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Editorial

Carbon Emission Reduction—Carbon Tax, Carbon Trading, and Carbon Offset

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1. Introduction

The Paris Agreement was signed by 195 nations in December 2015 to strengthen the global response to the threat of climate change following the 1992 United Nations Framework Convention on Climate Change (UNFCC) and the 1997 Kyoto Protocol. In Article 2 of the Paris Agreement, the increase in the global average temperature is anticipated to be held to well below 2 °C above pre-industrial levels, and efforts are being employed to limit the temperature increase to 1.5 °C. The United States Environmental Protection Agency (EPA) provides information on emissions of the main greenhouse gases. It shows that about 81% of the totally emitted greenhouse gases were carbon dioxide (CO_2), 10% methane, and 7% nitrous oxide in 2018. Therefore, carbon dioxide (CO_2) emissions (or carbon emissions) are the most important cause of global warming. The United Nations has made efforts to reduce greenhouse gas emissions or mitigate their effect. In Article 6 of the Paris Agreement, three cooperative approaches that countries can take in attaining the goal of their carbon emission reduction are described, including direct bilateral cooperation, new sustainable development mechanisms, and non-market-based approaches.

The World Bank stated that there are some incentives that have been created to encourage carbon emission reduction, such as the removal of fossil fuels subsidies, the introduction of carbon pricing, the increase of energy efficiency standards, and the implementation of auctions for the lowest-cost renewable energy. Among these, carbon pricing refers to charging those who emit carbon dioxide (CO_2) for their emissions, including carbon taxes, emissions trading systems (ETSs), offset mechanisms, results-based climate finance (RBCF), and so on. In view of the urgent need for carbon emission reduction, this special issue collects 19 related papers concerning carbon emission reduction by using various models and methods.

2. Summary Information of 19 Papers in the Special Issue

Table 1 shows the summary information of 19 papers in this special issue, including Research Topic, Papers' Author, Method/Model, Research Object, and Industry/Field. From Table 1, we can see that this special issue has 5 papers for investigating the influencing factors of carbon emissions; 2 papers for exploring the relationship among carbon emissions, economic growth, and agricultural production; and 6 papers for discussing various tools of carbon emission reduction such as carbon tax, carbon trading, carbon offset, carbon storage, and carbon footprint. In additions, there are 6 papers involving the related issues for carbon emission reduction.

Table 1. Summary information of 19 papers in this special issue.

Topic		Paper/Author	Method/Model	Research Object	Industry/Field
1. Influencing Factors of Carbon Emissions	1.1 Transportation Carbon Emissions	Zhu, Gao [1]	Panel Data Model	57 'the Belt and Road Initiative' (BIT) countries	Transportation
		Zhu, Du [2]	LMDI (Logarithmic Mean Divisia Index) Decomposition Method	Six Asia-Pacific countries	Transportation
		Zhu, Wang, Yang [3]	LMDI (Logarithmic Mean Divisia Index) Decomposition Method	Regions in China	Transportation
	1.2 Agricultural Carbon Emissions	Chen, Li, Su, Li [4]	Ordered Weighted Regression (OWA); Geographically-and-Temporally-Weighted Regression (GTWR)	Fujian, China	Agricultural Industry
	1.3 Carbon Emissions from Energy Consumption	Li, Li, Shao [5]	Expanded STIRPAT * Model	China	National level
2. Relationship among Carbon Emissions, Economic Growth, and Agricultural Production		Ali, Ying, Shah, Tariq, Chandio, Ali [6]	Autoregressive Distributed Lag (ARDL) Model; Pairwise Granger Causality Test	Pakistan	Agricultural Industry
		Ali, Gucheng, Ying, Ishaq, Shah [7]	Autoregressive Distributed Lag (ARDL) Model; Kwiatkowski–Phillips–Schmidt–Shin (KPSS) Test	Pakistan	Agricultural Industry
3. Carbon Tax		Che, Zhang, Lang [8]	Mixed Integer Nonlinear Programming Model	Numerical Experiments	Electric-power Industry
		Hsieh, Tsai, Chang [9]	Mixed Integer Linear Programming (MILP) Model	Taiwan	Paper Industry
4. Carbon Trading		Duan, Han, Mu, Yang, Li [10]	Two-stage Game Theory Model	China	Iron and Steel Industry
5. Carbon Offset		Krasovskii, Khabarov, Lubowski, Obersteiner [11]	Two-stage Stochastic Technological Portfolio Optimization Model	Not specified	Power Industry
6. Carbon Storage		Cao, Liu, Hou, Mehmood, Liao, Feng [12]	Literature Review	Review Paper	Not specified
7. Carbon Footprint		Quintana-Pedraza, Viera-Agudelo, Muñoz-Galeano [13]	Cradle-to-Grave Multi-Pronged Methodology	Sweden and China	Electronic Industry
8. Others	Carbon Leakage	Fan, Zhang, Gao, Chen, Li, Miao [14]	Single-Region Input–Output Model	China	Industrial Sector
	Gas Leaks	Log, Pedersen [15]	Differential Absorption Lidar (DIAL) Technique	Norway	Oil and Gas Industry
	CO_2 Efficiency Break Point	Bat'a, Fuka, Lešáková, Heckenbergerová [16]	Modified Life Cycle Assessment (LCA)	Czech Republic	Transportation
	Efficiency of Sustainable Development Policy	Sutthichaimethee, Naluang [17]	SEM-VARIMAX ** Model	Thailand	National Level
	Optimization in the Stripping Process of CO_2 Gas	Chen, Lai [18]	Taguchi Method	Not specified	Not specified
	Low Emission Taxiing Path Optimization	Li, Sun, Yu, Li, Zhang, Tsai [19]	Path Optimization Model	China	Airport

<Note> * STIRPAT: Stochastic Impacts by Regression on Population, Affluence, and Technology. ** SEM-VARIMAX: Structural Equation Modeling/Vector Autoregressive Model with Exogenous Variables.

3. Review of the Special Issue

3.1. Influencing Factors of Carbon Emissions

3.1.1. Transportation Carbon Emissions

Zhu and Gao [1] used the Panel Data Model to investigate the factors affecting the carbon emissions of the transportation industry in 57 of 'the Belt and Road Initiative' (BRI) countries. The research results indicate that the positive factors influencing carbon emissions of the transportation industry are capita

GDP, urbanization level, and energy consumption structure, while the negative factors are technology level and trade openness. Zhu and Du [2] applied the Logarithmic Mean Divisia Index (LMDI) decomposition method to research the driving factors for carbon emissions of the road transportation industry in six Asia-Pacific countries from 1990 to 2016. This research found that the economic output and the population size have positive driving influences on carbon emissions for the road transportation industry; the energy intensity and the transportation intensity have different influences on driving carbon emissions for the road transportation industry for these six Asia-Pacific Countries. In addition, the carbon emissions coefficient has a relatively small influence. Based on data from 1997 to 2017, Zhu, Wang, and Yang [3] adopted the Logarithmic Mean Divisia Index (LMDI) decomposition method to analyze the influencing degree of several major factors on the carbon emissions of transportation industry in different regions, and they put forward some suggestions according to local conditions and provided references for the carbon reduction of Chinese transportation industry. Their results showed that economic output effect is the most important factor to promote the carbon emissions of transportation industry in various regions. The regional energy intensity effect in most stages inhibited carbon emissions of the transportation industry.

3.1.2. Agricultural Carbon Emissions

Based on the carbon emission sources of five main aspects in agricultural production, Chen, Li, Su, and Li [4] applied the latest carbon emission coefficients released by Intergovernmental Panel on Climate Change of the UN (IPCC) and World Resources Institute (WRI), and then used the ordered weighted aggregation (OWA) operator to remeasure agricultural carbon emissions in Fujian from 2008–2017. The research results showed that the regression coefficients of each selected factor in the cities were positive or negative, which indicated that the impacts on agricultural carbon emission had the characteristics of geospatial nonstationarity.

3.1.3. Carbon Emissions from Energy Consumption

Li, Li, and Shao [5] used the IPCC (The Intergovernmental Panel on Climate Change) method to calculate the carbon emissions of energy consumption in China from 1996 to 2016, and used it as a dependent variable to analyze the influencing factors. Their results showed that the order of impact on carbon emissions from high to low is total population, per capita GDP, technology level, industrial structure, primary energy consumption structure, and urbanization level.

3.2. Relationship among Carbon Emissions, Economic Growth, and Agricultural Production

Ali, Ying, Shah, Tariq, Chandio, and Ali [6] employed augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests to check the stationarity of the variables. The results of the analysis revealed that there is both a short- and long-run association between agricultural production, economic growth, and carbon dioxide emissions in the country.

Ali, Gucheng, Ying, Ishaq, and Shah [7] aimed to explore the casual relationship between agricultural production, economic growth, and carbon dioxide emissions in Pakistan. An autoregressive distributed lag (ARDL) model was applied to examine the relationship between agricultural production, economic growth, and carbon dioxide emissions using time series data from 1960 to 2014. The results showed both short-run and long-run relationships between agricultural production, gross domestic product (GDP), and carbon dioxide emissions in Pakistan.

3.3. Carbon Tax

Carbon tax is a tax on energy sources that emit carbon dioxide. It is a pollution tax and a form of carbon pricing. The objective of a carbon tax is to reduce the harmful and unfavorable levels of carbon dioxide emissions, thereby decelerating climate change and its negative effects on the environment and human health. A Carbon tax also can prompt companies to find more efficient ways to manufacture their products or deliver their services. Generally, a carbon tax is determined by the carbon tax rate and the quantity of carbon emissions that a company processes in its manufacturing, and it is represented as the amount paid for every ton of greenhouse gas released into the atmosphere. However, carbon tax also will have some disadvantages, such as imposing expensive administration costs for businesses, prompting them to move their operations to "pollution havens," and so on.

Che, Zhang, and Lang [8] formulated the generation self-scheduling problem under the proposed carbon-tax policy as a mixed integer nonlinear programming model. Numerical results demonstrated that the proposed decomposition algorithm can solve the considered problem in a reasonable time and indicated that the proposed carbon-tax policy can enhance the incentive for generation companies to invest in a low-carbon generation capacity.

Using mathematical programming with activity-based costing (ABC) and based on the theory of constraints (TOC), Hsieh, Tsai, and Chang [9] proposed a green production model for the traditional paper industry to achieve the purpose of energy saving and carbon emission reduction. A numerical example was used to demonstrate how to apply the model presented in their paper.

3.4. Carbon Trading

Carbon trading is another form of carbon pricing under cap-and-trade systems. Cap-and-trade is one method for regulating and ultimately reducing the amount of carbon emissions. The government sets a cap on carbon emissions for the whole country, and then limits the amount of carbon dioxide that companies are allowed to release. A company that can more efficiently reduce carbon emissions can sell any extra permits in the emission market to companies that cannot easily afford to reduce carbon emission. Thus, carbon trading markets are set up. The number of emissions trading systems around the world is increasing. In addition to the EU emissions trading system (EU ETS), national or subnational systems are already in operation or under development in Canada, China, Japan, New Zealand, South Korea, Switzerland, and the United States.

To study the emission reduction policies' impact on the production and economic level of the steel industry, Duan, Han, Mu, Yang, and Li [10] constructed a two-stage dynamic game model and analyzed various emission reduction policies' impact on the steel industry and enterprises. The research results indicated that with the increasing emission reduction target (15–30%) and carbon quota trading price (12.65–137.59 Yuan), social welfare and producer surplus show an increasing trend and emission macro losses show a decreasing trend.

3.5. Carbon Offset

A carbon offset is a reduction in emissions of carbon dioxide or greenhouse gases made in order to compensate for or to offset an emission made elsewhere. One ton of carbon offset represents the reduction of one ton of carbon dioxide or its equivalent in other greenhouse gases. There are two markets for carbon offsets: (1) The larger compliance market, where companies, governments, or other entities buy carbon offsets in order to comply with caps on the total amount of carbon dioxide they are allowed to emit; and (2) the smaller voluntary market, where individuals, companies, or governments purchase carbon offsets to mitigate their own greenhouse gas emissions from transportation, electricity use, and other sources. Carbon offset usually supports projects that reduce the emission of greenhouse gases in the short- or long-term. A common project type is renewable energy, such as wind farms, biomass energy, or hydroelectric dams. Others include energy efficiency projects, the destruction of industrial pollutants or agricultural byproducts, the destruction of landfill methane, LULUCF (land use, land-use change, and forestry), REDD (reducing emissions from deforestation and forest degradation), and so on.

Krasovskii, Khabarov, Lubowski, and Obersteiner [11] were motivated by the risks associated with the future CO_2 price uncertainty in the context of the offsetting of carbon emissions by regulated entities. They asked whether it is possible to reduce these financial risks. In this study, authors considered the bilateral interaction of a REDD supplier and a greenhouse gas (GHG)-emitting energy producer in an incomplete emission offsets market. Their results showed that flobsion's flexibility had advantages compared to a standard option, which can help GHG-emitting energy producers with managing their compliance risks, while at the same time facilitating the development of REDD programs.

3.6. Carbon Storage

Cao, Liu, Hou, Mehmood, Liao, and Feng [12] aim to provide the latest developments of CO_2 storage from the perspective of improving safety and economics. This review demonstrates that CO_2 storage in depleted oil and gas reservoirs could play an important role in reducing CO_2 emission in the near future and CO_2 storage in saline aquifers may make the biggest contribution due to its huge storage capacity. Comparing the various available strategies, CO_2—enhanced oil recovery (CO_2—EOR) operations are supposed to play the most important role for CO_2 mitigation in the next few years, followed by CO_2—enhanced gas recovery (CO_2—EGR).

3.7. Carbon Footprint

Quintana-Pedraza, Viera-Agudelo, and Muñoz-Galeano [13] propose the application of a cradle-to-grave multi-pronged methodology to obtain a more realistic carbon footprint (CF) estimation of electro-intensive power electronic (EIPE) products. The proposed methodology is applied in a cradle-to-grave scenario, being composed of two approaches of LCA. Results show that D-STATCOM considerably decreases the CF and saves emissions taken place during the usage stage. A comparison was made between Sweden and China to establish the environmental impact of D-STATCOM in electrical networks, showing that saved emissions in the life cycle of D-STATCOM were 5.88 and 391.04 ton CO_2eq in Sweden and China, respectively.

3.8. Others

3.8.1. Carbon Leakage

On the basis of trade data for China's 20 industrial sectors, Fan, Zhang, Gao, Chen, Li, and Miao [14] built a panel data model to test the effect of trade on carbon dioxide emissions and the presence of carbon leakage for all industrial sectors. They derived a single-region input–output model for open economies based on the industrial sectors' diversity and carbon dioxide emissions, and performed an empirical test. The results show that higher trade openness leads to a reduction in the intensity of CO_2 emissions and gross emissions and that there are obvious structural differences in different sectors with different carbon emission intensity. The coefficient of trade openness for LCSs is −0.073 and is statistically significant at the 1% level, so higher trade openness for LCSs leads to a reduction in the CO_2 emissions intensity.

3.8.2. Gas Leaks

Log and Pedersen [15] developed a simple logarithmic table based on an existing consequence matrix for safety related incidents extended to include non-safety related fugitive emissions. An evaluation sheet was also developed as a guide for immediate risk evaluations when new leaks are identified. The leak rate table and evaluation guide were tested in the field at five land-based oil and gas facilities during Optical Gas Inspection (OGI) campaigns. It is demonstrated how the suggested concept can be used for presenting and analyzing detected leaks to assist in Leak Detection and Repair (LDAR) programs.

3.8.3. CO_2 Efficiency Break Point

Bat'a, Fuka, Lešáková, and Heckenbergerová [16] aim to deal with CO_2 emissions in energy production process in an original way, based on calculations of total specific CO_2 emission and, depending on the type of fuel and the transport distance. It is based on a modified life cycle assessment (LCA), supplemented with a system of equations. Their key finding is the break point for associated processes at a distance of 1779.64 km, since it is better to burn brown coal than wood in terms of total CO_2 emissions. The research can conclude that, in some cases, it is more efficient to use coal instead of wood as fuel in terms of CO_2 emissions, particularly in regard to transport distance and type of transport.

3.8.4. Efficiency of Sustainable Development Policy

Sutthichaimethee and Naluang [17] aim to predict the efficiency of the Sustainable Development Policy for Energy Consumption under Environmental Law in Thailand for the next 17 years (2020–2036), and aim to analyze the relationships among causal factors by applying a structural equation modeling/vector autoregressive model with exogenous variables (SEM-VARIMAX Model). With the implementation of the Sustainable Development Policy for Energy Consumption under Environmental Law (S.D.EL), the forecast results derived from the SEM-VARIMAX Model indicate a continuously high change in energy consumption from 2020 to 2036, and the change exceeds the rate determined by the government.

3.8.5. Optimization in the Stripping Process of CO_2 Gas

Chen and Lai [18] aimed to explore the effects of variables on the heat of regeneration, the stripping efficiency, the stripping rate, the steam generation rate, and the stripping factor. The results showed that the stripping efficiency was in the range of 20.98–55.69%, the stripping rate was in the range of 5.57×10^{-5}–4.03×10^{-4} kg/s, and heat of regeneration was in the range of 5.52–18.94 GJ/t.

3.8.6. Low Emission Taxiing Path Optimization

Li, Sun, Yu, Li, Zhang, and Tsai [19] considered the aircraft's taxiing distance, the number of large steering times, and collision avoidance in the taxi, and established a path optimization model for aircraft taxiing at airport surface with the shortest total taxi time as the target. The experimental results show that the total fuel consumption and emissions of the aircraft are reduced by 35% and 46%, respectively, before optimization, and the taxi time is greatly reduced, which effectively avoids the taxiing conflict and reduces the pollutant emissions during the taxiing phase.

4. Concluding Remarks

The World Bank stated that there are some incentives that have been created to encourage carbon emission reduction, such as the removal of fossil fuels subsidies, the introduction of carbon pricing, the increase of energy efficiency standards, and the implementation of auctions for the lowest-cost renewable energy. Among these, carbon pricing refers to charging those who emit carbon dioxide (CO_2) for their emissions, including carbon taxes, emissions trading systems (ETSs), offset mechanisms, results-based climate finance (RBCF), and so on. This Special Issue collects 19 carbon emissions-related papers (including 5 that are carbon tax-related) and 5 energy-related papers using various methods or models. Although this special issue did not fully satisfy our needs, it still provides abundant related material for energy conservation and carbon emissions reduction. However, there still are many research topics waiting our efforts to study to solve the problems of global warming.

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