	0.005	0.005	0.004	0.029	0.012
I	0.000	0.001	0.001	0.001	0.000	0.002	0.008	0.001	0.025	0.002	0.001	0.001	0.007	0.003	0.002	0.002	0.003	0.022	0.009
J	0.001	0.002	0.003	0.003	0.007	0.003	0.048	0.005	0.009	0.321	0.007	0.006	0.086	0.003	0.007	0.006	0.008	0.053	0.031
K	0.004	0.009	0.011	0.018	0.021	0.018	0.131	0.011	0.017	0.014	0.264	0.028	0.032	0.004	0.002	0.003	0.008	0.018	0.009
L	0.025	0.002	0.003	0.005	0.006	0.004	0.127	0.004	0.042	0.025	0.014	0.058	0.017	0.002	0.001	0.002	0.005	0.025	0.030
M	0.002	0.012	0.011	0.006	0.008	0.020	0.131	0.004	0.017	0.016	0.014	0.020	0.206	0.005	0.002	0.009	0.005	0.014	0.011
N	0.003	0.004	0.003	0.002	0.011	0.020	0.021	0.009	0.011	0.007	0.005	0.018	0.006	0.009	0.000	0.001	0.002	0.012	0.012
O	0.000	0.002	0.001	0.004	0.003	0.001	0.007	0.001	0.001	0.002	0.001	0.002	0.001	0.000	0.001	0.033	0.015	0.007	0.002
P	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.003	0.001	0.000
Q	0.000	0.001	0.000	0.001	0.002	0.000	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.008	0.003	0.001
R	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.015	0.007	0.046	0.029
S	0.000	0.000	0.000	0.000	0.001	0.000	0.003	0.000	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Share	0.097	0.049	0.366	0.039	0.006	0.047	0.108	0.062	0.007	0.027	0.029	0.040	0.026	0.010	0.025	0.030	0.021	0.006	0.005

* Notes: own elaboration; * * The letters indicate the corresponding EA cyphers (see note in Table 1); 0.000 indicates that the specific consumption of the resource per unit of the cost of the volume of output in this EA is less than 0.1 kopiyka (kopeck) for 1 UAH

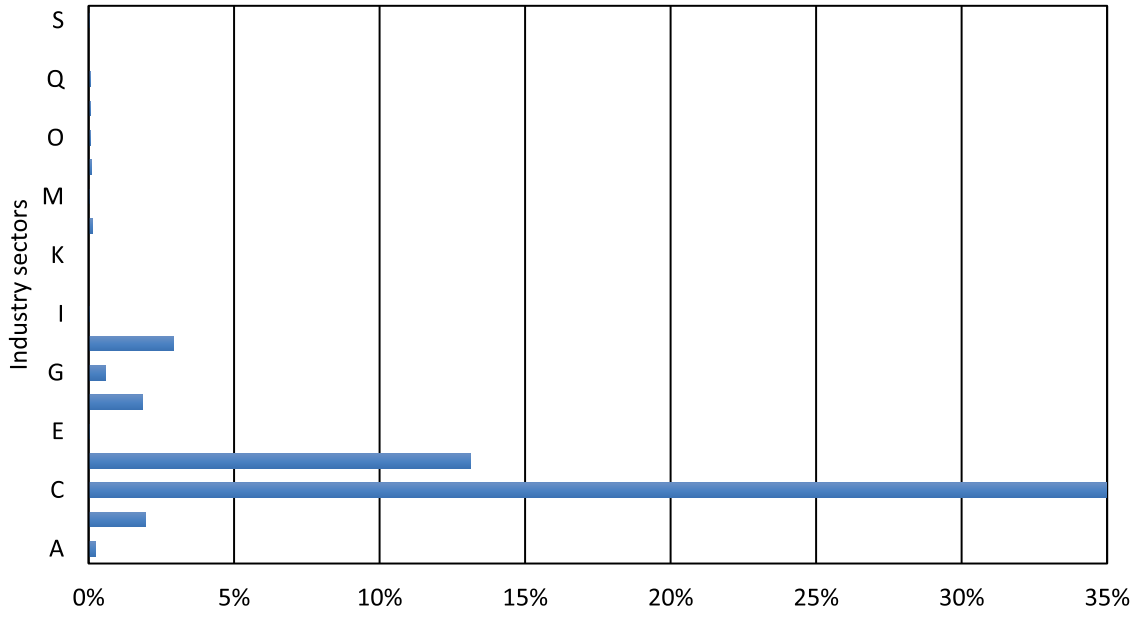

Fig. 3. The share of consumption of natural resources in 2020 by each type of EA. * Notes : own elaboration; * * The letters indicate the corresponding EA cyphers (see the note to Table 1).

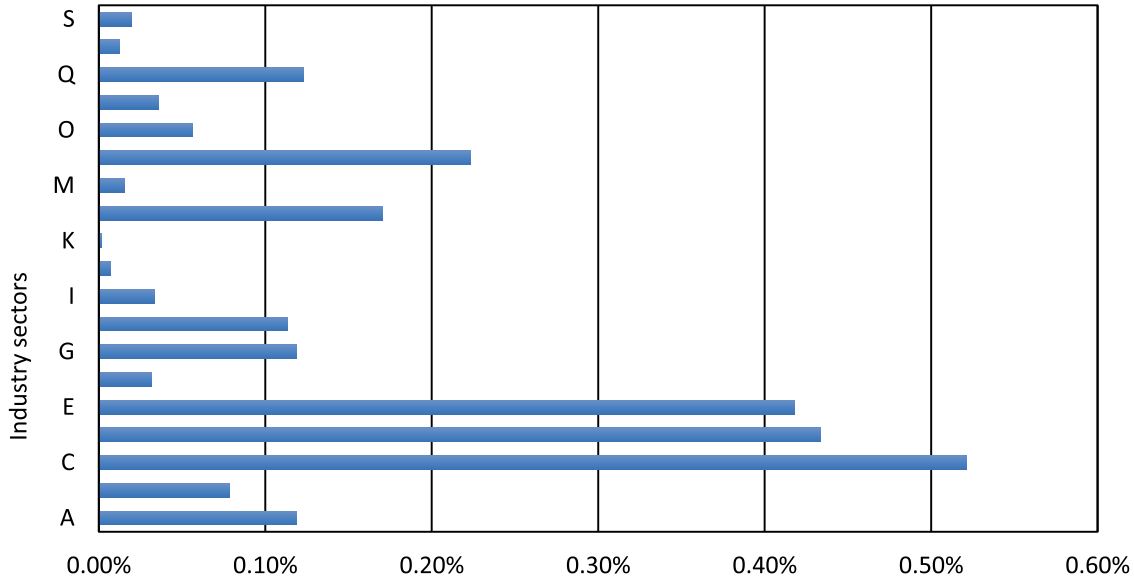

Fig. 4. The share of costs for the consumption of water resources and their sewerage in 2020 by each type of EA.* Notes : own elaboration; * * The letters indicate the corresponding EA cyphers (see the note to Table 1).

sewerage were determined for each sector of the economy of Ukraine (Figure 5). These values were calculated according to the formula (11).

The obtained results for all sectors of the economy according to the Leontief model are presented by the developed resource-capacity matrix diagram in Figure 5. The size of the ball on the resource-capacity matrix diagram reflects the share of each sector of the economy in the overall structure of the output of goods and services.

Different sectors of industry have different shares in the total production of goods and services of the entire economy. We used it as the weight (contribution) of the researched sector of the economy in the overall structure of the production of goods and services. Industry sector C - Manufacture has the largest share in the total production of goods and services (33.08% of the total production of goods and services- the top panel in Figure 5). In second place are two types of economic activity A – Agriculture, forestry and fishing (10.15% - the bottom panel in Figure 5) and G – Wholesale and retail trade; repair of motor vehicles and motorcycles (10.82% - the top panel in Figure 5). These three sectors of the economy account for more than 50% of the total production of goods and services.

As shown in Figure 5, in the upper right quadrant with the highest shares of consumption of natural and water resources is the industry sector C - Manufacture, the size of the ball is the largest. In the second quadrant of the matrix with a high share of spending on water resources, there are two industry sectors D - Electricity, gas, steam and air conditioning supply and E - Water supply; sewerage, waste management and remediation activities, with shares in the total production of goods and services of 4.23% and 0.55%, respectively (the top panel in Figure 5). It is these three industrial sectors that require significant investment in high technology and coordinated action by government and civil society. The remaining 16 sectors are in the fourth quadrant of the matrix with the smallest shares of costs in the consumption of natural and water resources, respectively. In Figure 5 their share in the total production of goods and services is indicated in the signature to the bullet after the code of the economic sector. In the fourth quadrant

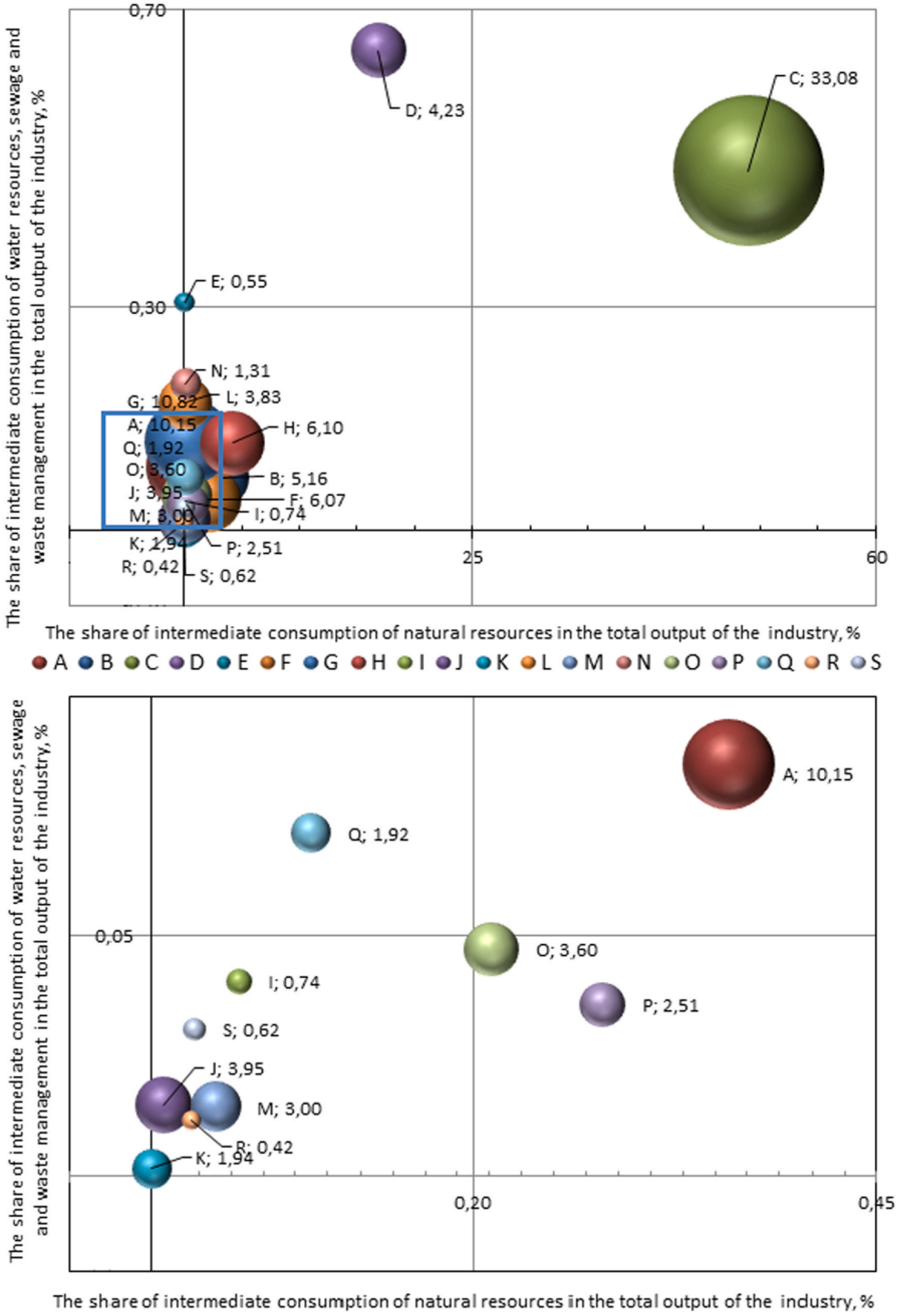

Fig. 5. The resource-capacity matrix diagram of economic sectors. The top panel shows the full analysis and the bottom panel shows an enlargement of the blue square from the top panel. *Notes
: own elaboration; * *The letters indicate the corresponding EA cyphers (see the note to Table 1).

of our matrix (Figure 5) are A – Agriculture, forestry and fishing with a share in the total production of goods and services of 10.15% and G – Wholesale and retail trade; repair of motor vehicles and motorcycles - 10.82%. Even though these two sectors have low shares of costs for natural and water resources in intermediate consumption, in total they make up more than 20% of the total production of goods and services, therefore it also requires significant investments in green business, capital investments in modern resource-saving technologies and coordinated actions by the state and civil society. Each of the subsequent three industrial sectors of this fourth quadrant contributes to the total production of goods and services in the range from 5% to 10%, namely - B – Mining and mining support service activities (5.16%); F – Construction (6.07%); H – Transport (6.10%). The group of sectors with the lowest costs for intermediate consumption of natural and water resources is circled by a blue square in Figure 5 (the top panel). The location of these sectors with the enlarged axis scale is shown in the lower panel in Figure 5. Share in the total production of goods and services in Figure 5 has not been scaled.

To build a model of the innovative remodeling of the economy, we will calculate those investments in high technologies that will enable a reduction in resource consumption due to a decrease in the consumption of natural resources and the consumption of water resources. We propose implementing the green economy policy and forming a significant number of effective green businesses in each of the identified economic activities (EA) based on knowledge-capacitive technologies. They will contribute to the growth of the economic complexity of products by increasing the added value, which is the difference between the cost of finished products or services and the cost of resources spent on their production (intermediate consumption).

We used the coefficient values for calculating the equation system (8) obtained as a result of the analysis of the structure of the inter-industry balance (Table 2). The predicted values of the goods and services released $X_j^{(t)}$ (it is the actual volume of production of goods and services under the *i*-th green EA in the current year) were obtained by taking into account the following elements: 1) Intermediate consumer costs in green EA; 2) Investment needs for the growth of fixed capital in green EA; 3) Needs for goods and services for the final consumption of households, ensuring export-import processes in EA.

According to the scenario approach, the predicted structure of EA resource capacity was obtained, taking into account the above-listed components of EA of the green economy, the predicted diagram of which is shown in Figure 6.

In the proposed model, investment flows in the innovative development of a green economy were increased by no more than 10% and only in 3 industry sectors belonging to the critical group (A – Agriculture, forestry and fishing; C – Manufacture; G – Wholesale and retail trade; repair of motor vehicles and motorcycles). The critical group consists of three industry sectors that make the largest contribution to the gross output of goods and services of the entire national economy (54.3%) and collectively have the largest resource capacity, respectively, nature capacity – 35.81% and water capacity – 0.76%. Although it does not bring drastic changes in these three industries, it significantly improves the resource capacity indicators of the remaining industry sectors (the bottom panel in Figure6). As a result, the share of consumption of natural resources in sectors A – Agriculture, forestry and fishing; C – Manufacture; D – Electricity, gas, steam and air conditioning supply decreased slightly (the balls representing these sectors have moved to the left concerning Figure 5). In sectors C – Manufacture; D – Electricity, gas, steam and air conditioning supply; E - Water supply; sewerage, waste management and remediation activities the share of water resources consumption decreased from 40% to 20%. It did not allow industry sectors C – Manufacture; D – Electricity, gas, steam and air conditioning supply to even leave the first quadrant of the matrix (Figure 6). A positive result of the proposed investments in green business is an increase in the gross output of the entire economy in the share of production of goods and services of the remaining industries with lower shares of consumption of natural and water resources (Figure 6). This gives reason to consider small investments in green economy in a critical group of industries as appropriate.

Figure 6 shows the value of the shares of consumption of natural resources and shares of costs for the consumption of water resources and their sewerage, which is calculated according to the formula (11).

The proposed model of investment in the green economy, specifically in the field of critical infrastructure, can serve as a justification for the choice of investment directions during the remodeling of Ukraine's economy after the war. As a result of the war, Ukraine also lost opportunities to increase indicators of the economic complexity of products in most sectors of the economy.

5. Discussion

We focused our work on building a model of innovative remodeling of the economy, which aims to increase economic complexity by developing and investing in the green economy. Innovative remodeling of the economy is purposeful actions accompanied by investments in the reproduction of production activities of economic entities based on economic innovations, that is, for the goal of sustainable development, morally and physically outdated equipment and technologies are replaced by highly efficient and resource-saving equipment and technologies of a new generation through reconstruction already existing production processes. Innovative remodeling of the economy at the macro level is designed to promote the diversification of industry following market needs, increase the quality of products, and stimulate new competitive and high-tech sectors of the economy with an innovative direction. In the context of Ukraine's situation, economic remodeling should also take into account investments in the fastest possible reconstruction of buildings and industries destroyed during the war, taking into account current European standards in the form of Best Available Techniques (BAT) (Commission implementing decision, 2018), as well as modern energy-efficient technologies aimed at reducing greenhouse gas emissions. The BAT are technologies aimed at the most effective protection of the environment, based on the economic feasibility of their implementation by the characteristics of each industrial sector. These technologies also include the conditions for their use to prevent or reduce the volume of industrial waste, discharges and emissions that have a destructive effect on the environment, and methods of environmentally friendly operation of these industrial facilities (Jonek-Kowalska, I, 2022). The result of the implementation of the BAT by the industrial facility is the achievement of low levels of pollution: emissions of pollutants into the atmospheric air, discharges of return water into water bodies and wastewater of enterprises into the sewage system, soil or groundwater pollution as a result of waste management operations, etc., which is in line with the principles of the green economy.

We propose to consider such a system in the model of innovative remodeling of the economy, the elements of which will make it possible to achieve a reduction in resource capacity by limiting the consumption of natural resources and the consumption of water resources.

Implementing modern (knowledge-rich) green technologies will make it possible to reduce the consumption of natural and water resources (Bublyk et al., 2021a,2021b,2021c). It should be carried out in the first group with a critical state of these indicators: C – Manufacture; D – innovative; E - Water supply; sewerage, waste management and remediation activities. Modernization of this type of economic activity (EA) includes, in accordance with the principles of green economy, investing in the development of green energy (wind, solar, bioenergy and small hydropower), which is generally associated with the emergence of new green types of EA. It is also necessary to continue modernizing existing production technologies for electricity, gas, and steam supply, reducing their resource capacity and replacing expensive energy resources with cheap ones. Among them, we recommend investing in the use of secondary energy resources, which can include a variety of

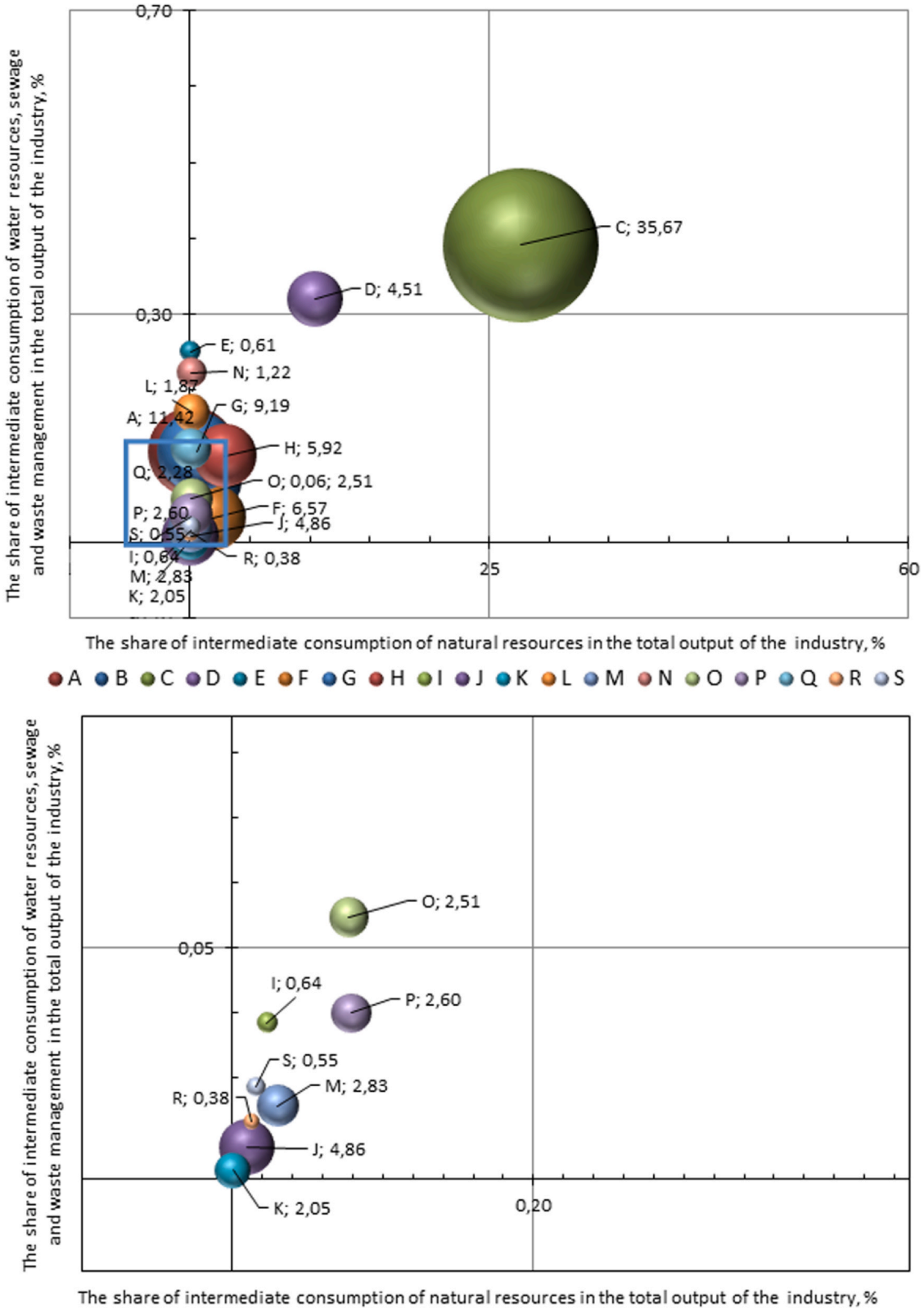

Fig. 6. The resource-capacity matrix diagram of EA, obtained as a result of the projected green economy development. The top panel shows the full analysis and the bottom panel shows an enlargement of the blue square from the top panel.* Notes
: own elaboration; * * The letters indicate the corresponding EA cyphers (see the note to Table 1).

industrial and household waste, in technologies for collecting methane from coal seams as an energy resource, and, of course, in equipping power plants with treatment facilities.

Regarding the modernization of the existing water supply, sewerage and waste management, investments should be focused on reducing their resource capacity by introducing new (green)

technologies for collecting and processing industrial and household waste. Modernization of the infrastructure and the housing and communal services will reduce losses during water supply and form closed cycles of water supply, which will significantly reduce the resource capacity of this type of EA (Bublyk et al., 2021a,2021b,2021c). Protecting surface water from pollution can be recommended by implementing waste-free and water-free (green) technologies, building closed water supply systems, green wastewater treatment technologies, pumping wastewater into deep aquifers, and cleaning and disinfecting surface water.

The green wastewater treatment technologies, which are the primary mechanical treatment technology, using sedimentation and filtration, ozonation technology, filtration technology using ion exchange resins, and reverse osmosis technology, have long been used since the EU countries have set a high fee for the discharge of wastewater depending on their volume and content of nitrogen, hydrocarbons and heavy metals in them. In addition, in many European countries, the anaerobic treatment of sewage sludge technology is used for wastewater treatment, making it possible to obtain energy.

In the second group of EAs are A – Agriculture, forestry and fishing with a share in the total production of goods and services of 10.15%, G – Wholesale and retail trade; repair of motor vehicles and motorcycles (10.82%), B – Mining and mining support service activities (5.16%); F – Construction (6.07%) and H – Transport (6.10%). Their total share of production of goods and services in the gross production of the entire national economy exceeds 40%. For these sectors of the economy, investments should be directed to innovative green industry sectors, as well as to the modernization of existing technologies, equipment, etc. We recommend investing in organic production in agriculture, forestry and fisheries, introducing ecolabelling technologies, expanding lists of prohibited or harmful concentrations of components of food products and consumer goods, and introducing control over compliance with international ISO standards, etc.

We also recommend investing in new green building (construction) technologies. These technologies must use materials produced with minimal harm to the environment. It is also necessary to introduce fuel- and energy-saving technologies and develop green transport (electric cars, bicycles, trolleybuses, trams, etc.).

Investing in new ecologically clean (green) EA ensures increased economic complexity of manufactured and exported products. Investing in the modernization of entire types of economic activity industries contributes to improving the competitiveness of these produced green goods and services and increasing the economic complexity of all exports, their diversity and prevalence.

Green business development also requires state support to create a favorable environment for starting a new business and tax and financial benefits. It must include green tariffs for electricity, green purchases, the formation of a carbon market and support for joint proceedings projects under the Kyoto Protocol's economic mechanism. Strict measures should be taken to limit emissions, discharges and waste and measures to reproduce forests and protected areas, etc. (Burlakova et al., 2017; Samborska and Kolesnik, 2020).

Green business is not only a new type of independent, systematic and risky economic activity, which is carried out by economic entities on their initiative to minimize (up to eliminating) the volume of emissions, discharges and waste in the process of their economic activity while achieving the result is profit. It is also part of a general corporate strategy based on corporate social responsibility for its actions towards future generations and aimed at increasing economic complexity. It is also part of the current European regulations, approved in the form of the best available guidelines (Commission implementing decision, 2018), which promote the green economy.

After analyzing the state and structure of resource-capacitive sectors of the economy in Ukraine, we determined which sectors are the most resource-capacitive. Using the Input-Output table, the value of these resource capacity indicators was calculated. This made it possible to justify the selection of those sectors of the economy that need investment in innovative technologies in accordance with the principles of the green economy and to present the results of their expected impact on the matrix diagram of the resource capacity of economic sectors. The studied group included industry sectors with the maximum values of resource capacity (natural and water resources) and the total share of production of goods and services exceeding 90% of the gross output of the entire Ukrainian economy. The obtained values of costs for intermediate consumption of resources indicate a significant improvement in their resource capacity indicators.

A tree-shaped map showing the distribution of exports or imports of products for Ukraine for 2019 is presented in Figures 7–8. For comparison, according to a study by Harvard scientists, the export structure (Figure 7) has lower economic complexity than the import structure (Figure 8) (The Growth Lab at Harvard University, 2019).

As can be seen from Figure 7, in the structure of exports for 2019, a significant share is made up of industry sectors H – Transport, warehousing, postal and courier activities (transport services – 9.14%), R – Arts, entertainment and recreation (travel and tourism – 2.37%), A – Agriculture, forestry and fishing, (corn – 7.22%, sunflower seed oil – 5.92%, wheat and meslin – 5.61%, rape or colza seeds – 1.84%, soya beans – 1.59%, solid vegetable oil and fat residues – 1.48% and more than 100 other agricultural products with an export share of less than 1%), raw iron and steel products (total less than 20%). All products have either a low or a very low share of economic complexity. Information and communication technologies, which belong to products with high economic complexity, account for only 3.63% (Figure 7). In general, about 50% of exports in 2019 are products of the listed sectors of the economy with a high share of nature and water intensity and a low share of knowledge-intensive technologies (Bublyk et al., 2021a,2021b,2021c). A similar situation is observed when studying the tree-shaped map of the distribution of product imports for Ukraine in 2019 (Figure 8). The obtained results once again confirm that the economy of Ukraine has low competitiveness and has a raw material export structure. Therefore, the increase in economic complexity is an important determinant of the expediency of the innovative remodeling of the economy, the ultimate goal of which is the GDP per capita growth in Ukraine.

Economic development of the country is impossible without the accumulation of high-tech and scientific (productive) knowledge to use in increasingly complex (high-tech) types of EA. The Growth Lab's Digital Development & Design Team at Harvard University develops the ranking of countries. Harvard Growth Lab's Country Rankings assesses Ukraine's current state of productive knowledge using the Economic Complexity Index (ECI). Table 5 shows the Top 10 Country Rankings. Ukraine is in 47th place according to ECI among 133 countries. To improve its ECI ranking, Ukraine needs to increase the number and complexity of products it successfully exports.

To determine Ukraine's rating according to the ECI, the Atlas of Economic Complexity makes it possible to evaluate changes in the export policy of Ukraine according to the ECI for 1995–2019, as well as to compare it with other countries. Table 5 also shows changes in the rating position over the past five years. We can see that Ukraine worsened its position by four points during this period.

The researched Country Rankings assess the current state of its productive knowledge. Such a low ranking (47th position out of 133) indicates that Ukraine has not realized its potential for productive knowledge in products as exported. It is also explained by the low participation of computer companies in developing Ukrainian products. Ukraine's information and communication market works more on the export of human capital by the type of outsourcing and not on the export of the final product by the type of product company (Bublyk et al., 2020a,2020b). As shown earlier in the case of Ukraine, there is a link between economic complexity and foreign direct investment (FDI) (Erkan and Ceylan, 2021), the remodeling of Ukraine's economy should also contribute to increasing FDI in the future.

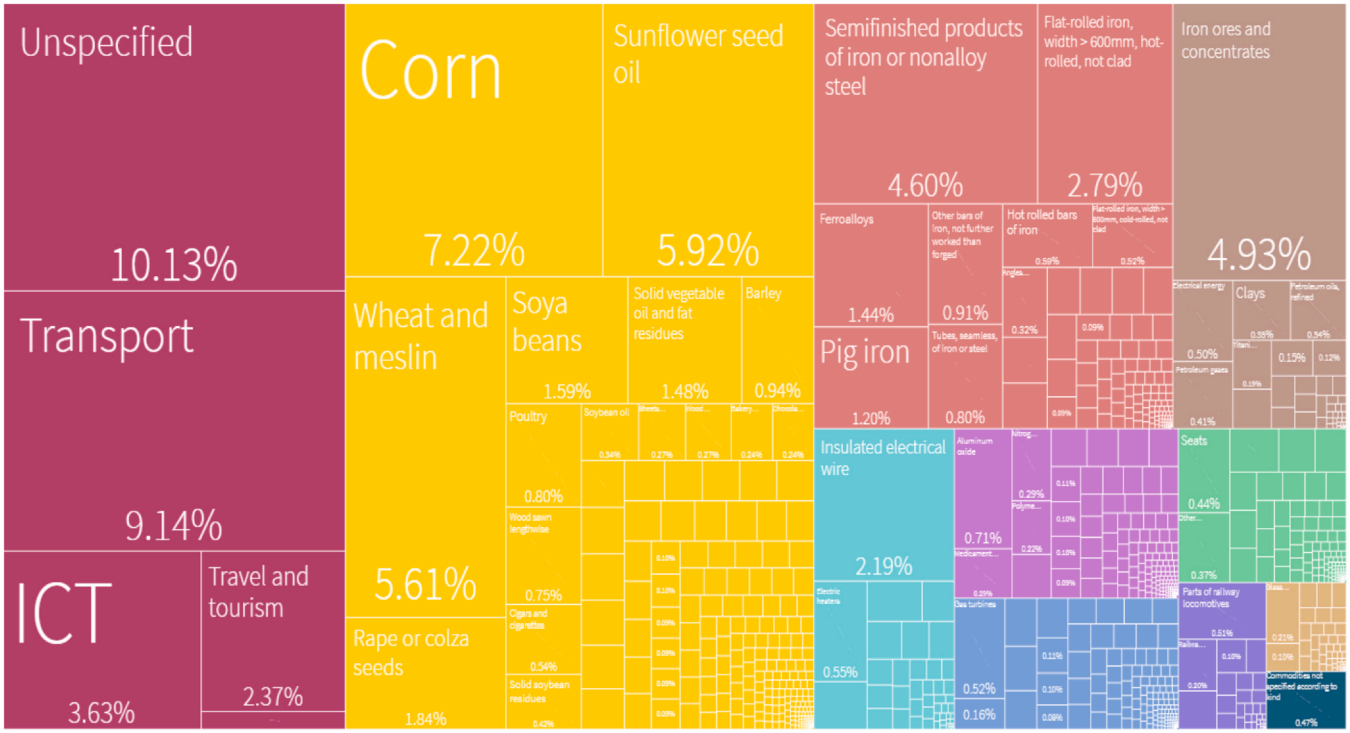

Fig. 7. The Tree Map of Ukraine export in 2019. * Notes: built on The Growth Lab at Harvard University (2019).

The concept of the green economy promotes the production and sale of high-tech and environmentally friendly products. Therefore, by implementing its principles, the production of products using clean technologies will contribute to saving energy and natural resources, protecting the environment and consuming natural products. This will significantly increase the competitiveness of these green goods and services and the economic complexity of export.

Open green innovation is directly related to the development of new green products, services and technologies in cooperation with various companies, government institutions and consumers (Chin et al., 2022; Loučanová et al., 2022; Tjahjadi et al., 2020). Therefore, in the period of reconstruction of Ukraine's economy, achieving the goals of Social Environmental Management (ESG) in three dimensions (environmental, social and managerial) is an important task for sustainable development.

As Melece (2015) points out, the green economy is the basis for implementing sustainable development. It integrates the concept of economic growth with the efficiency of the use of natural resources and means a qualitative increase in production (Loiseau et al., 2016). Achieving the environmental dimension of sustainable development goals involves, first of all, according to Wang et al. (2023), developing a sustainable and ecologically clean economy, reducing the destructive impact on the environment and preserving natural resources. To successfully achieve this goal, in our opinion, it is necessary to promote

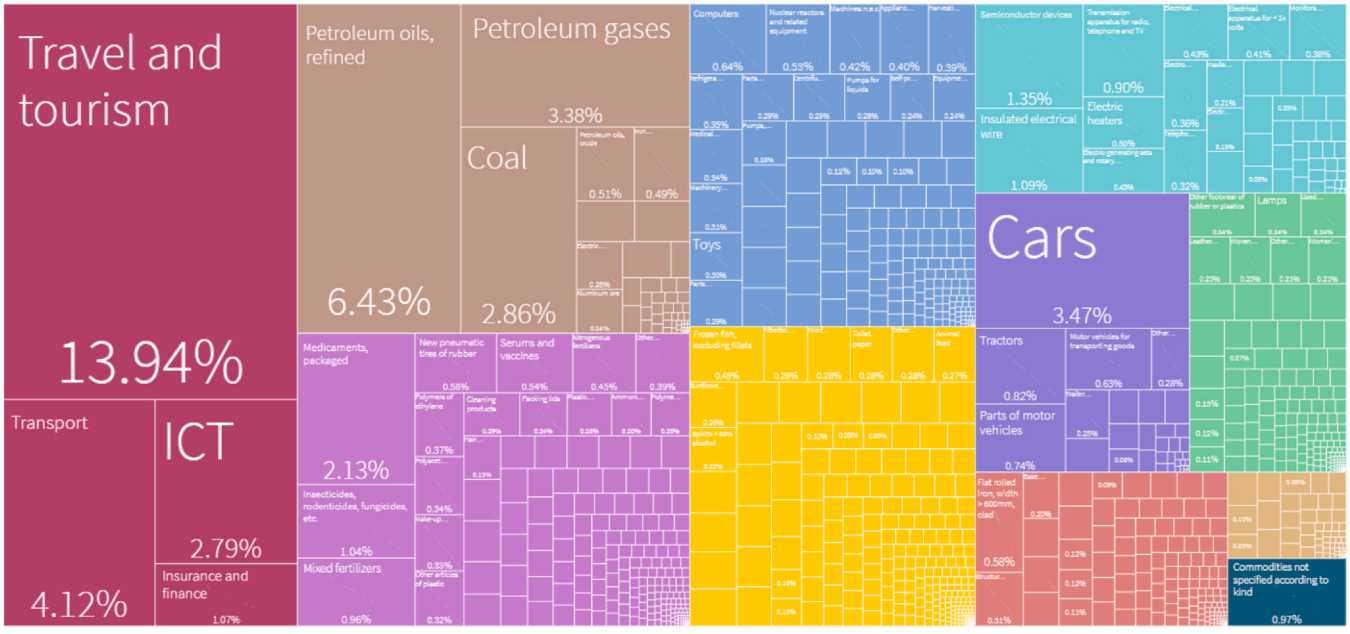

Fig. 8. The Tree Map of Ukraine import in 2019. * Notes: built on The Growth Lab at Harvard University (2019).

Table 5
The Economic Complexity Index of Top 10 Country Rankings by Harvard Growth Lab in 2019.

Rank	Country	Economic Complexity Index	Change in 5 years (2014–2019)
1	Japan	2.49	=
2	Switzerland	2.13	↑1
3	Germany	2.07	↓1
4	South Korea	2.05	=
5	Singapore	2.00	↑2
6	Czechia	1.80	=
7	Austria	1.77	↓2
8	Sweden	1.75	=
9	Slovenia	1.64	↑3
10	Hungary	1.63	↓1
47	Ukraine	0.30	↓4

* Notes: author's calculation based on The Growth Lab at Harvard University (2019).

interaction between various interested parties, create mechanisms for exchanging knowledge and resources in green business, and also support the creation of a favorable innovative environment for its development. Open green innovation, according to Tjahjadi et al. (2020), precisely forms the necessary competitive advantages in green economy, reducing the negative impact on the environment and satisfying the needs of consumers for environmentally friendly goods and services. Among the recommended measures to achieve the ecological goal, we consider it appropriate to focus on the following:

1. Development and implementation of environmentally friendly technologies and products through cooperation with private companies, research institutions and government bodies.
2. Promotion of the development of renewable energy and efficient use of resources.
3. Formation of environmental standards and regulatory policies to ensure sustainable development and preservation of natural resources.

The most critical for Ukraine in the process of remodeling will be the introduction of energy-efficient technologies and measures in construction and industry, which will significantly reduce energy consumption and reduce carbon emissions. Here we should use the successful experience of introducing open business models of eco-innovation for sustainable development in Slovakia, which is described by Loučanová et al. (2022), as well as ways to introduce "green" production (Allen and Clouth, 2012). The development of renewable energy, such as solar, wind, and hydropower, will not only reduce the dependence of the Ukrainian economy on carbon sources, and reduce the number of harmful emissions but also contribute to the development of an energy-independent green type of production.

It is also important to create conditions for the development of ecological (organic) agriculture, which should use sustainable methods of growing products and minimize the use of artificial fertilizers and pesticides (or even completely switch to organic fertilizers).

Open innovation can combine knowledge and resources from various sources, including the deep knowledge of highly qualified specialists, the benefits of green technologies from leading green business companies, and ways to create stable conditions for economic growth. Achieving the social dimension of the goals of sustainable development involves ensuring justice, equal opportunities and improving the quality of life of the population, which green innovations are designed to solve. Among the recommended measures to achieve the social goal, we consider it appropriate to focus on the following:

1. Support socially responsible enterprises and organizations that contribute to the development of society and ensure the well-being of the population based on open green innovations.
2. Involvement of public organizations and consumers in the process of development and implementation of green innovative solutions.
3. Ensuring equal opportunities for all segments of the population through free access to the benefits of green technologies, as well as reducing social inequalities.

As part of the remodeling of Ukraine's economy, a very important element is also the development of an inclusive policy, ensuring equal opportunities for all groups of the population. Considering that the environmental, social and governance dimensions of the sustainable development goals are interrelated, this drive to revitalize the economy creates significant needs for the development of effective green management practices that will guarantee the implementation of transparent and accountable corporate governance to promote the sustainable economy and attract investments in green business. Of the recommended means to achieve the management goal, we consider it appropriate to focus on the following:

1. Implementation of transparent and effective management green practices to ensure responsible corporate governance and reduce corruption in all areas of green business.
2. Promoting the development of mechanisms for responsible investment and financing of green projects that contribute to sustainable development.
3. Involvement of government bodies, the public and the private sector in the joint development and implementation of green growth policies aimed at achieving ESG goals.

To implement the green economy, legislation should be reformed and effective regulatory policies should be implemented, which will contribute to the creation of favorable conditions for green business and the attraction of green investments. Yun et al. (2016) assign a key role to open innovation, which cannot be ignored when making green investments in resource-saving and knowledge-intensive technologies. Establishing open and transparent public procurement mechanisms in green business will reduce corruption and stimulate the development of competition. The development of mechanisms for responsible green investment contributes to the inflow of capital to green projects aimed at a sustainable and innovative economy. Allal-Chérif et al. (2023) provide examples of sustainable management strategies where open green innovation products play a significant role in companies' success. In general, a green economy is a waste-free production, job creation and resource-efficient business aimed at simultaneously achieving all three ESG goals.

The implementation of these measures will contribute to the achievement of ESG goals of sustainable development and the remodeling of Ukraine's economy, creating stable conditions for growth, improving the quality of life of the population and preserving natural resources. In addition, it can contribute to Ukraine's attractiveness to foreign investors and help build a sustainable and competitive business environment.

The Ukrainian economy does not need the latest technologies, but it does need stable and efficient technologies for rapid post-war recovery. Proven green innovations, which are already used by the world's leading companies, are meant to fulfil such a role. The role of the governments of developed countries is to provide these green technologies for Ukrainian business in the form of open innovation.

We will focus on the challenges of the green economy and the complexity of the economy, and we will summarize approaches to addressing these challenges through open innovation.

1. A high level of expenditure on natural resources and the fuel and energy component in the production of goods and services. Low cost of digital and high technology. The same trend is observed in the export and import of goods and services. One of the recommended

approaches to address this challenge is to deepen the Diya portal (Diia.City, 2023) and transform it into an open green innovation platform, where knowledge sharing and green technologies for low-carbon production, energy-efficient and environmentally friendly goods and services will be accessed.

2. During and after the war, the challenges related to the deteriorating health of the population and the deterioration of the ecological situation are urgent. This will lead Ukraine's economy to increase spending on health care and environmental restoration (Bublyk et al., 2020a,2020b). To solve this challenge, we recommend creating open innovation ecosystems that will unite enterprises, universities, research centers and public organizations for the joint development and implementation of ecologically innovative products and services, which will contribute to the development of green business.
3. The sudden impoverishment of the population, the loss of a large part of the working population and the ageing of the population. All this leads to a reduction in the labor force and an increase in the costs of health care and social programs. As a solution to this problem, it is possible to recommend the creation of such innovative systems based on open technologies, which would free a significant part of the population from performing low-paid work and contribute to the development of new medical technologies and "smart city" or "smart home" technologies.
4. Sectors of the economy which lost their level of competitiveness due to the destruction of the energy infrastructure, the decrease of fertile soil, the decrease of employment, etc., will have the greatest need for open technologies. Open innovation platforms that allow enterprises and research centers to cooperate on the development of new products and services will increase the competitiveness of such sectors of the Ukrainian economy as the metallurgical, mining, processing and food industries. In addition, open innovation can facilitate the introduction of new technologies and business models, allowing companies to increase efficiency and reduce costs.

The proposed solutions emphasize the role of open innovations in the reconstruction of Ukraine's economy and indicate areas where green investments will contribute to the development of Ukraine's innovative economy based on a green economy.

Thus, the implementation of the green economy and promotion of green business can be considered a real (achievable) model for the innovative reconstruction of the Ukrainian economy. This should increase high-tech production, strengthen export diversification, and the diversity of exported products and their distribution among countries, which are key signs of increasing economic complexity.

6. Conclusions

In the article, the development of economic complexity through the implementation of innovative green business technologies based on the goals of the green economy has been proposed. The developed model of innovative remodeling of the economy is built based on a comprehensive statistical analysis of the shares of natural resources and water resources of each economic sector. In the work, for the first time, data on costs for intermediate consumption from the first quadrant of the Input-Output table (Leontief model) were used to determine the shares of resource capacity of each economic sector. The economic sector that is the most resource-capacity and requires investments in innovative green technologies has been identified. In the proposed model of innovative renovation of the economy, it is recommended to concentrate investment flows on the innovative development of green economy in 3 sectors of the economy that belong to the critical group. The critical group consists of three industry sectors: A – Agriculture, forestry and fishing; C – Manufacture; G – Wholesale and retail trade; repair of motor vehicles and motorcycles, which make up more than half of the entire gross output of goods and services, and also have the highest resource capacity in total, respectively 2/3 (two thirds) of the total natural resource capacity and 1/3 (one third) of the total water capacity of all sectors. A positive effect of the proposed investments in line with the concept of the green economy in some sectors of the economy is the general increase in gross production of the entire economy and the share of production of goods and services in other industries with a lower share of consumption of natural resources and water resources.

The proposed increase in the economic complexity during the innovative remodeling of the Ukrainian economy by increasing investments in the green economy will make it possible to obtain a significant improvement in resource capacity indicators. The green economy is proven to be a viable model of innovative renovation of the Ukrainian economy. The novelty of the work consists in the use of the Input-Output table to assess the resource capacity of each economic sector and select priority sectors of industry that require investment flows for the development of the green economy. The results of the impact of projected investment flow in the green economy in a critically important group of industry sectors are demonstrated on the resource capacity diagram.

The practical value of the obtained results lies in the justification of ways to remodeling Ukraine's economy based on increasing the economic complexity of the production of goods and services. The proposed model consists in investing in green business technologies in critical sectors of the economy. This may be the basis for the selection of objectives, directions and size of investments by countries, investment organizations and private investors. The proposed model can be used by any other country for innovative remodeling of its economy.

Ethical Statement

Not applicable.

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Conflict of Interest

Authors declare no conflict of interest.

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