sustainability

MDPI

Article

Green Financial Instruments of Cleaner Production Technologies

Viktor Koval [1,*], Olga Laktionova [2], Dzintra Atstāja [3], Janis Grasis [3], Iryna Lomachynska [4] and Roman Shchur [5]

[1] Department of Business and Tourism Management, Izmail State University of Humanities, 68600 Izmail, Ukraine
[2] Department of Finance and Banking, Pryazovskyi State Technical University, 87555 Mariupol, Ukraine
[3] Legal Department, Faculty of Law, Rīga Stradiņš University, LV-1007 Riga, Latvia
[4] Faculty of Economics and Law, Odessa I.I. Mechnikov National University, 65000 Odessa, Ukraine
[5] Department of Finance, Vasyl Stefanyk Precarpathian National University, 76018 Ivano-Frankivsk, Ukraine
* Correspondence: victor-koval@ukr.net

Abstract: Despite the rather long period of solving environmental issues and research, the problems of attracting green financial instruments as sources of financing and stimulating the development and implementation of clean technologies have not been sufficiently studied. The aim of the study is to: conduct a theoretical analysis of the available data; identify trends and study green financial instruments and propose their classification; formulate hypotheses for the development of green financial instruments; and apply empirical methods of analysis to identify the dynamics of the development of environmental taxation in the EU budget. A theoretical analysis of available sources identified existing green financial instruments, which were classified as: (a) aimed at improving existing technologies for the production of goods and services through the development of greening and eco-modernization projects that contribute to the reduction of greenhouse gas emissions; (b) aimed at the development and implementation of innovative projects that change the technology for the production of goods and services, completely eliminating the emission of greenhouse gases. The hypotheses put forward for the study of the management of green financial instruments through the use of financial management mechanisms are formulated through theoretical analysis based on the environmental taxation of production technologies.

Keywords: green financial instruments; cleaner production; environmental taxes; financial management

Citation: Koval, V.; Laktionova, O.; Atstāja, D.; Grasis, J.; Lomachynska, I.; Shchur, R. Green Financial Instruments of Cleaner Production Technologies. *Sustainability* **2022**, *14*, 10536. https://doi.org/10.3390/su141710536

Received: 25 July 2022
Accepted: 21 August 2022
Published: 24 August 2022

1. Introduction

Global warming as a result of greenhouse gas emissions is a threat to humanity and has become a problem. Greenhouse gases (water vapor, CO_2, methane CH_4) absorb infrared heat rays from the sunlight spectrum (400–800 nm) [1]. According to the European Green Deal program, it is necessary to make the transition to a carbon-neutral (clean) economy, that is, decarbonize the European economy. Research on financial management systems in the field of greening and eco-modernization of low-carbon technologies for the production of goods and services require analysis and systematization, as well as further identification of areas of "growth points" for the development of innovative "green" financial instruments and mechanisms in decarbonization technologies. The following areas are especially funded: energy efficiency, climate resilience, climate information systems, climate risk management, energy storage, carbon dioxide removal, and solar energy conversion [2].

There is a need to attract various green financial instruments (GFIs). A preliminary analysis of the available data showed that carbon taxes and investment in renewable energy and technologies for the production of goods and services can, to varying degrees, significantly reduce carbon stocks and CO_2 emissions. The process of carbon substitution can be carried out along the path of "priority of taxes at an early stage and investments

at a later stage" [3]. It was revealed that, along with taxes in the economic system, GFI funding sources can be foreign direct investment encouraged by government policy aimed at stimulating R&D in the field of low-carbon (clean) technologies [4]. State "green" loans are attracted for research and development in the field of low-carbon technologies focused on the environment and production. Overall Green Factor Productivity (GTFP) growth can be greatly improved through green credit regulatory policies, indicating that environmental research and development is the driving force behind GTFP [5].

However, there is a need for further research and development of GFI classifications, especially in the field of clean technologies aimed at greening and eco-modernization of processes for the production of goods and services. Not enough work has been devoted to solving this problem. Therefore, carrying out a theoretical and empirical analysis of the available data regarding green financial instruments (GFI) and their classification is particularly relevant. It is also relevant to form hypotheses regarding the further development of taxation of greenhouse gas emissions into the atmosphere. It is also time to solve the problem of using several GFIs managed using financial management mechanisms.

2. Theoretical Analysis of Green Financial Instruments in Stimulating Corporate Technologies of Decarbonization

2.1. Green Financial Instruments in Stimulating Research Aimed at Developing Low-Carbon Technologies for Enterprises

According to a study [6,7], the essence of state subsidies for R&D and environmental legislation that help improve the efficiency of research and development in the field of low-carbon technologies is in question. It was revealed that state subsidizing of R&D increases the development trends and efficiency of R&D on low-carbon technologies, especially in energy-intensive enterprises. Heterogeneity analysis showed that government subsidies for R&D have a greater impact on state-owned enterprises than on small and medium-sized enterprises (SMEs) [7]. As a GFI, there is a proposal to use green bonds (GB) issued for the organization of R&D in the fight against waste and environmental pollution, as well as to improve energy efficiency [8]. GB can be used as climate finance to promote decarburization. Eco-financing has been found to significantly reduce carbon emissions in the short and long term [8]. The impact of green finance on carbon emissions is more pronounced in developed credit markets and in countries where R&D is accompanied by higher innovation success and greater exposure to climate change. The results obtained are stable in the short and long term [8,9].

To stimulate development in line with the Green Policy financing (GCP) and direct resources to the development of environmentally friendly manufacturing enterprises and achieve the goal of environmental management, the Chinese government released the Green Credit Policy (GCP) program in 2012 [9].

The implementation of the program revealed: (1) GCP contributes to the financial development of the enterprise in the short term (high energy consumption and high pollution). In the long term, a fiscal character is manifested, which slows down the investment development of enterprises; (2) GCP contributes to the reduction of greenhouse gas emissions; (3) GCP has a greater influence on investment and financial behavior among state-owned and large enterprises "with high energy consumption and pollution" than among medium-sized and micro-enterprises; and (4) there is regional heterogeneity in the impact of GCP on investment and financing [9].

The impact of digital financial resources on reducing carbon intensity using econometric models and Durbin's spatial model for a comprehensive analysis is described in [10]. Theoretical analysis demonstrates that carbon taxes can help reduce emissions while increasing production [11]. Lower corporate income tax rates are being reported as a means of encouraging investment. The carbon tax encouraged factories to produce more with less energy. Data are provided showing how a revenue-neutral carbon tax can lead to reductions in emissions while boosting the economy. A study [12] reports that financial inclusion contributes to economic development by allowing individuals and businesses, especially small and medium ones, to have access to financial resources and explores the

relationship between affordability and environmental quality. The relationship between technological innovation, environmental openness, access to financial services, and CO_2 emissions in the BRICS countries, in which economic growth and energy consumption are controlled, is presented. Technological innovation and green openness reduce emissions and contribute to environmental sustainability.

The results of the study [12,13] show that (1) in China, a pilot low-carbon city policies stimulate green technological innovation by enterprises, which is manifested in their application of patents for environmentally friendly inventions; (2) the introduction of pilot policies is highly conducive to green technology innovation in eastern cities and enterprises in high-carbon industries; and (3) tax credits and government subsidies are important fiscal and tax (financial) instruments that play a policy pilot role in low-carbon cities. By easing restrictions on corporate finance, this policy effectively promotes environmentally friendly technology innovation for enterprises. The study described in [14] reports that injection of CO_2 into coal seams effectively increases the recovery of methane from coal seams. However, this process is limited due to high investment and production costs. To facilitate the application of CO_2 injection techniques to coal bed methane production, the study proposes a mechanism for mixed subsidies based on a balance between government and enterprises, which combines direct subsidies with indirect tax incentives. This reduces carbon emissions and saves energy. Further analysis showed that the marginal benefits of energy efficiency improvements exceeded the administrative costs of a strict energy use policy and that the goal of protecting the environment had a larger impact on the performance of the CBM plant.

Study [15] explored the dynamic relationship between financial risk, renewable energy technology budgets, and the environmental footprint of the Environmental Kuznets Curve (EKC) in Organization for Economic Cooperation and Development (OECD) countries. We used advanced panel data evaluation techniques that address slope inhomogeneity and cross-section dependency issues. The results show that improving the financial risk index significantly reduces environmental impact, and renewable energy technology budgets also contribute to environmental sustainability. The paper [16] examines the impact of the Technological and Financial Integration Pilot (TFIP) on carbon emissions and its dynamic effects, heterogeneity, and mechanisms in 252 Chinese cities. The results of the study showed that (1) TFIP can effectively reduce the scale and intensity of carbon emissions in pilot cities. TFIP shows a U-shaped distribution with CO_2_Size and CO_2_intensity, reaching a minimum in the fifth year. TFIP has a lagging effect on carbon emissions, which significantly reduces carbon emissions in the second year. (2) The effect of TFIP is heterogeneous across spatial and urban attributes. (3) The mechanism of impact shows that TFIP reduces carbon emissions by increasing the potential for green innovation and rationalizing the structure of production in the pilot cities. G7 countries, to solve the problem of reducing CO_2 emissions [17] reoriented policy, carried out an analysis of the non-linear and asymmetric impact of financial development and renewable energy production on CO_2 emissions. The study used non-linear autoregressive distributed delay (NARDL) and two-stage least squares (2SLS) methods. Based on the results of these studies, a policy framework focused on the SDGs was recommended. A study [18] shows that innovation is needed to advance the energy transition, reduce CO_2 emissions, and remove resource and environmental constraints.

Financialization has become an important part of the firm's asset portfolio. Different forms of financialization have large differences in liquidity, return, risk, and purpose. This paper focuses on the impact of heterogeneity in financialization on firm innovation to provide evidence for the transition to energy from an R&D perspective, using annual data from non-listed companies in Shanghai and Shenzhen from 2009 to 2018. Fixed effect regression, Heckman's two-stage model, and regression with an instrumental variable are implied. The study also examines the impact of agency conflict on the relationship between the heterogeneity of financialization and firm innovation.

The results show that first, there is heterogeneity in financialization with different motivations and influences on firm innovation. Second, transaction-driven financialization can significantly improve firm innovation, while there is a negative correlation between investment-driven financialization and firm innovation. Finally, the existence of two types of agency conflict not only weakens the role of transactional financialization in promoting firm innovation but also enhances the "crowding out" effect of investment-oriented financialization. The study [19] shows that due to the acceleration of China's industrialization and rapid economic growth, environmental pollution has also attracted a lot of attention. Technological innovations from highly polluting enterprises contribute to reducing pollutant emissions and promoting health. Financial trend investment and the behavior of real enterprises have a significant impact on the decision-making of enterprises in the field of technological innovation. This paper uses a panel model to empirically test the impact of the financialization of highly polluting Chinese enterprises on technological innovation based on data from listed companies in highly polluting industries from 2008 to 2019.

The results show that the financialization of highly polluting enterprises has a significant crowding out effect on technological innovation. Further studies show that arbitrage motivation weakens the inhibitory effect of enterprise financialization on technological innovation; that is, the stronger the arbitrage motivation, the less the negative impact of financialization on enterprise technological innovation, which weakens this effect. Finally, the listed enterprises in highly polluting industries are classified into state enterprises and non-state enterprises according to their corporate attributes. Non-state enterprise financialization is more related to technological innovation than state enterprise financialization, and arbitrage motivation has a greater regulatory impact on the impact of enterprise financialization on technological innovation [20]. There are significant differences between countries in terms of environmental taxation; higher levels of taxation correspond to higher spending on research and development in some countries; in other countries, there is no such relationship.

2.2. Analysis of the Impact of Green Financial Instruments on Decarbonization

A better understanding of the role of government intervention in corporate investment decisions is driving the development of better formal evaluation systems to achieve sustainable development in emerging economies [21]. A study [22] showed that the impact of green credit policies on investment in research and development using heterogeneity analysis is determined by the market environment, geography, and type of firm. Economic policy uncertainty affects the disincentive effect of green credit policies on investment in R&D [22]. Firms' environment, governance (ESG), sustainability, and social reports often fail to pass an audit. ESG disclosures by firms are unreliable, and firm greenwashing behavior can be a barrier to integrating ESG factors into investment decisions. Comprehensively examining the mechanisms for reducing the green behavior of firms in terms of ESG, studies identify with "green washcloths" firms that seem very transparent and reveal a lot of ESG data, but perform poorly in terms of ESG. "Greenwashing" in ESG measurements can be contained by scrutiny from: (a) independent directors, (b) institutional investors, (c) powerful public interests through a country's less corrupt system, and (d) cross-listing [23].

In general, green finance supports decarbonization policies and the development of low-carbon technologies and promotes the development of green technologies in economic systems through the greening and eco-modernization of the production of goods and services, which is facilitated by the use of green financial instruments (GFI, including green fiscal investments, green credit, green insurance, and green bonds). It is noted that all of the above are important for reducing CO_2 emissions. Of the four types of GFIs, the strongest support comes from green fiscal investments, together with insurance and lending. However, the market for "green" finance is controlled by the state. There is a need to transform the market into a market-driven model [24]. The relationship between green finance, the use of non-fossil energy, and carbon intensity has been explored. Empirical data from China based on a vector error correction model were used. The features of the

study conducted by Chinese economists were that they studied the relationship between "green" finance, new energy use, and carbon emission intensity. The model of vector error correction was used in the work. The Green Finance Development Index was built on the basis of four green indicators. Green finance and new energy use have been found to reduce carbon intensity. Increasing carbon intensity has been found to discourage green finance and the use of new energy. This study proposes ways to improve the implementation of green finance policies, expand non-fossil energy consumption, and develop a carbon trading market [25]. Green finance can significantly boost corporate technology innovation, and corporate social responsibility (CSR) has a positive moderating effect on this link between green finance and corporate technology innovation. According to the analysis of heterogeneity, the positive impact of green finance on technological innovation is greater in large companies than in companies in the more economically developed eastern regions of China [26].

The Green Credit Policy (GCP) allows you to manage the development of a green economy with the help of financial resources. However, empirically, little is known about the relationship between GCP and industrial carbon intensity (CEI). The study aims to explore the impact of GCP on the CEI of highly polluting industries (HPI) by considering the Green Credit Guidelines as a quasi-natural experiment [27]. Green credit policies improve economic performance and reduce pollutant emissions. Green credit policy promotes the scale of innovation and increases its effectiveness. Intermediary effect models show that the Porter effect of green credit can be achieved by increasing the efficiency of innovations [28,29].

In order to reduce anthropogenic climate change, developed countries have pledged to contribute 100 billion USD annually from 2020 to meet the needs of developing countries. The economic implications and impacts on CO_2 emissions of the following options for attracting climate finance from public sources in developed countries were studied: (i) pricing of CO_2 emissions; (ii) tax on electricity consumption; and (iii) phase out of fossil fuels and fuel subsidies. General equilibrium analyses have shown that these options not only generate very different global costs of raising a given amount of climate funds, but also have very different consequences for the distribution of costs between developed and developing countries. Similarly, global CO_2 emissions from alternative fundraising policies vary considerably. The pricing of CO_2 emissions and taxes on electricity consumption in developed countries shifts much of the burden of the cost of increased climate finance to developing countries, while the removal of fossil fuel subsidies in developed countries results in improved prosperity for developing countries. While CO_2 pricing and electricity consumption taxes increase emissions in developing countries, the removal of fossil fuel subsidies encourages the decarbonization of developing countries' economies through higher fossil fuel prices. From a global economic efficiency point of view, the elimination of subsidies is the least attractive option, but it becomes more attractive for the policy portfolio when the ratio of costs between developed and developing countries, as well as the impact on CO_2 emissions in developing countries, is taken into account [30].

Debt swaps and social or sustainable development bonds, which have been used by some countries in the Balkans, are becoming popular instruments for financing sustainable green development. This is a novelty and represents a potential for developing countries in the Balkan region. The focus of the article [31] is the analysis of the state of the public debt of the Western Balkan countries. The rising level of public debt over the past decade indicates a lack of adequate intervention and a relatively urgent need for fiscal consolidation. The study suggests that environmental, social, governance/sustainability bonds, and debt-for-climate investments are innovative financial instruments that promise to raise additional financing to support the sustainable development goals of the six countries of the Western Balkans. This capital inflow would be particularly beneficial given their EU accession needs and their economic and structural problems. The policy advice is based on the history and characteristics of green bonds and debt-for-nature swaps and their various underlying mechanisms, which can be adapted to the respective countries.

The Western Balkan countries will benefit from exploring more innovative approaches to financing sustainable societies. In close cooperation with the EU and taking into account the European Green Deal, it is recommended that the six countries of the Western Balkans develop funding mechanisms that will increase the transparency of various policies and greater accountability for their implementation. Applying the recommended method can help solve the problem of public debt, and additional funds can support the implementation of structural reforms [31]. Studies aimed at increasing government oversight of the targeted use of eco-finance are presented in [32]. There is a U-shaped relationship between environmental policy regulation and green product innovation. The level of oversight by governments, in particular China, needs to be further enhanced. The above studies confirmed that public policy can stimulate macroeconomic R&D in the field of low-carbon technologies, but there is a problem of control [32].

A methodology has been proposed for estimating pollution damage using carbon prices, demand for renewable energy sources, and cleaner technologies in China: the blue economy versus the green one [33].

The Ecological Footprint in OECD countries is characterized by the influence of accessibility and infrastructure on it, and by being higher than emissions from domestic production [32–34]. Expanding access to financial instruments (FI) has been proven to be the backbone of any economy; a sustainable environment is also needed. The relationship between FI and the environment, ecological footprint (EF), is investigated by monitoring energy consumption (EC), economic growth (Y), infrastructure (INF), and corruption (CR) in OECD countries from 2004 to 2017. To confirm this relationship, the researchers built the FI and Infrastructure Index using Principal Component Analysis (PCA). In addition, to evaluate the aforementioned relationship, the study uses the methods of "expanded mean group (AMG) and mean group of total correlated effects (CCE-MG)" to obtain reliable results. The results show a supportive role for INF, pointing to the need to promote INF to achieve a sustainable environment. FI, EC, and CR are found to be the main causes of environmental degradation. This study has major policy implications for OECD countries [34]. The estimation of the shadow price of air pollutants—sulfur dioxide, nitrogen oxides, and carbon dioxide—in chemical companies from 2007 to 2012 using a parameterized function showed that the traditional targeted emission reduction policy during the 11th Five-Year Plan was not cost-effective in China. Using the Marginal Abatement Cost Curve (MACC), it was found that in order to achieve the pollution abatement targets set by the 13th Five Year Plan, the effective environmental tax rate would need to be much higher than the current environmental tax and would require some adjustment. The implicit price of nitrogen oxides is much higher than that of sulfur dioxide, so an adjustment to the tax rate on nitrogen oxides will be required. The results can serve as a guide for creating a more complete environmental tax system in the future [35].

2.3. Hybrid Green Financial Instruments in Support of Decarbonization

The shift in CO_2 costs due to environmental policies will increase overall prices. Using a partial input-output model and the theory of complex networks, it was determined that three factors—market structure, technological level, and cost transfer capabilities—differ between sectors. The average price increase in the partial transfer scenario is 0.24% less than the average price increase of 0.58% in the full transfer scenario. The work is needed for further research on the impact of a carbon tax on the welfare of producers and consumers [36].

Reducing greenhouse gas emissions by industry is a moral and economic obligation due to the imposition of carbon taxes in several major global markets. Carbon prices are rising and are putting strong pressure on the competitiveness of less environmentally efficient producers, which entails balancing both environmental and economic sustainability. Therefore, large-scale industry is increasingly interested in investing in technologies aimed at improving energy efficiency, and when assessing them, it is necessary to take into account the economic effect of green taxes [37].

In the short term, due to the higher cost of emission reduction technologies, carbon cap-and-trade (ETS) mechanisms are more cost-effective than environmental taxes. These two policies (carbon tax and ETS) complement each other in the medium term. Under certain conditions, the carbon trading mechanism and the carbon tax mechanism are equivalent. In terms of impact on public welfare, a hybrid instrument is considered to be more effective than a carbon tax on its own. Several mixed emission reduction schemes are proposed to be implemented in 2030: Carbon tax + Subsidy + CCS/Carbon trading + Subsidy + CCS [38].

Some of the studies [39,40] concern financing the challenge of switching to cleaner energy sources in order to achieve the goals of the Paris Agreement as well as increasing access to affordable and reliable sources of energy. This applies to Southeast and East Asia, which is one of the fastest growing regions in the world in terms of growth in greenhouse gas emissions due to increased burning of fossil fuels. The critical role of public policy in accelerating the region's transition to clean energy is emphasized, namely by setting binding long-term climate and renewable energy targets; support for efficient market development; financing of innovative investments; and backbone infrastructure [39]. Some factors hinder the financing (investment) of renewable energy projects, which can lead to a high cost of capital.

In total, five main financing options are theoretically possible: lending, primarily with the help of international financial institutions; financing of renewable energy projects by municipalities; voluntary associations of citizens; securities; irrevocable financial assistance. Future instruments include securities and the recently announced Green Deal renewable energy project financing facility. The most common option for financing renewable energy projects was lending with the help of international financial institutions [39–41].

Further studies report on the problems of environmental taxation in previously published papers [42–44]. In addition to simple and derivative financial instruments, the international financial reporting system considers combined FI. Hybrid FIs are one of the varieties of combined FIs. Hybrid FI is used to insure the risks of changes in loan interest, commodity prices, exchange rates, price, or rate indexes.

In the economic system, the sources of financing for "green" financial instruments (GFI) can be: foreign direct investment encouraged by government policy; "green" credit; government subsidies for R&D; green bonds (GB); joint use of tax incentives and government subsidies; mixed subsidies based on the balance between the authorities and enterprises, which combine direct subsidies with indirect tax incentives; exchanges of debt and social or sustainable development bonds, which are becoming popular instruments for financing sustainable green development; environmental, social, sustainability management bonds and debt-for-climate investments are innovative financial instruments.

Five financing options have received the most frequent use in practice: lending, primarily with the help of international financial institutions; financing of renewable energy projects by municipalities; voluntary associations of citizens; securities; and irrevocable financial assistance. Some publications report that "green" financial instruments aimed at greening and eco-modernization of clean technologies for the production of goods and services include: "green" fiscal investments, "green" taxation, "green" renewable lending, green insurance, green government subsidies, green investment, green bond issuance; monetization of the client base; environmental funds; and other financial instruments [45,46]. An analysis of the existing definitions of "green" financial instruments (GFI) allowed the authors to give the following: GFI is, first of all, "green" sources of financing aimed at and/or reducing emissions of harmful substances through the development and implementation of projects of greening and eco-modernization to improve and further develop clean technologies; or complete replacement of existing technologies with innovative ones that completely reduce the emission of harmful substances. At the same time, GFI is managed using financial management (FM) mechanisms, which reduce the need for equity, debt, and borrowed capital.

3. Theoretical Analysis and Formulation of Hypotheses

Tax revenues from all types of environmental taxes are increasing due to the increase in tax rates. According to Porter's hypothesis, with an increase in environmental tax rates comes an increase in environmental tax revenues to the budget. Upon reaching a certain value of the tax rate, business entities begin to develop and implement greening and eco-modernization projects to obtain clean technologies. With a decrease in the tax rate, the tax base increases (more production, more taxes). With an increase in tax rates, the taxable base is reduced and tax revenues to the budget are reduced. Business entities are beginning to actively implement environmental projects. Tax rates can be increased by up to a certain amount (according to Laffer and Porter). The Laffer curve displays the relationship between tax revenues and tax rates, which implies that there is an optimal level of taxation rate at which tax revenues are maximized. A further increase in the rate drives subjects into the shadows, and there is a decrease in tax revenues.

Hypothesis 1. *The transfer of the tax burden from labor taxes to environmental taxes is impossible in full due to the incompatibility of income amounts and the different nature of the elements of these taxes (taxpayer; object of taxation; the tax base; unit of taxation; tax incentives; tax rate; calculation procedure; tax payment).*

Hypothesis 2. *Projects of greening and eco-modernization of the production and the development of clean technologies are financed with the help of green financial instruments, by using own, borrowed and attracted financial resources, managed with the help of financial management mechanisms as cash management systems streams.*

A theoretical analysis of the available sources revealed the existing green financial instruments, which were classified into: (a) aimed at improving existing technology production through the development of greening and eco-modernization projects that contribute to the reduction of greenhouse gas emissions; (b) aimed at the development and implementation of innovative projects that change the technology for production and completely exclude the emission of greenhouse gases.

4. Empirical Data of Environmental Taxes

The forecast values of environmental tax revenues were calculated as follows (based on econometrics). The sequence of values of total environmental taxes (Figure 1, Table 1, variable y) is a time series with dependence on the year $N, N = 2002, 2003, \ldots$ Let's introduce the variable $x = N - 2002$, which takes the values $x = 0, 1, \ldots$ and examine the dependence of y on x.

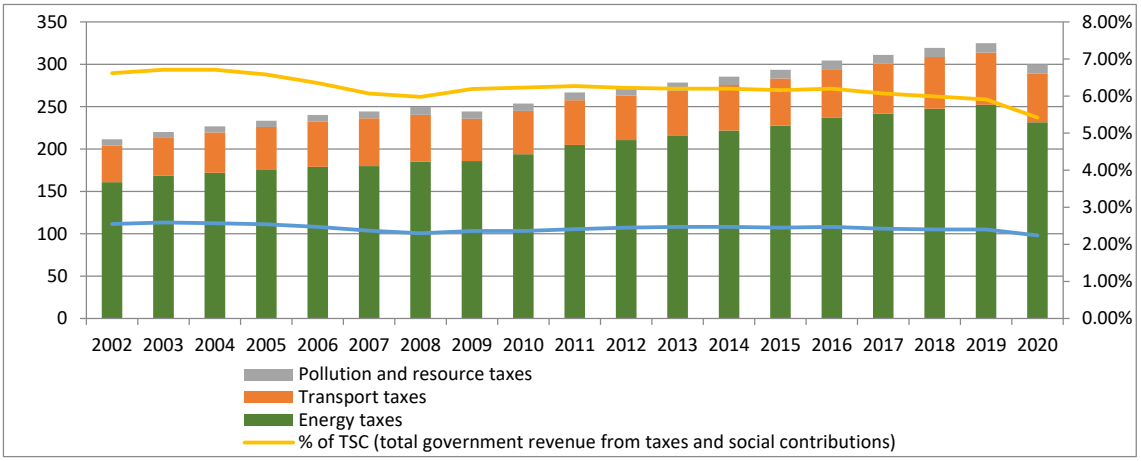

Figure 1. Dynamics of environmental tax revenues European Union-27 countries, billion euros. Adapted with permission from [47]. Copyright 2022, Eurostat.

Table 1. Dynamics of environmental tax revenues of the EU-27 countries, billion EUR.

TAX/TIME	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
TET, BI	217.62	226.68	235.46		249.79	254.04	255.00
ET, BI	167.25	175.56	179.06	182.47	186.39	187.34	189.35
TT, BI	42.46	43.33	48.53	52.05	54.87	57.78	56.28
TP/R	7.90	7.78	7.86	7.97	8.51	8.90	9.36
% of TSG	6.62	6.71	6.71	6.58	6.35	6.07	5.98
% of GDP	2.55	2.59	2.57	2.54	2.47	2.37	2.3
TAX/TIME	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
TET, BI	249.48	259.60	272.35	278.48	284.17	290.97	299.06
ET, BI	189.75	198.63	209.37	215.34	220.85	226.24	231.76
TT, BI	50.92	52.03	53.64	53.41	53.61	54.66	56.73
TP/R	8.87	8.93	9.33	9.72	9.70	10.07	10.56
% of TSG	6.19	6.23	6.27	6.22	6.2	6.2	6.16
% of GDP	2.36	2.36	2.41	2.45	2.47	2.47	2.45
TAX/TIME	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
TET, BI	310.17	316.63	324.95	330.57	331.45	341.000	351.26
ET, BI	241.21	246.04	252.40	257.53	256.76	258.35	260.23
TT, BI	58.42	59.93	61.94	62.43	62.53	62.98	62.99
TP/R, BI	10.53	10.65	10.60	10.61	10.76	10.98	10.87
% of TSG	6.2	6.07	5.99	5.91	5.90	5.92	5.94
% of GDP	2.47	2.42	2.4	2.37	2.36	2.37	2.38

TET—Total environmental taxes; ET—Energy taxes; TT—Transport taxes; TP/R—Taxes on Pollution/Resources; TSG—Total Government Revenue from Taxes and Social Contributions; GDP—Gross Domestic Product. Source: based on the information provided by Eurostat database [47].

The study will be carried out using the method of least squares numerically minimizing the sum of squared deviations between empirical and theoretical data. Consider the function in Formula (1):

$$L(a_0, a_1, \ldots) = \sum_i (f(x_i, a_0, a_1, \ldots) - y_i)^2 \quad (1)$$

where $y = f(x, a_0, a_1, \ldots)$. is the equation of the expected dependence. As for the values of the unknown parameters $a_0, a_1, \ldots$, choose the values corresponding to the minimum value of the function L.

To prove the hypothesis in the study, the data in Table 1 will be used.

However, according to Eurostat [47], environmental tax revenues to the EU budget in 2020 decreased to 300,121.02 million euros, which is due to several factors, including COVID-19. In this case, expert assessments and other methods can be used to determine the projected amount of environmental revenues for the EU budget. The largest amounts of environmental revenues belong to energy taxes (ET), followed in decreasing order by transport taxes (TT) and taxes on pollution/resources (TP/R). Environmental taxes in the government's total income from taxes and social contributions are insignificant at 5.90–6.71% for the period 2002–2022, and between 2.3–2.58% of the total Gross Domestic Product (GDP). There is a need to increase the rates and, accordingly, the amounts of environmental tax revenues to the EU budget.

5. Results

The forecast values of environmental tax revenues were calculated as follows (based on econometrics). The sequence of values of total environmental taxes (Table 1, variable y) is a time series with dependence on the year N (N = 2002, 2003, . . .). Let's introduce the variable x = N − 2002, which takes the values x = 0, 1, . . . and examine the dependence of y on x. The study will be carried out using the method of least squares. The dynamics of the increase in tax revenues is shown in Figure 1.

Based on Formula (1), the study considers 15 functions f that are continuous in terms of the set of arguments and contain no more than 3 parameters. The existence of the smallest value is guaranteed by the non-negativity of the function L and its continuity. The optimization was carried out numerically using the well-known Nelder–Mead algorithm. The quality of the model was determined by the value of the coefficient of determination $R^2, 0 \leq R^2 \leq 1$.

$$R^2 = \frac{\sum_i (f(x_i, a_0, a_1, \ldots) - \overline{y})^2}{\sum_i (y_i - \overline{y})^2} \quad (2)$$

The best model with 2 parameters corresponds to the exponential model:

$$y = 222.060e^{0.0229x}, \left(R^2 = 0.9845\right) \quad (3)$$

Or represented in an equivalent form:

$$y = 222.06 \cdot (1.0232)^x \quad (4)$$

Dynamics of total revenues from environmental taxes in the countries of the European Union-27, according to Equation (4), is presented in Figure 2.

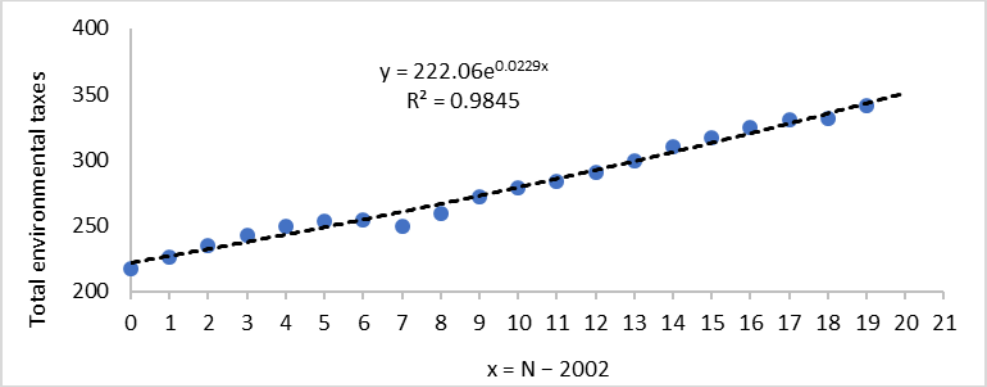

Figure 2. Dynamics of total environmental taxes revenues EU-27, billion euros.

The best model with 3 parameters corresponds to the quadratic model:

$$y = 0.0819x^2 + 4.8043x + 222.74, \left(R^2 = 0.9863\right) \quad (5)$$

Calculating the forecast value for N = 2022, (equivalent to x = 20), in both cases: $y_p = 3,512,652$.

Thus, the resulting forecast shows an increase in the total value of environmental taxes in the revenue side of the EU budget. The calculation of environmental taxes of other types was similarly carried out (Table 1). With a sharp decrease in indicators, as shown in Figure 3 in 2020 (according to Equation (5)), forecasting indicators in 2021 and 2022 using the above methodology is impossible (Table 1). In 2020, there was a sharp decrease in tax revenues to the budget due to COVID-19. In this case, you can apply other forecasting methods, including expert assessments.

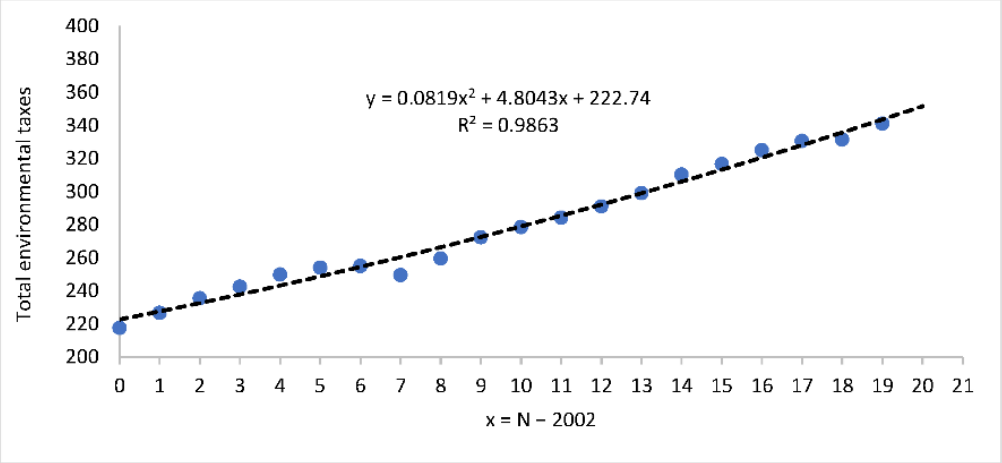

Figure 3. Dynamics of total environmental taxes, billion euros.

In 2020, tax revenues to the EU budget amounted to 289.9 billion euros, which amounted to 5.6% of total government revenue from taxes and social contributions (TSC) and 2.2% of the gross domestic product (GDP) of the EU.

Such indicators allow us to conclude that the proceeds from environmental taxes in the EU are insignificant and not enough for further greening and eco-modernization of the economy [48–50]. Thus, compared to 2019, environmental revenues decreased by 9.1% in 2020. There was growth from 2002–2019 at an average annual rate of 4.2% of environmental tax revenues. In 2020 for most EU countries compared to 2019, the average reduction in environmental taxes was −9.8%. This indirectly reports that there has been a decrease in production volumes, payers of environmental taxes. The biggest decline in EU countries was in Estonia (−26.1%), followed by Luxembourg (−18.4%) and Slovenia (−14.4%) [47]. An increase in environmental taxes between 2019 and 2020 occurred in three EU Member States: Lithuania (+3.6%), Latvia (+1.6%), and Bulgaria (+1.1%) [47]. It should be noted that the increase in income is insignificant [51–53]. All this indirectly indicates that there is no active greening of the economy in the EU countries. The highest value of the share of tax revenues in total state revenues from taxes and social contributions (TSA) was in 2003 (6.7%). This confirms the conclusion that active actions of greening and eco-modernization of the economy are not taking place [47].

In 2020, EU environmental tax revenues amounted to 299.9 billion EUR, representing 5.4% of total government revenue from taxes and social contributions and 2.2% of the gross domestic product (GDP) of the EU [47]. The share of labor taxes is 53.5% of the total taxes in 2020, which is almost ten times higher than the share of environmental taxes—5.4% (Table 2).

Table 2. Labor and environmental taxes as a share of total taxation in the EU 2008–2020, %.

Year	i	Labor Tax (L_i),%	Environmental Tax (E_i),%	$l_i = L_i/L_0$	$e_i = E_i/E_0$
2008	0	51.4	5.98	100	100
2009	1	53.2	6.19	104	104
2010	2	52.6	6.23	102	104
2011	3	52.3	6.27	102	105
2012	4	52.2	6.22	102	104
2013	5	52.3	6.2	102	104
2014	6	52.1	6.2	101	104
2015	7	51.6	6.16	100	103

Table 2. *Cont.*

Year	i	Labor Tax (L_i),%	Environmental Tax (E_i),%	$l_i = L_i/L_0$	$e_i = E_i/E_0$
2016	8	51.5	6.2	100	104
2017	9	51.5	6.07	100	102
2018	10	51.7	6	101	100
2019	11	51.7	5.91	101	99
2020	12	53.5	5.4	104	90

Source: based on the information provided by Eurostat database [47]. Adapted with permission from [47]. Copyright 2022, Eurostat.

Environmental taxes as a share of total taxation have fallen sharply as a result of the COVID-19 pandemic, which caused a decrease in the activity of economic entities. According to Figure 4, the share of environmental taxes in the total amount of tax revenues is negligible. There is no significant growth in environmental taxes for the period 2008–2020. This once again confirms the conclusion that environmental taxation is not of a fiscal nature and cannot be the main source of filling the revenue part of the EU budget. The diagram shows the change in labor taxes (LT_n) and environmental taxes ET_n relative to 2008, expressed as a percentage (%, axis—Y).

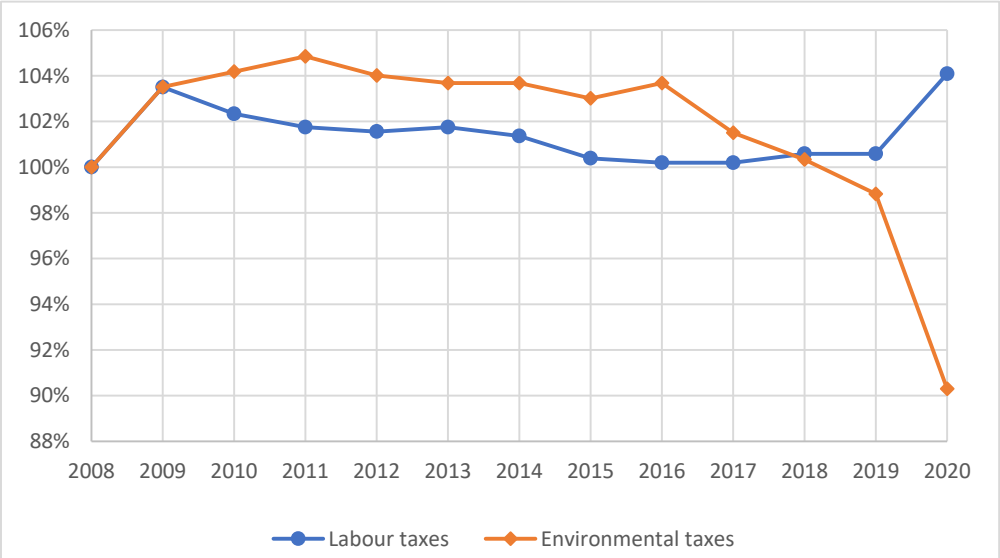

Figure 4. Labor and environmental taxes as a share of total taxation, EU 2008–2020, (index 2008–2020), % [47]. Reprinted with permission from [47]. Copyright 2022, Eurostat.

The value is determined by the Formula (6):

$$E_n = \frac{ET_n}{ET_{2008}} \quad (6)$$

Environmental taxation is regulated in relation to the development of "clean" technologies and is aimed at decarbonizing the processes of production of goods and services. The spending of environmental tax revenues in the EU budget should be targeted and directed towards greening and eco-modernization of technologies for the production of goods and services. The presented amounts of environmental revenues, due to their insignificance, cannot be an independent source of financing for environmental projects. It is required to attract other financial instruments and manage them using financial management mechanisms that increase the turnover rate of attracted capital and allow multiple uses of capital [54,55]. The cost of environmental capital (ecological capital) or capital (cost

of capital) for greening and/or eco-modernization of production and development of clean technologies of a business entity is determined by the formula:

$$CC_e = OC + DC_e + BC \quad (7)$$

where OC—equity capital; DC_e¯debt capital; BC—borrowed capital.

In addition to the search for green financial instruments (GFI) involved in the debt capital model, there is a need to manage cash flows using financial management (FM) mechanisms. Mechanisms of financial management allow an increase in the return on equity when attracting borrowed capital. This happens when using the mechanisms of financial leverage (FLE), operational leverage (OLE), and general leverage. The Total Leverage Effect (TLE) is a combination of both the FLE (financial leverage) and the OLE (operating leverage). It can be calculated using the following equation:

$$TLE = FLE \times OLE \quad (8)$$

For the components of ecological capital (Formula (8)), there are enough financial management mechanisms for their use, taking into account the specifics of ecological capital (virtually zero return on first turnovers). In the future, it is necessary to devote time to the development of a financial infrastructure, including a fiscal mechanism, for greening and eco-modernization of production technologies and the development of clean technologies.

6. Discussion

A policy based on the fact that the purpose of environmental taxes is to fill the budget and also that the tax burden from taxes on labor can be shifted to environmental taxes does not meet modern challenges. According to the data obtained in the study, the share of environmental tax revenues in EU budget revenues is insignificant, amounting to only 5.4% of total tax and social security revenues and 2.2% of GDP in 2020. The share of labor tax is significant and amounts to 53.5% of total taxes in 2020, which is almost ten times the environmental tax share of 5.4%. In addition, these taxes have different goals, objectives, functions, and elements of taxation (tax base, tax rate, and tax calculation procedure). As the study showed, insignificant amounts of environmental taxes should be supplemented with other financial instruments for the implementation of initiatives for greening, eco-modernization, and the development of "clean" technologies in the production. Existing publications describe individual green financial instruments, for which there is no complete list. In practice, however, there is ongoing development and the emergence of new products, including innovative financial instruments. This implies the organization of their monitoring, possibly on the terms of financial outsourcing. The study also proposes an expanded list of existing green financial instruments as sources of capital financing (own, borrowed, and attracted), possibly on an outsourcing basis. In addition, it is proposed to classify green financial instruments as sources of financing for the development of clean technologies as follows: green financial tools necessary for the processes of improvement of production technologies and development of clean technologies; green financial instruments to finance full replacement processes with innovative technologies without greenhouse gas emissions.

Due to the insignificant amounts of tax revenues to the budget, it is required to attract several green financial instruments, which should be managed using financial management mechanisms. This will speed up the turnover of capital and reduce the cost of organizing development financing. Further research is required, including using scientometric tools to identify "points of growth"—innovative "green" financial instruments. It is necessary to develop classifications with other classification features. There is also a need to develop financial models of green financial instruments using financial management mechanisms to improve the efficiency of cash flow management aimed at accelerating capital turnover. It is necessary to form a financial mechanism for managing environmental projects aimed at the development and use of natural resources both at the micro and macro levels [56–58].

7. Conclusions

It was found that avoiding the negative effects of climate change is possible only if global sustainable development is ensured and the transition to a clean and low-carbon economy is ensured. It is the financial sector that is able to ensure these qualitative changes under these conditions. Traditional financing methods may not be commercially attractive or applicable. Low returns coupled with increased risks may discourage private investors from financing and investing in environmental projects. There is a need for state support for projects of greening and eco-modernization of the production of goods and services and the development of clean technologies.

The definition of environmental (green) financial instruments (GFI) is given in relation to this study as sources of financing that are attracted to form capital (own, borrowed, attracted) aimed at greening and eco-modernization of the production of goods and services and the development of clean technologies, including innovative ones that exclude the emission of greenhouse gases altogether. Environmental (green) financial instruments (GFI) aimed at greening and eco-modernization of clean technologies for the production of goods and services include: green fiscal investments; green taxation; green credit (green revolving lending); green insurance; green bonds; monetization of the client base; environmental funds; and other financial instruments, including innovative ones. Research hypotheses are formulated through theoretical analysis based on environmental taxation of technologies for the production of goods and services. The use of methods of econometric analysis made it possible to prove the hypotheses put forward. Directions for improving the management of green financial instruments through the use of financial management mechanisms on the terms of financial outsourcing services are proposed. In the practice of using individual financial instruments, it is proposed to use them in combination with the use of financial management mechanisms.

Identified green financial instruments (GFI) aimed at greening and eco-modernization of the development of "clean" technologies for the production of goods and services amounted to 341,000.68 million euros, including energy taxes (ET)—258,354.03 million euro, and pollution taxes/resources (TP/R)—10,981.15 million euros. The following hypotheses of "green" financial instruments were formulated and proven: Hypothesis 1 (H1). Shifting the tax burden from labor taxes to environmental taxes is not possible in full due to the discrepancy between the amount of income and different types of tax elements. Tight environmental regulations can increase productivity and spur innovation through the introduction of cleaner technologies that improve the environment. However, the authors do not agree that the savings that can be obtained in this way are sufficient to offset the direct costs associated with compliance with the rules and the costs of introducing innovations. Hypothesis 2 (H2). Income from the environmental tax is transferred to the local budget and should be purposefully used for greening and eco-modernization. In the case of insufficiency, environmental revenues are supplemented by other sources of "green" financing (financial instruments), which should be managed taking into account financial management mechanisms. This will allow the reuse of capital already created and added from various sources of funding.

Author Contributions: Conceptualization, V.K. and O.L.; methodology, D.A. and O.L.; software, I.L.; validation, J.G. and R.S.; formal analysis, J.G. and I.L.; investigation, V.K.; resources, O.L.; data curation, D.A.; writing—original draft preparation, R.S.; writing—review and editing, V.K.; project administration, D.A.; funding acquisition, J.G. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Law Faculty of Rīga Stradiņš University, Latvia.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Zhang, Y.; Qi, L.; Lin, X.; Pan, H.; Sharp, B. Synergistic Effect of Carbon ETS and Carbon Tax under China's Peak Emission Target: A Dynamic CGE Analysis. *Sci. Total Environ.* **2022**, *825*, 154076. [CrossRef] [PubMed]
2. AbdulRafiu, A.; Sovacool, B.K.; Daniels, C. The Dynamics of Global Public Research Funding on Climate Change, Energy, Transport, and Industrial Decarbonisation. *Renew. Sustain. Energy Rev.* **2022**, *162*, 112420. [CrossRef]
3. Wen, S.; Jia, Z. The Energy, Environment and Economy Impact of Coal Resource Tax, Renewable Investment, and Total Factor Productivity Growth. *Resour. Policy* **2022**, *77*, 102742. [CrossRef]
4. Fan, J.; Teo, T. Will China's R&D Investment Improve Green Innovation Performance? An Empirical Study. *Environ. Sci. Pollut. Res.* **2022**, *29*, 39331–39344. [CrossRef]
5. Zhang, D. Green credit regulation, induced R&D and green productivity. Revisiting the Porter Hypothesis. *Int. Rev. Financ. Anal.* **2021**, *75*, 101723.
6. Yi, M.; Wang, Y.; Yan, M.; Fu, L.; Zhang, Y. Government R&D Subsidies, Environmental Regulations, and Their Effect on Green Innovation Efficiency of Manufacturing Industry: Evidence from the Yangtze River Economic Belt of China. *Int. J. Environ. Res. Public Health* **2020**, *17*, 1330. [CrossRef]
7. Bai, Y.; Song, S.; Jiao, J.; Yang, R. The Impacts of Government R&D Subsidies on Green Innovation: Evidence from Chinese Energy-Intensive Firms. *J. Clean. Prod.* **2019**, *233*, 819–829. [CrossRef]
8. Al Mamun, M.; Boubaker, S.; Nguyen, D.K. Green Finance and Decarbonization: Evidence from around the World. *Financ. Res. Lett.* **2022**, *46*, 102807. [CrossRef]
9. Zhang, S.; Wu, Z.; Wang, Y.; Hao, Y. Fostering Green Development with Green Finance: An Empirical Study on the Environmental Effect of Green Credit Policy in China. *J. Environ. Manag.* **2021**, *296*, 113159. [CrossRef]
10. Zhao, H. How Does Digital Finance Affect Carbon Emissions? Evidence from an Emerging Market. *Sustainability* **2021**, *13*, 12303. [CrossRef]
11. Ahmadi, Y. How Do Carbon Taxes Affect Emissions? Plant-Level Evidence from Manufacturing. *Environ. Resour. Econ.* **2022**, *82*, 285–325. [CrossRef] [PubMed]
12. Ahmad, M.; Ahmed, Z.; Bai, Y.; Qiao, G.; Popp, J.; Oláh, J. Financial inclusion technological Innovation and Environmental Quality Analyzing the Role of Green Openness. *Front. Environ. Sci.* **2022**, *80*, 851263. [CrossRef]
13. Ma, J. Does the low-carbon city pilot policy promote green technology innovation? Based on green patent data of chinese a-share listed companies. *Int. J. Environ. Res. Public Health* **2022**, *18*, 3695. [CrossRef] [PubMed]
14. Fan, L.; Xu, J. Authority–enterprise equilibrium based mixed subsidy mechanism for carbon reduction and energy utilization in the coalbed methane industry. *Energy Policy* **2020**, *147*, 111828. [CrossRef]
15. Ahmad, M.; Ahmed, Z.; Gavurova, B.; Oláh, J. Financial Risk, Renewable Energy Technology Budgets, and Environmental Sustainability: Is Going Green Possible? *Front. Environ. Sci.* **2022**, *10*, 909190. [CrossRef]
16. Lu, Y.; Guo, J.; Ahmad, M.; Zhang, H. Can Sci-Tech Finance Pilot Policies Reduce Carbon Emissions? Evidence from 252 Cities in China. *Front. Environ. Sci.* **2022**, *10*, 933162. [CrossRef]
17. Xu, D.; Sheraz, M.; Hassan, A.; Sinha, A.; Ullah, S. Financial Development, Renewable Energy and CO_2 Emission in G7 Countries: New Evidence from Non-Linear and Asymmetric Analysis. *Energy Econ.* **2022**, *109*, 105994. [CrossRef]
18. Yu, W.; Zhan, Q.; Ameer, W.; Li, L.; Tarczyński, W.; Mentel, U. Effects of Heterogeneity of Financialization on Firm Innovation: Evidence in Context of Energy Transition in Lens of Research and Development. *Front. Energy Res.* **2022**, *10*, 930974. [CrossRef]
19. Zhou, Y.; Du, Y.; Lei, F.; Su, Z.; Feng, Y.; Li, J. Influence of Financialization of Heavily Polluting Enterprises on Technological Innovation under the Background of Environmental Pollution Control. *Int. J. Environ. Res. Public Health* **2021**, *18*, 13330. [CrossRef]
20. Prokopenko, O.; Mishenin, Y.; Mura, L.; Yarova, I. Environmental and Economic Regulation of Sustainable Spatial Agroforestry. *Int. J. Glob. Environ. Issues* **2020**, *19*, 109. [CrossRef]
21. Lee, C.C.; Wang, F. How does digital inclusive finance affect carbon intensity? *Econ. Anal. Policy* **2022**, *75*, 174–190. [CrossRef]
22. Zhong, Q.; Wen, H.; Lee, C.-C. How Does Economic Growth Target Affect Corporate Environmental Investment? Evidence from Heavy-Polluting Industries in China. *Environ. Impact Assess. Rev.* **2022**, *95*, 106799. [CrossRef]
23. Zhang, D. Credit policy, uncertainty, and firm R&D investment, A quasi-natural experiment based on the Green Credit Guidelines. *Pac. Basin Financ. J.* **2022**, *73*, 101751. [CrossRef]
24. Yu, E.P. Greenwashing in environmental, social and governance disclosures. *Res. Int. Bus. Financ.* **2022**, *52*, 101192. [CrossRef]
25. He, W.; Liu, P.; Lin, B.; Zhou, H.; Chen, X. Green Finance Support for Development of Green Buildings in China: Effect, Mechanism, and Policy Implications. *Energy Policy* **2022**, *165*, 112973. [CrossRef]
26. Ren, X.; Shao, Q.; Zhong, R. Nexus between Green Finance, Non-Fossil Energy Use, and Carbon Intensity: Empirical Evidence from China Based on a Vector Error Correction Model. *J. Clean. Prod.* **2020**, *277*, 122844. [CrossRef]
27. Li, X.; Yang, Y. Does Green Finance Contribute to Corporate Technological Innovation? The Moderating Role of Corporate Social Responsibility. *Sustainability* **2022**, *14*, 5648. [CrossRef]
28. Zhang, A.; Deng, R.; Wu, Y. Does the Green Credit Policy Reduce the Carbon Emission Intensity of Heavily Polluting Industries? -Evidence from China's Industrial Sectors. *J. Environ. Manag.* **2022**, *311*, 114815. [CrossRef]

29. Wang, Y.; Lei, X.; Zhao, D.; Long, R.; Wu, M. The Dual Impacts of Green Credit on Economy and Environment: Evidence from China. *Sustainability* **2021**, *13*, 4574. [CrossRef]
30. Shi, J.; Yu, C.; Li, Y.; Wang, T. Does Green Financial Policy Affect Debt-Financing Cost of Heavy-Polluting Enterprises? An Empirical Evidence Based on Chinese Pilot Zones for Green Finance Reform and Innovations. *Technol. Forecast. Soc. Chang.* **2022**, *179*, 121678. [CrossRef]
31. Böhringer, C.; Schneider, J.; Springmann, M. Economic and Environmental Impacts of Raising Revenues for Climate Finance from Public Sources. *Clim. Policy* **2020**, *21*, 546–562. [CrossRef]
32. Lukšić, I.; Bošković, B.; Novikova, A.; Vrbensky, R. Innovative Financing of the Sustainable Development Goals in the Countries of the Western Balkans. *Energy Sustain. Soc.* **2022**, *12*, 15. [CrossRef] [PubMed]
33. Nie, P.-Y.; Wen, H.-X.; Wang, C. Cooperative green innovation. *Environ. Sci. Pollut. Res.* **2022**, *29*, 30150–30158. [CrossRef] [PubMed]
34. Khurshid, A.; Qayyum, S.; Calin, A.C.; Saleem, S.F.; Nazir, N. The Role of Pricing Strategies, Clean Technologies, and Ecological Regulation on the Objectives of the UN 2030 Agenda. *Environ. Sci. Pollut. Res.* **2022**, *29*, 31943–31956. [CrossRef] [PubMed]
35. Hussain, M.; Ye, C.; Ye, C.; Wang, Y. Impact of Financial Inclusion and Infrastructure on Ecological Footprint in OECD Economies. *Environ. Sci. Pollut. Res.* **2021**, *29*, 21891–21898. [CrossRef]
36. Chen, X.; Xu, J. Estimation of the shadow price of pollutants in chemical enterprises—Based on parameterized directional distance function. *J. Peking Univ.* **2021**, *57*, 341–350. [CrossRef]
37. Ma, N. The short-term price effects and transmission mechanism of CO_2 cost pass-through in China: A partial transmission model. *Resour. Policy* **2021**, *70*, 101972. [CrossRef]
38. Traviesa, L.; Vigil Berrocal, M.; Ortega Fernández, F.; Martínez Huerta, G.M. The importance of the carbon footprint for the evaluation of investments: Use of heat pipes for the production of STEAM. In Proceedings of the 25th International Congress on Project Management and Engineering, Alcoi, Spain, 6–9 July 2021; pp. 1690–1700.
39. Duan, Y.; Han, Z.; Zhang, H.; Wang, H. Research on the Applicability and Impact of CO_2 Emission Reduction Policies on China's Steel Industry. *Int. J. Clim. Chang. Strateg. Manag.* **2021**, *13*, 352–374. [CrossRef]
40. Aleluia, J.; Tharakan, P.; Chikkatur, A.P.; Shrimali, G.; Chen, X. Accelerating a Clean Energy Transition in Southeast Asia: Role of Governments and Public Policy. *Renew. Sustain. Energy Rev.* **2022**, *159*, 112226. [CrossRef]
41. Laktionova, O.; Harbar, Z.; Melikhov, A.; Slobodianiuk, O.; Gevko, V.; Desiatskyi, S. Financing the greening of enterprises in industrial regions of ukraine in the context of sustainable development. *Manag. Theory Stud. Rural. Bus. Infrastruct. Dev.* **2022**, *43*, 574–584. [CrossRef]
42. Arsawan, I.W.E.; Koval, V.; Duginets, G.; Kalinin, O.; Korostova, I. The Impact of Green Innovation on Environmental Performance of SMEs in an Emerging Economy. *E3S Web Conf.* **2021**, *255*, 01012. [CrossRef]
43. Howaniec, H. Knowledge and Perception of Corporate Social Responsibility Among Polish Customers. *Responsib. Sustain.* **2015**, *3*, 37–44.
44. Pimonenko, T.; Prokopenko, O.; Dado, J. Net zero house: EU experience in Ukrainian conditions. *Int. J. Ecol. Econ. Stat.* **2017**, *38*, 46–57.
45. Mazur, A.; Kubai, O. Scientific-methodological and practical principles of regional economic systems integration. *Balt. J. Econ. Stud.* **2019**, *5*, 117. [CrossRef]
46. Harbar, Z.; Selezneva, O.; Litvinov, O.; Kaptalan, S.; Gonchar, V. Strategic Marketing Management of Innovative Activities In Ensuring Enterprise Economic Security. *REICE Rev. Electrón. Investig. Cienc. Econ.* **2020**, *8*, 298–313. [CrossRef]
47. Eurostat. Statistics Database. Available online: https://ec.europa.eu/eurostat/data/database (accessed on 10 June 2022).
48. Mavlutova, I.; Fomins, A.; Spilbergs, A.; Atstaja, D.; Brizga, J. Opportunities to Increase Financial Well-Being by Investing in Environmental, Social and Governance with Respect to Improving Financial Literacy under COVID-19: The Case of Latvia. *Sustainability* **2021**, *14*, 339. [CrossRef]
49. Shkola, V.; Prokopenko, O.; Stoyka, A.; Nersesov, V.; Sapiński, A. Green Project Assessment within the Advanced Innovative Development Concept. *Stud. Appl. Econ.* **2021**, *39*. [CrossRef]
50. Bazaluk, O.; Havrysh, V.; Nitsenko, V.; Baležentis, T.; Streimikiene, D.; Tarkhanova, E.A. Assessment of Green Methanol Production Potential and Related Economic and Environmental Benefits: The Case of China. *Energies* **2020**, *13*, 3113. [CrossRef]
51. Howaniec, H.; Kasiński, P. How to communicate CSR activities? Should companies communicate their social commitment? In Proceedings of the 38th International Business Information Management Association, Seville, Spain, 23–24 November 2021; pp. 7214–7227.
52. Atstaja, D.; Koval, V.; Grasis, J.; Kalina, I.; Kryshtal, H.; Mikhno, I. Sharing Model in Circular Economy towards Rational Use in Sustainable Production. *Energies* **2022**, *15*, 939. [CrossRef]
53. Trachenko, L.; Lazorenko, L.; Maslennikov, Y.; Hrinchenko, Y.; Arsawan, I.W.E.; Koval, V. Optimization Modeling of Business Processes of Engineering Service Enterprises in the National Economy. *Nauk. Visnyk Natsionalnoho Hirnychoho Universytetu* **2021**, *4*, 165–171. [CrossRef]
54. Lohosha, R.; Mykhalchyshyna, L.; Prylutskyi, A.; Kubai, O. Institutionalization of the Agrarian Market in Ukraine and European Economic Community: Genesis, Evaluation and Analysis. *Indep. J. Manag. Prod.* **2020**, *11*, 727. [CrossRef]
55. Zhen, L.; Huang, L.; Wang, W. Green and sustainable closed-loop supply chain network design under uncertainty. *J. Clean. Prod.* **2019**, *227*, 1195–1209. [CrossRef]

56. Suryantini, N.P.S.; Arsawan, I.W.E.; Darmayanti, N.P.A.; Moskalenko, S.; Gorokhova, T. Circular Economy: Barrier and Opportunities for SMEs. *E3S Web Conf.* **2021**, *255*, 01017. [CrossRef]
57. Sybir, A.; Hubynskyi, M.; Fedorov, S.; Hubynskyi, S.; Vvedenska, T.; Bezuglyi, V. Effect of heat shock on graphitization of Donbass anthracite. *Min. Miner. Depos.* **2020**, *14*, 43–49. [CrossRef]
58. Matkivskyi, S. Increasing hydrocarbon recovery of Hadiach field by means of CO_2 injection as a part of the decarbonization process of the energy sector in Ukraine. *Min. Miner. Depos.* **2022**, *16*, 114–120. [CrossRef]