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Review

The Environmental Kuznets Curve (EKC) Hypothesis in China: A Review

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Abstract: China is the largest total pollution emitter country on the globe and a vast literature has investigated the environmental Kuznets curve (EKC) hypothesis in China. Thus, we aim to review empirical studies on the testing of the EKC hypothesis using different pollution proxies and area samples in China. The EKC hypothesis can be validated by establishing an inverted U-shaped or an N-shaped relationship between pollution and economic growth. In this review of the Chinese literature, the validity of the EKC hypothesis is found more often than its absence. In comparison, a higher proportion of the studies validated the EKC hypothesis using global pollution proxies compared with local pollution proxies. Moreover, a greater percentage of the studies substantiated the EKC hypothesis using Chinese provincial and city-level data compared with aggregate national data. To validate these findings, we applied logistic regression, and the chance of the validity of the EKC hypothesis was found to be 5.08 times higher than the absence of the EKC if a study used a global pollution proxy. Moreover, the chance of the existence of the EKC hypothesis was found to be 4.46 times higher than the nonexistence of the EKC if a study used Chinese provincial, city, sectoral, or industrial data.

Keywords: the environmental Kuznets curve (EKC); China; empirical studies; pollution

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1. Introduction

The target of economic growth can make countries careless toward environmental issues. Many international agencies set goals to reduce pollution emissions. For instance, COP21 and the Sustainable Development Goals (SDGs) stretched to reduce pollution emissions for the target of reducing global temperature by 1.5–2 degrees centigrade. Over the past several years, China has seen a dramatic increase in CO_2 emissions, which is making it harder to achieve Kyoto Protocol commitments. Tisdell [1] argued that globalization leads to environmental improvements as it provides sustainable development opportunities. Nevertheless, the author also argued that as much as there is evidence of the prevalence of the EKC, there are some limitations to this idea, especially if only the "weak" conditions are met. The EKC is more likely to hold if strong conditions are met so that globalization can surely lead to economic development. Additionally, global political action can have a negative effect on the global environment as well, which brings the debate back to the idea of strong and weak conditions for sustainable development. The author argued that in light of WTO's policies on trade and negligence on environmental issues, there is a need to review these policies, especially in the context of current economic conditions. It is crucial to understand how economic growth tends to shape global environmental conditions, especially for developing and upper-middle countries such as China.

In recent years, the impressive trade and economic performance of China may cause environmental concerns and might shape the EKC in the economy. To predict the environmental effect of growth, we present a scatter plot of the relationship between indicators of economic growth and CO_2 global emissions during the period of 1990–2020. Figures 1 and 2 show that aggregate gross domestic product (GDP) has an N-shaped relationship with territorial-based CO_2 (TBC) and consumption-based CO_2 (CBC) emissions, which depicts the N-shaped environmental Kuznets curve (EKC) in China. The same N-shaped relationship is also shown between per capita GDP and per capita territorial and consumption-based CO_2 emissions in Figures 3 and 4. This relationship depicts that both TBC and CBC emissions are rising in the first phase of the EKC, then falling in the second phase, and ultimately rising in the third phase of the EKC. Thus, the net effect of economic growth is rising TBC and CBC emissions in China.

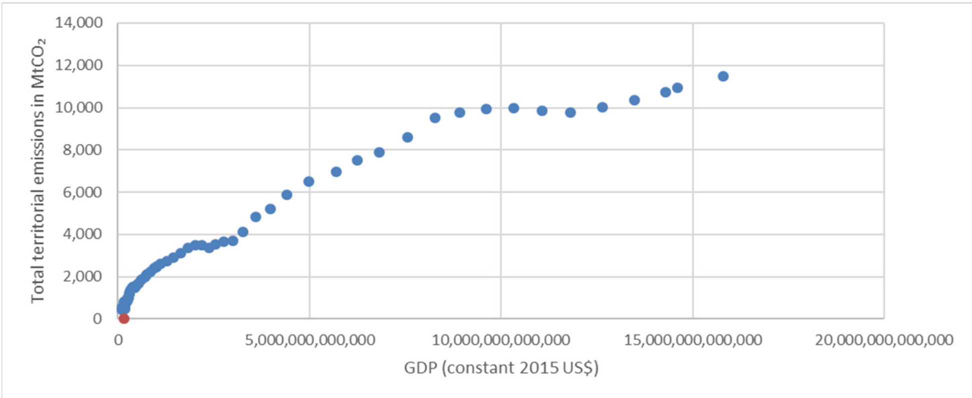

Figure 1. A scatter plot of the relationship between total territorial CO_2 emissions and GDP. Sources of data: Global Carbon Atlas [2] and World Bank [3].

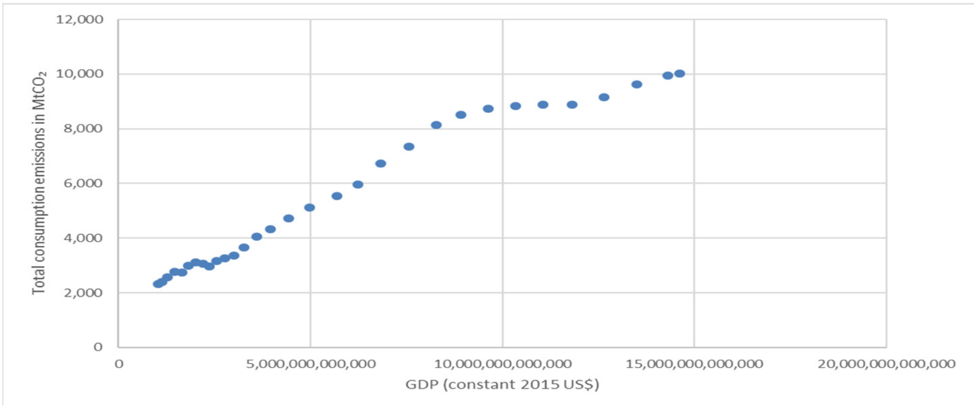

Figure 2. A scatter plot of the relationship between total consumption-based CO_2 emissions and GDP. Sources of data: Global Carbon Atlas [2] and World Bank [3].

After presenting the N-shaped relationship between economic performance and emissions, we try to understand the sources of CO_2 emissions from various energy sources and economic sectors from 1960 to 2021. First, Figure 5 shows that China has achieved better carbon productivity in recent years compared with the past as territorial emissions per unit of GDP are declining over the period of 1960–2021. This shows higher energy efficiency achievement in recent years. Nevertheless, coal emissions are higher than other emissions, which shows the heavy dependence of China on the most polluted energy source: coal. In the same line, we present the trends in total territorial and per capita territorial CO_2 emissions from 1960 to 2021 in Figures 6 and 7. Both figures show positive trends. Thus, emissions from all energy sources and sectors are rising over time. Again, emissions from coal are at the top compared with other energy sources and economic sectors. Then, we compare the total primary energy consumption (TPEC) and renewable energy consumption (REC) in Figure 8. The trend in the percentage of REC in TPEC is rising in Figure 9, which shows the progress of the Chinese economy toward REC. However, the percentage of REC in TPEC is not very impressive. Moreover, Figure 8 shows a sharp growth in TPEC over time. Thus, the total energy consumption could cause environmental concerns in China.

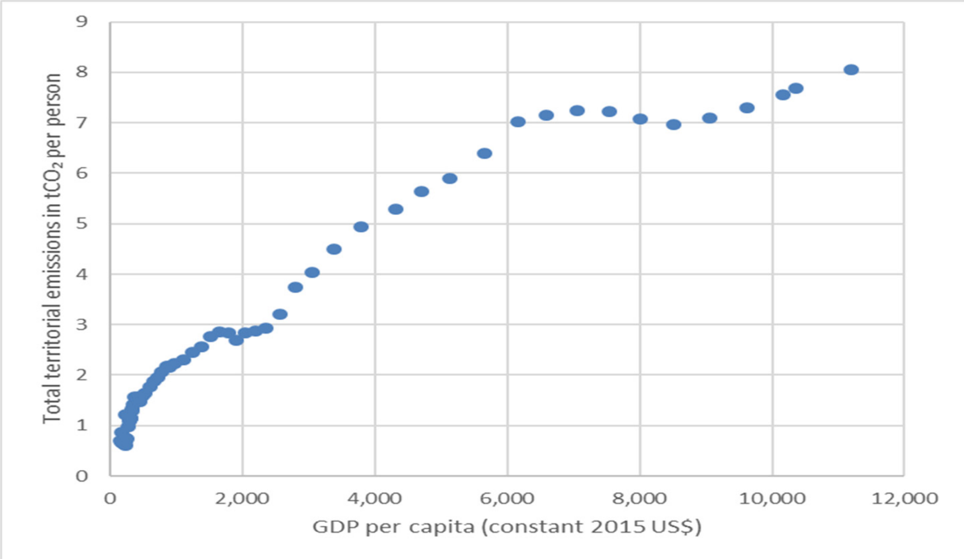

Figure 3. A scatter plot of the relationship between per capita territorial CO_2 emissions and per capita GDP. Sources of data: Global Carbon Atlas [2] and World Bank [3].

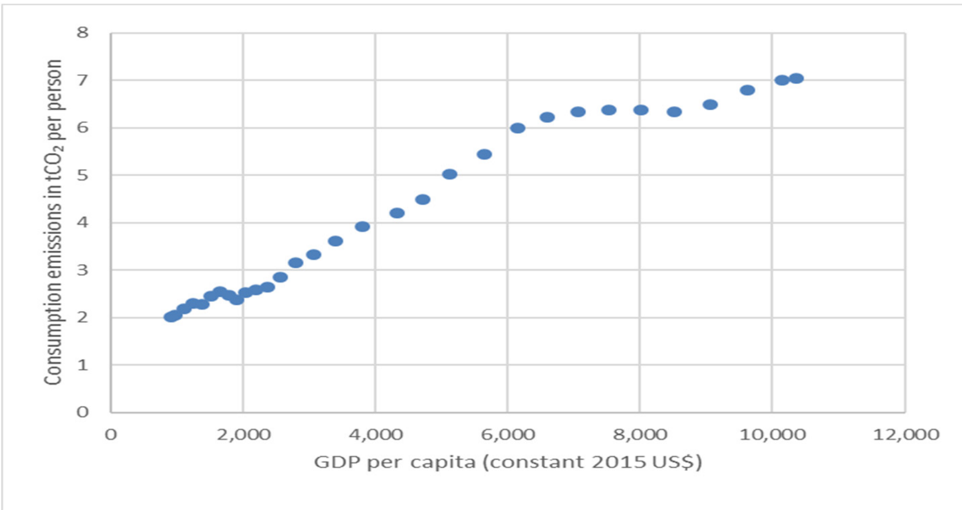

Figure 4. A scatter plot of the relationship between per capita consumption-based CO_2 emissions and per capita GDP. Sources of data: Global Carbon Atlas [2] and World Bank [3].

Figures 8 and 9 show that China is extensively using fossil fuels to support economic growth, which also supports the presence of an N-shaped EKC in Figures 1–4. In addition, trade may also play a significant role in pollution emissions as China is a very open economy and has a large international trade sector that holds a net exporter position on the globe. To comprehend this argument, we compare the trends in territorial, consumption, and transfer emissions in Figures 10–12, which show the role of Chinese trade in transferring production-based emissions to the importing partners. Figure 12 shows that trends in territorial, consumption, and transfer emissions per unit of GDP are declining, which shows the rising carbon productivity of export production in China. However, the trend in transfer emissions is still positive, which reflects the net exporting position of China in the global market. Thus, China is responsible for transferring the emissions to its trading partners. In addition, Figures 10 and 11 show the rising trends in territorial and consumption emissions and the positive trend in transfer emissions. Thus, China is responsible for emitting global emissions of CO_2 on the one hand, and is also transferring its production-based emissions to its trading partners because of its net exporter position on the globe.

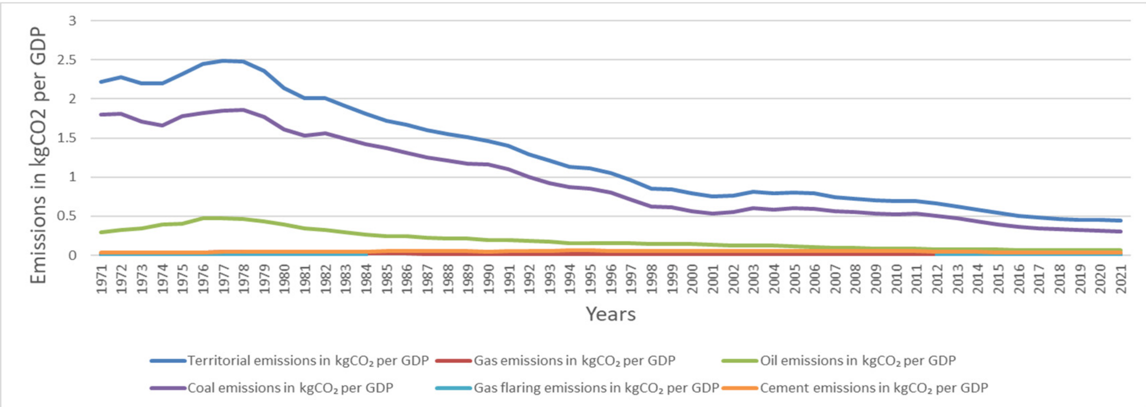

Figure 5. The trend in average CO_2 emissions per unit of GDP from various energy and sectoral sources. Source of data: Global Carbon Atlas [2].

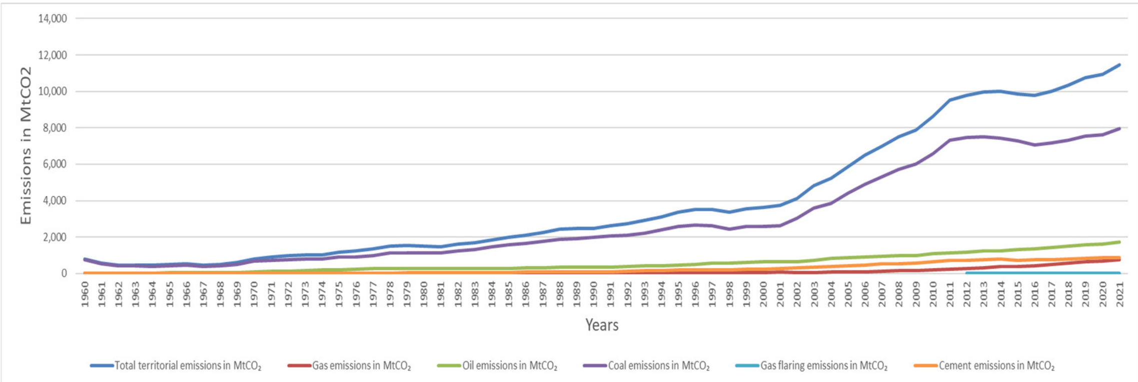

Figure 6. The trend in total CO_2 emissions from various energy and sectoral sources. Source of data: Global Carbon Atlas [2].

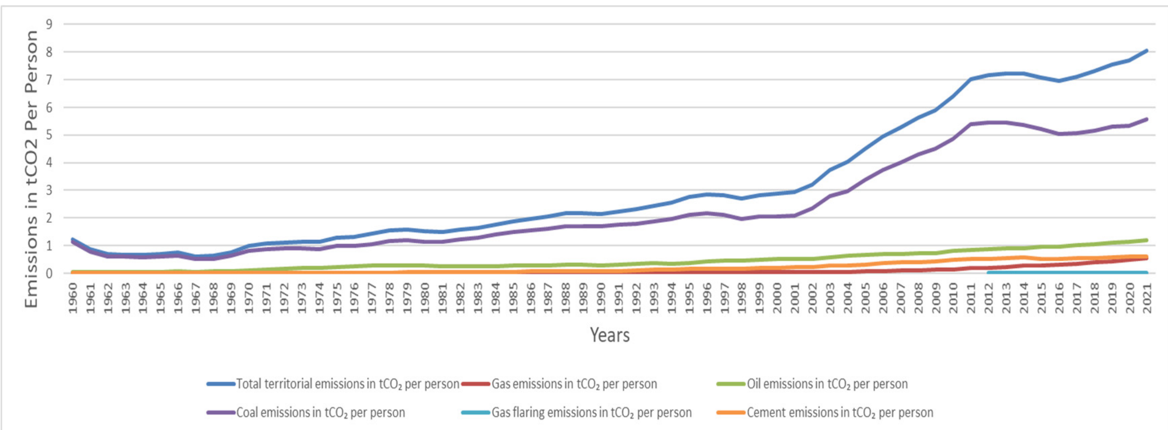

Figure 7. The trend in per capita CO_2 emissions from various energy and sectoral sources. Source of data: Global Carbon Atlas [2].

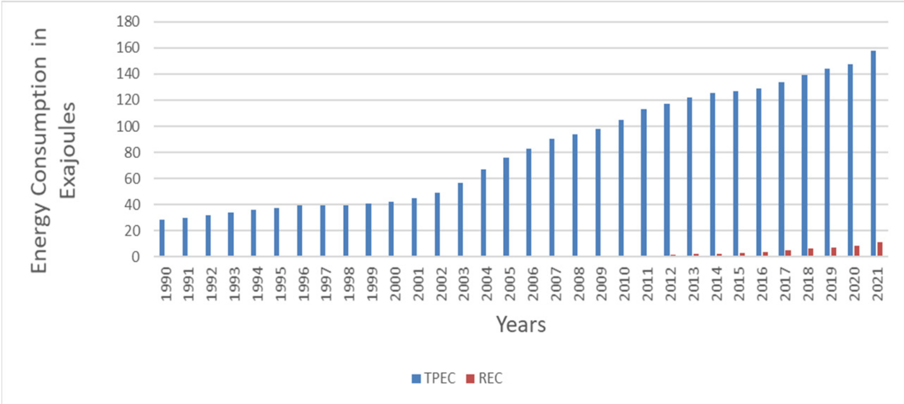

Figure 8. Trends in REC and TPEC. Source of data: BP [4].

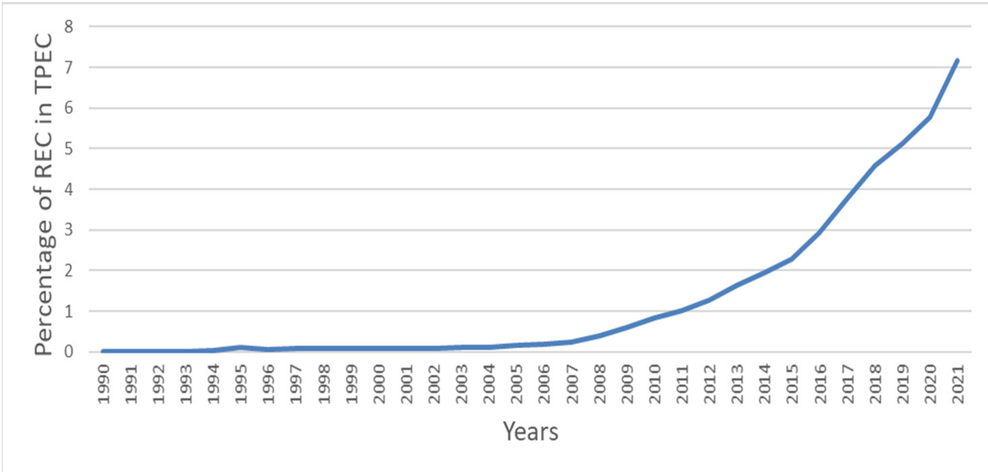

Figure 9. The trend in the percentage of REC in TPEC. Source of data: BP [4].

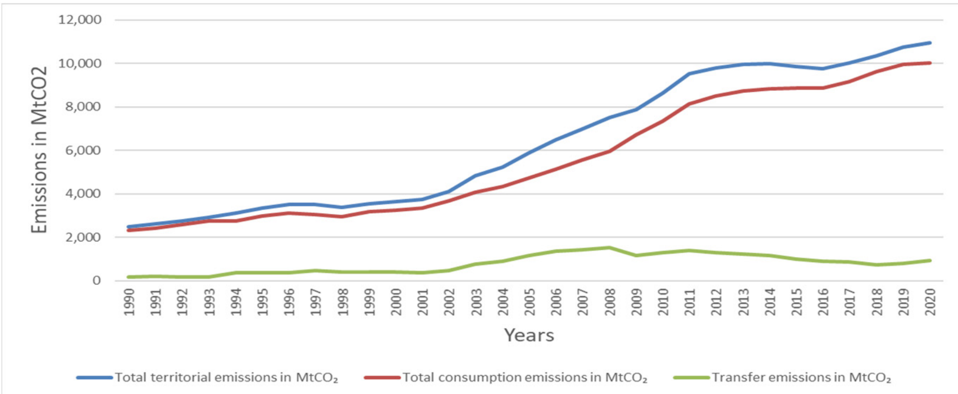

Figure 10. The trends in total territorial, consumption, and transfer emissions. Source of data: Global Carbon Atlas [2].

The role of economic growth and trade in emissions leads the literature toward EKC testing in China. A vast literature has investigated the EKC using aggregate data, provincial-level data, city-level data, and industrial data, which is discussed in detail in Section 3 and is a basic objective of this review article. However, few studies have reviewed the theoretical literature on the EKC hypothesis [5,6]. Furthermore, Shahbaz et al. [7] have reviewed the empirical literature on the EKC hypothesis. Moreover, some studies have utilized bibliometric and metadata approaches to analyze the academic publications on the EKC hypothesis [8–12]. In the regional review literature, studies have reviewed the

EKC literature in Bangladesh [13] and in the GCC region [14]. These studies motivate us to review the EKC literature in China. A vast literature has explored the EKC hypothesis in China and no review study has been conducted on the Chinese EKC literature so far. Thus, the present study fills this literature gap. For this purpose, we searched for the words EKC and China on the Scopus database on 12 January 2023 and found 1115 papers with these words. The focus of this study is to review the empirical studies performing macroeconomic analyses of the EKC hypothesis. Thus, we applied a filter to choose research papers in the Scopus subject area of "Economics, Econometrics, and Finance". Then, we chose for review all empirical studies in this selection that have used different global and local pollution proxies and different sample areas from China. Firstly, we investigated whether disaggregated data are more helpful in validating the EKC than aggregated national data or not. Secondly, we investigated what the role of global and local pollution proxies is in validating the EKC in China. To achieve these objectives, we applied logistic regression. These objectives also differentiate the present study from previous review literature on the EKC. Therefore, we are contributing to the global review literature on the EKC and Chinese review literature as well.

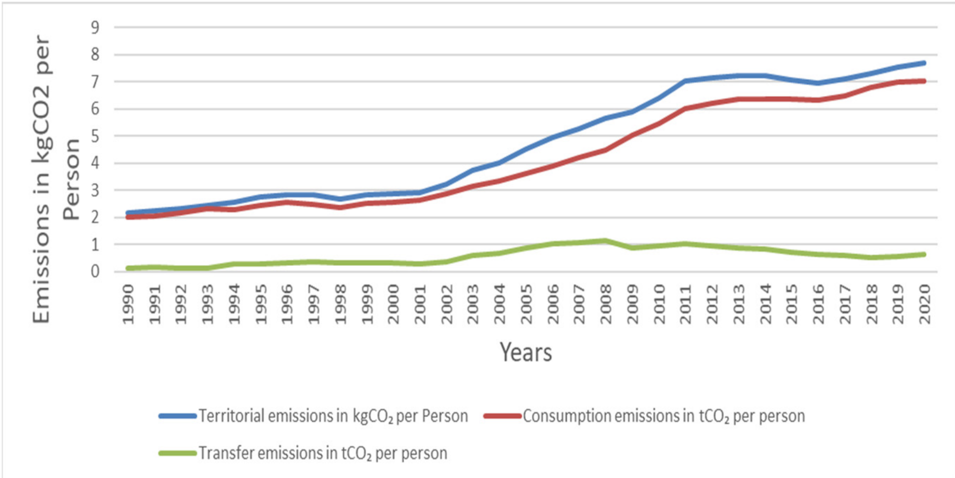

Figure 11. The trends in per person territorial, consumption, and transfer emissions. Source of data: Global Carbon Atlas [2].

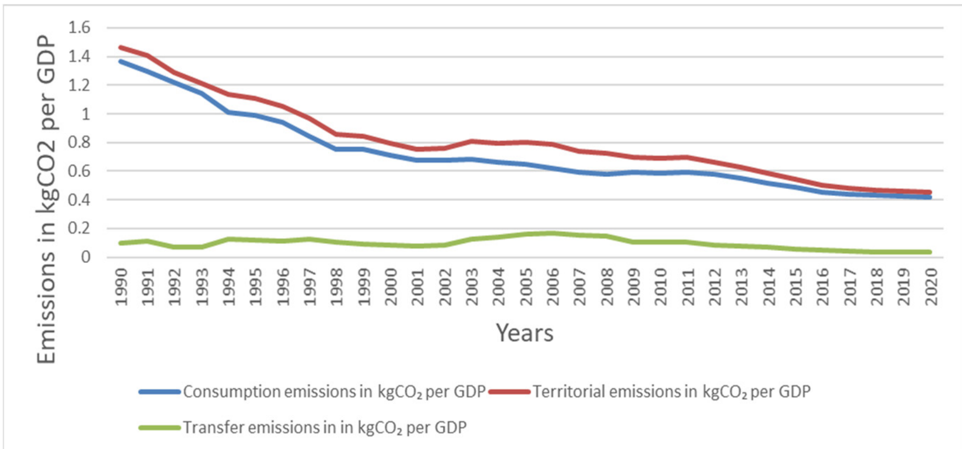

Figure 12. The trends in territorial, consumption, and transfer emissions per unit of GDP. Source of data: Global Carbon Atlas [2].

2. Theoretical Background of the EKC

Before presenting the empirical work on testing the EKC in China, we discuss the theoretical foundation of the EKC. First, Grossman and Kreuger [15] investigated the EKC hypothesis using the three proxies, i.e., SO_2, suspended particles, and dark matter. Later, the literature tested the EKC using different pollution indicators. Two major categories describe the level of pollution. The first is the global category, and most of the literature has worked on global air pollution such as CO_2 emissions. However, the literature has also focused on local gases such as urban air concentration, SO_2 emissions, NOx emissions, CO emissions, suspended particulate matter, etc. Moreover, the literature has also focused on water pollution, such as the existence of pathogens and heavy metals in the water. However, the focus of the literature is centered on the relationship between the macroeconomic performance of the economies and pollution emissions in testing the EKC hypothesis.

2.1. Role of Economic Growth in the EKC

After a seminal paper by Grossman and Kreuger [15], the world realized the issue of environmental degradation, and many studies were initiated to gauge the environmental effects of economic performance along with other macroeconomic indicators. In this domain, a nonlinear relationship between economic growth and pollution emissions is mostly explored in the literature. This is termed the EKC hypothesis [16], which is based on a seminal paper by Kuznets [17] on the nonlinear relationship between income inequality and development. In the first phase of the EKC, economies may shift from basic economic activities toward industrialization. This notion is matched with the concept of growing first and cleaning up later [18]. Thus, economies prefer employment and economic growth over environmental concerns [19]. In the desire for economic growth, developing economies relax their trade and environmental policies, which accelerates the scale of the economy, alters the composition of the economy, and affects the techniques of production. Thus, natural resources and energy are used on a massive scale to fuel economic growth, and this pollutes the environment [15]. Afterward, communities care for the environment in order to attain a higher standard of living [20] and governments develop environmental regulations to serve the communities for a clean environment. Thus, this stage may encourage the development of clean technology and energy sources to reduce pollution levels. Moreover, a structural change may also occur, and dirty industries may replace the service industry or cleaner manufacturing industries [21]. Furthermore, economic growth may support research and development (R&D) activities, which would replace dirty technologies with cleaner ones, which is a technique effect [22]. Therefore, technique and composition effects may emerge at this stage to create pleasant environmental effects of economic growth [13].

2.2. The Role of Technological Progress and Energy Efficiency

Technological progress could be helpful in the development of the shape of the EKC by reducing energy intensity, recycling waste, and increasing total factor productivity in the production processes. Thus, it can help reduce pollution emissions and achieve the second phase of the EKC. R&D would generate the technologies for this purpose [23]. In particular, government spending on R&D could target specific environmental problems [19] to provide better solutions for pollution abatement with the latest energy and production technologies. On the other hand, over-reliance on the oil sector could contribute to emissions [24]. However, the concept of a green economy has the potential to reduce pollution [25]. Moreover, technological progress could encourage REC or improve energy efficiency by changing the combinations of energy and material [26]. The latest energy-saver machines and equipment could raise energy and production efficiency [27], which could reduce emissions and shape the EKC. Every technology is first generated, then diffused, and then replaced with other better technologies. This is because every technology has its own ecological problems and needs to be checked by the government in order to develop better regulations to avoid causing pollution. Thus, technical progress and innovations have a continuous cycle to generate further technologies [28]. Moreover, technologies also help in generating new products that consume less energy, such as, for instance, hybrid cars, which may reduce pollution on the consumption side.

2.3. The Role of Trade, Foreign Direct Investment (FDI), Financial Development, and Regulations

Trade is an important determinant of pollution and can shape the EKC. Firstly, exports are a direct component of GDP, thus increasing economic size and energy consumption, which would accelerate the pollution emissions through a scale effect [29]. However, increasing economic growth would put pressure on the regulatory bodies to impose tight environmental regulations for a demand for a higher standard of living. The consequent environmental regulations put a high cost on the polluters in the country [30]. Thus, a pollution-oriented industry would shift from a strong-regulation to a weaker-regulation country [31], and international trade may facilitate this transformation. Developing countries usually relax their regulations to reduce the cost of production of exporting firms, which may help the exporting firms to achieve a competitive advantage in international trade [32]. Moreover, developing countries might relax their regulations to attract FDI. The displacement hypothesis explains that international trade and FDI would shift pollution-oriented industries from developed to developing economies. In addition, the structure of trade and the nature of FDI reveal the pattern of energy consumption in an economy [33]. A country involved in more manufacturing exports tends to use more energy [34]. Thus, trade specialization may explain the pattern of the EKC and would displace pollution-intensive industries in developing economies [35]. By relaxing environmental regulations, developing countries provide a pollution haven to the tightly regulated developed countries.

In terms of positive environmental aspects, foreign trade and investments could increase the employment and income levels of developing economies, which would be helpful in adopting tight environmental policies after a certain level of development [36]. Thus, regulations would abate pollution and shape the EKC to be flatter and smoother toward the second stage. There are two ways to regulate. The first way is through informal regulations, in which communities take some action against pollution to preserve the environment for better health through social and religious campaigns or by taking some legal action against polluters [37]. On the other hand, formal regulatory bodies could abate pollution by setting environmental regulations, which would help in tracing the EKC [19]. The regulations should be set out to reward clean producers and punish polluters. However, corruption can reduce the positive environmental effects of regulations and is also a factor that shapes the EKC [38]. Corruption can be responsible for pollution emissions with unequal treatment in society in terms of the implication of environmental regulations. Thus, economic growth could not reduce pollution if corruption allowed pollution in production and other economic activities. However, less developed countries depend on FDI for technology transfers, which could help them to reduce pollution. Thus, international trade and investment have become sources of technology diffusion in developing economies [39] and could help in achieving the technique and composition effects of international trade [21]. Consequently, foreign trade and investment could have a pleasant environmental effect on an economy.

FMD is another factor that can shape the EKC by promoting production and energy consumption. FMD can finance energy-intensive consumer items and raise pollution emissions [40]. Contrarily, it can also promote a green environment by providing green loans and financing for energy-efficient projects [41]. Furthermore, FMD could also finance R&D projects to generate ecofriendly technologies [42]. Local and foreign migration may also play a role in avoiding and reducing pollution levels in a country. Local migration would help communities to avoid pollution-concentrated areas and to shape the EKC [43]. Moreover, international migration would reduce the population pressure in a populated country [44], and China is an example in this regard. However, no study has been initiated to gauge the effect of migration on emissions in China.

3. Empirical Studies on Testing the EKC in China

3.1. Studies on Testing the EKC Using Aggregate National Data

This section explains the studies examining the EKC in the time series analyses of China using aggregate national data, and Table 1 shows an overview. For instance, Yaguchi et al. [45] investigated SO_2 and CO_2 emissions in Japan and China from 1975 to 1999 by applying the ordinary least square (OLS), fixed effects (FE), and random effects (RE) models. They found that high trends in past energy consumption reduced the SO_2 emission factor in Japan but not in China. In both countries, per capita income or energy consumption did not reduce the emission factor. Thus, the EKC was not confirmed in either country. Halkos and Tzeremes [46] used Chinese data from 1960 to 2006 and conducted a time series analysis. The results proved an inverted U-shaped relationship between per capita GDP and CO_2 emissions, proving the prevalence of the EKC in the country. They also showed that trade increased environmental degradation in China. In another study, Jalil and Feridun [47] used an autoregressive distributed lag (ARDL) approach on national data from China from 1953 to 2006 and found that FMD increased environmental degradation in the country, and the EKC was also confirmed. Guo [48] investigated China from 1978 to 2010 and mentioned a negative relationship between income and CO_2 emissions after a threshold point, which validated the EKC hypothesis. Thus, emissions eventually tended to decline with increasing income levels. Zhang [49] investigated China from 1971 to 2014 by using an ARDL approach and found an N-shaped EKC between economic growth and emissions. Moreover, energy consumption increased and urbanization reduced CO_2 emissions. Sarkodie and Strezov [50] investigated China along with three other countries from 1971 to 2013 and substantiated the evidence for the EKC between economic growth and CO_2 emissions in China.

Table 1. EKC testing using aggregate national data.

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Yaguchi et al. [45]	*Environment and Development*	1975–1999 (Japan) 1975–1999 (China)	Japan and China	OLS, FE, RE	SO_2, CO_2	No
Halkos and Tzeremes [46]	*Journal of Chinese Economic and Foreign Trade Studies*	1960–2006	China	Cointegration	CO_2	Yes
Jalil and Feridun [47]	*Energy Economics*	1953–2006	China	ARDL	CO_2	Yes
Guo [48]	*The Singapore Economic Review*	1978–2010	China	VECM	CO_2	Yes
Zhang [49]	*Journal of Risk and Financial Management*	1971–2014	China	ARDL	CO_2	Yes
Sarkodie and Strezov [50]	*Journal of Cleaner Production*	1971–2013	Australia, China, Ghana, and USA	ARDL	CO_2	Yes in China
Onafowora and Owoye [51]	*Energy Economics*	1970–2010	South Africa, South Korea, Mexico, Japan, Egypt, Brazil, and China	ARDL	CO_2	Yes in China
Pal and Mitra [52]	*Journal of Policy Modeling*	1971–2012	India and China	ARDL	CO_2	No
Moriwaki [53]	*Asia and the Pacific Policy Studies*	1961–2011	China, Japan, South Korea, and Taiwan	Cointegration	NBAL, water pollution, GHG	No

Table 1. *Cont.*

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Shahbaz et al. [54]	*The Singapore Economic Review*	1970–2012	China	VECM, ARDL	CO_2	No
Dogan [55]	*Panoeconomicus*	1971–2010	China	ARDL, FMOLS	CO_2	Yes
Mesagan et al. [56]	*Environment, Development and Sustainability*	1992–2014	BRICS countries	DOLS	CO_2	Yes in China
Gessesse and He [57]	*Agriculture Economics*	1971–2015	China	ARDL	CO_2	Yes
Farhani and Balsalobre-Lorente [58]	*The Chinese Economy*	1965–2017	China, USA, and India	OLS, FMOLS, DOLS, CCR	CO_2	Yes in China
Shahbaz et al. [59]	*Energy Economics*	1984–2018	China	BARDL	CO_2	Yes
Bozoklu et al. [60]	*Eurasian Economic Review*	1960–2014	India, Brazil, Mexico, Malaysia, Indonesia, South Korea, Egypt, Philippines, Greece, Colombia, Thailand, and Turkey	Cointegration	CO_2	Yes in China
Hussain et al. [61]	*Revista de economía mundial*	1961–2016	China	Cointegration	CO_2	No
Bese [62]	*International Journal of Energy Economics and Policy*	1978–2014	China	ARDL	SO_2	Yes
Pata and Isik [63]	*Resources Policy*	1981–2017	China	Dynamic ARDL	CO_2, SO_2, NOx	Yes
Zhu et al. [64]	*Economic Research*	1995–2017	China	ARDL	PM2.5, GHG	Yes
Jin et al. [65]	*Economic Research*	1988Q1–2018Q4	China	ARDL	CO_2	Yes
Liu et al. [66]	*Economic Research*	1995–2018	China	ARDL	CO_2	Yes
Kongkuah et al. [67]	*Environment, Development and Sustainability*	1971–2014	China	FMOLS, VECM	CO2	No
Hao and Cho [68]	*Environment, Development and Sustainability*	1990–2017	China	GARCH, ARDL	CO_2	Yes
Han et al. [69]	*Frontiers in Energy Research*	2000–2019	China	Tapio decoupling model	CO_2	Yes
Aminata et al. [70]	*International Journal of Energy Economics and Policy*	1984–2014	India and China	Cointegration, causality analyses	CO_2	No
Hussain et al. [71]	*Resources Policy*	1961–2016	China	ARDL	CO_2, ecological footprint	No
Chen et al. [72]	*Resources Policy*	1980–2020	China	ARDL	Ecological footprint	Yes

Onafowora and Owoye [51] studied seven countries including China from 1970 to 2010 by using the ARDL technique. They showed that the EKC had an inverted U-shaped curve in Japan and South Korea but showed an N-shape in other countries, including China. Similarly, Pal and Mitra [52] found an N-shaped EKC in China and India using data from 1971 to 2012. Moriwaki [53] analyzed the EKC using water pollution, greenhouse gas (GHG) emissions, and nutrient balance per arable land (NBAL) in East Asia. Unlike other countries, in China, NBAL, GHG, and water pollution increased because of increasing national income. Thus, the EKC was not validated. Shahbaz et al. [54] investigated China from 1970 to 2012. Using an ARDL and the vector error correction method (VECM), they found that emissions in China were declining with increasing globalization. However, CO_2 emissions were rising with increasing economic growth and the EKC was not validated. Nevertheless, pollution rates were starting to decline with increasing economic growth. On the other hand, Dogan [55] analyzed China using data from 1971 to 2010 in the CO_2 emissions model and tested the EKC by using the ARDL and fully modified OLS (FMOLS) methods. The results corroborated the EKC in China.

Mesagan et al. [56] tested the EKC in Brazil, Russia, India, China, and South Africa (BRICS) from 1992 to 2014. Using dynamic OLS (DOLS), they showed that electricity consumption increased emission rates, but capital investment reduced these levels. Moreover, the EKC was confirmed in China. Gessesse and He [57] used the ARDL approach to test data from 1971 to 2015 in China and corroborated the EKC. Farhani and Balsalobre-Lorente [58] validated the EKC in China using data from the period of 1965–2017. However, applying coal and oil consumption in the model turned the curve into a U-shaped curve. Using bootstrapping ARDL (BARDL), Shahbaz et al. [59] corroborated the EKC in China. According to Bozoklu et al. [60], the EKC existed in India, South Korea, China, the Philippines, and Colombia, as was determined using data from 1960 to 2014. However, it was not validated in Peru, Indonesia, Mexico, Chile, Brazil, Thailand, Turkey, Greece, Egypt, or Malaysia. Hussain et al. [61] used CO_2 emissions in testing the EKC in China. Using data from 1961 to 2016, the results did not confirm the EKC.

Bese [62] investigated the SO_2 emissions in China from 1978 to 2014 and validated the EKC by using the ARDL technique. Moreover, external debt and energy consumption increased emissions in China. Pata and Isik [63] investigated CO_2, SO_2, and NOx emissions in China from 1981 to 2017 and validated the EKC. The results also showed that energy intensity and income growth lead to higher load capacity factors that result in higher emissions. However, improvements in human capital tend to reduce emissions. In their study, Zhu et al. [64] explored PM2.5 and GHG emissions in China from 1995 to 2017 by using the ARDL technique, and the EKC was verified in China in the long run. Jin et al. [65] also used an ARDL method on quarterly data from 1988 to 2018 in China and validated the EKC. Their results showed that emission reduction was achieved through human capital development and eco-innovation. Moreover, Liu et al. [66] corroborated the EKC in China from 1995 to 2018 and argued that economic growth in China leads to fewer emissions in the long run.

Kongkuah et al. [67] tested the EKC by using FMOLS and VECM in China on data from 1971 to 2014 to see how economic and ecological variables are interconnected. The results showed that the EKC did not prevail in China, and they suggested that switching to cleaner technology and energy sources such as solar, hydro, and wind could be a good way to reduce emissions. Hao and Cho [68] explored the EKC in China in their ARDL and generalized autoregressive conditional heteroskedasticity (GARCH) models using data from 1990 to 2019 and confirmed the EKC in China. Han et al. [69] used data from 2000 to 2019 in China to conduct a Tapio decoupling analysis. The results showed that energy structures and industrial growth increased emissions. Additionally, when using industrial structure in the analysis, the U-shaped curve turned into an inverted U-shape, and the EKC was confirmed in China. Aminata et al. [70] tested the EKC in China and India from 1984 to 2014. Using VECM, they showed that population and economic growth increased emissions. Nevertheless, they found that the EKC did not exist in these countries.

Hussain et al. [71] investigated China from 1961 to 2016 and showed that the relationship between CO_2 emissions and the environmental footprint was shaped like a U-curve. Thus, the EKC was not validated. Other factors, including consumer prices, natural resources, and population density were seen to make the environmental quality worse. Chen et al. [72] investigated the ecological footprint in China from 1980 to 2020 by using ARDL methods and validated the EKC. The results also showed that natural resources could help reduce environmental degradation.

3.2. Studies on Testing the EKC in a Panel including China

Some studies utilize the panel data approach, including China in the sample, to test the EKC, as presented in Table 2. For instance, Abdouli et al. [73] investigated CO_2 emissions in BRICTS countries from 1990 to 2014 by using FE, RE, and the generalized method of moments (GMM). The EKC did not exist in the panel data. Jiang et al. [74] tested the EKC through the connection between income and CO_2 emissions in 39 countries including China from 1995 to 2011. They showed that the EKC was, in fact, N-shaped, while an inverted U-shape was also sustained, and trade had a huge role to play in that picture. Baloch and Wang [75] studied the EKC from the governance point of view in BRICS nations from 1996 to 2017 and applied a panel cointegration model. The results indicated that governance reduced emissions, and the EKC hypothesis was also validated. Using decomposition analysis, Sahu and Kamboj [76] conducted a regional analysis for ASEAN and BRICS countries and validated the EKC hypothesis. Mahmood et al. [77] explored six East Asian economies including China from 1991 to 2014 and corroborated the EKC in the spatial analyses. Moreover, FDI, energy intensity, and trade increased CO_2 emissions in the region. Moreover, FDI reduced emissions, and FMD, trade, and energy intensity increased emissions in neighboring economies. Ehigiamusoe [78] investigated ASEAN countries from 1990 to 2016 by using a pooled mean group (PMG) and confirmed the EKC hypothesis. Moreover, several factors including REC, FDI, and trade openness seemed to facilitate the improvement of the environmental profile of these countries while non-REC increased environmental degradation.

Table 2. EKC testing in a panel including China.

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Abdouli et al. [73]	*Empirical Economics*	1990–2014	BRICTS countries	FE, RE, GMM	CO_2	Yes
Jiang et al. [74]	*Structural Change and Economic Dynamics*	1995–2011	39 countries including China	Input–output analysis	CO_2	Yes
Baloch and Wang [75]	*Structural Change and Economic Dynamics*	1996–2017	BRICS	Panel cointegration	CO_2	Yes
Sahu and Kamboj [76]	*Journal of Economic Development*	1990–2016	BRICS, ASEAN, India, and China	Decomposition analysis	CO_2	Yes
Mahmood et al. [77]	*Sustainability*	1991–2014	East Asia including China	Spatial analyses	CO_2	Yes
Ehigiamusoe [78]	*The Singapore Economic Review*	1990–2016	ASEAN and China	PMG	CO_2	Yes
Awolusi and Mbonigaba [79]	*International Journal of Green Economics*	1990–2017	BRICS	ARDL	CO_2	Yes
He et al. [80]	*Emerging Markets, Finance, and Trade*	1985–2014	China, Finland, and Malaysia	Panel ARDL	CO_2	Yes

Table 2. *Cont.*

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Zhang et al. [81]	*Economic Research*	1990–2018	BRICS	ARDL	PM2.5	Yes
Adebayo et al. [82]	*Resources Policy*	1990–2018	Brazil, China, India, Mexico, Malaysia, Philippines, South Africa, Turkey, Indonesia, and Thailand	OLS, FMOLS, DOLS, FE, RE	CO_2	Yes
Thio et al. [83]	*Environment, Development and Sustainability*	2000–2014	China, USA, India, Russia, Japan, Germany, South Korea, Canada, Mexico, and South Africa	Quantile regression	CO_2	Yes
Gyamfi et al. [84]	*Journal of Economic Structures*	1995–2016	China, India, Indonesia, Russia, Mexico, Brazil, and Turkey	Panel cointegration and causality tests	CO_2	Yes

Awolusi and Mbonigaba [79] used ARDL to test the EKC in BRICS countries from 1990 to 2017 and confirmed the EKC. In another study, He et al. [80] also indicated that the EKC was N-shaped in China, Finland, and Malaysia by using panel ARDL on a dataset from 1985 to 2014. Zhang et al. [81] used PM2.5 as an emission indicator and investigated the EKC in BRICS countries from 1990 to 2018. The results showed the presence of the EKC in these nations over a longer period, which reinforced its importance in long-run development policymaking. Adebayo et al. [82] used DOLS, FMOLS, FE, and RE to check the importance of natural resource integration to achieve environmental goals. The study was conducted for 10 economies, including that of China, on data from 1990 to 2018. The results validated the EKC in these countries and also showed that REC increased environmental quality improvement. In their paper on the EKC hypothesis in over ten countries including China, Thio et al. [83] tested the EKC on data from 2000 to 2014. In the panel quantile regression, the EKC was validated in the selected countries, showing that after a certain cut-off of GDP, environmental quality started to improve. They also suggested that governments should focus on technological advancements so that energy technology can be made more sophisticated and emissions can keep declining. Gyamfi et al. [84] investigated seven countries including China from 1995 to 2016 and validated the EKC.

3.3. Studies on Testing the EKC by Using Provincial and Regional Data

Table 3 displays a summary of studies on testing the EKC by using provincial and regional data. Dean [85] found that free trade had a deteriorating effect on the environment in China. However, this negative effect was offset by income growth. Hence, unlike other studies suggesting that free trade could harm developing countries' environments, the net effect was positive for China. Moreover, the EKC was tested and corroborated in 28 Chinese provinces. De Groot et al. [86] analyzed the prevalence of the EKC in China from 1982 to 1997. They used a sample of 30 provinces and three types of pollution proxies were used: wastewater, water gas, and solid waste. In absolute levels of pollution, the results indicated an inverted N-shaped relationship for the wastewater proxy and an N-shaped relationship for the waste gas and solid waste proxies. Using the EKC model, Poon et al. [87] investigated the energy, transport, and trade sectors in China from 1998 to 2004. An inverted U-shaped relationship was found in the SO_2 model. However, for soot particulates, the relationship was U-shaped. Thus, soot particulates had more harmful effects than SO_2. Shen [88] investigated SO_2, dust fall, and water pollution in 30 provinces in China from 1993 to 2002. In a simultaneous equation model (SEM), a simultaneity between income and pollution was found. Pollution tended to negatively affect income. However, labor had a positive effect on income. Government expenditures on pollution abatement also reduced pollution. However, the EKC was not validated in SEM techniques for all pollution proxies. Nevertheless, the EKC was validated in the SO_2 model by using a simple polynomial equation.

Table 3. EKC testing using provincial and regional data.

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Dean [85]	*Canadian Journal of Economics*	1987–1995	28 provinces	Simultaneous equations	Water pollution	Yes
De Groot et al. [86]	*Environment and Development Economics*	1982–1997	30 provinces	Pooled cross-section analysis	Wastewater, waste gas, solid waste pollution	Yes in the cases of waste gas and solid waste. No in the case of wastewater
Poon et al. [87]	*Eurasian Geography and Economics*	1998–2004	30 provinces	SAR, SEM	SO_2, soot particulates	Yes in the case of SO_2. No in the case of soot particulates
Shen [88]	*China Economic Review*	1993–2002	30 provinces	Simultaneous equation model	SO_2, dust fall, water pollution	No
Wang et al. [89]	*Forest Policy and Economics*	1984–2003	30 provinces	Regression analysis	Forest cover	Yes between forest cover and economic growth
Auffhammer and Carson [90]	*Journal of Environmental Economics and Management*	1985–2004	30 provinces	FE	Waste gas	No
Song et al. [91]	*China Economic Review*	1985–2005	29 provinces	DOLS	Waste gas, wastewater, solid waste	Yes in the cases of waste gas and solid waste. No in the case of wastewater
Jiang et al. [92]	*SSRN Electronic Journal*	1985–2005	31 provinces	Regression	Waste gas, wastewater, solid waste	Yes in the cases of waste gas and wastewater. No in the case of solid waste
Song et al. [93]	*Energy Policy*	1993–2010	30 provinces	Graphical analyses	Industrial waste gas emission	Yes
He [94]	*Environment and Development Economics*	1991–2001	26 provinces	Regression	SO_2	Yes
He [95]	*Ecological Economics*	1991–2001	29 provinces	3SLS	SO_2 emissions	Yes
Taguchi and Murofushi [96]	*Environment and Development Economics*	1988–2007	29 provinces	FE	Wastewater, waste gas, solid waste	Yes
Du [97]	*Asian Social Science*	1991–2005	Eastern China, Middle China, and Western China	Simulation method	Industrial wastewater, industrial sulfur dioxide, industrial effluent	Yes

Table 3. *Cont.*

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Jayanthakumaran and Liu [98]	*Economic Modeling*	1990–2007	30 provinces	Simultaneous equations	SO_2 and COD	Yes
Jiang et al. [99]	*China Economic Review*	2003–2011	29 provinces	SDM	Energy intensity	Yes
Yang et al. [100]	*Ecological Economics*	1995–2010	29 provinces	Spatial models, sensitivity analyses	CO_2, SO_2, industrial dust, industrial waste gas, industrial smoke, industrial SO_2, industrial wastewater	No
Chen and Chen [101]	*Computational Economics*	1985–2010	31 provinces	FE, nonparametric methods	Industrial CO_2	Yes
Lee and Oh [102]	*China Economic Review*	2003–2010	30 provinces divided into 4 regions in China	Pooled OLS	CO_2	Yes
Shostya [103]	*International Advances in Economic Research*	2004–2013	31 provinces	Simultaneous equations	Particulate matter, SO_2, NOx	Yes
Guilhot et al. [104]	*Mondes en Développement*	2005–2011	30 provinces	FE	SO_2, the particulate concentration	Yes
Shimizu [105]	*Journal of Chinese Economic and Business Studies*	1995–2010	29 provinces	FE, GMM	CO_2, NOx, SOx	No
Liao et al. [106]	*Economics*	1990–2012	29 provinces	Panel cointegration	SO_2	Yes
Xu et al. [107]	*Zbornik radova Ekonomskog fakulteta Rijeka*	2000–2012	30 provinces	Spatial panel analysis	CO_2	Yes
Dong et al. [108]	*Resources, Conservation and Recycling*	1998–2012	30 provinces	GMM	CO_2 intensity	Yes between CO_2 and urbanization
Cohen et al. [109]	*Energy Economics*	1990–2012	30 provinces	EKC trend, elasticities	CO_2	Yes
Zeng et al. [110]	*Resources, Conservation and Recycling*	2004–2006	30 provinces	Fixed effects	SO_2	Yes
Zhang et al. [111]	*Applied Economics*	2005–2015	31 provinces	SAR, SDM	SO_2, NOx, PM2.5, PM10, VOC	Yes except for SO_2
Qiao et al. [112]	*Energy Economics*	2000–2016	30 provinces	CD-cointegration	Coal consumption	Yes
Wang et al. [113]	*Emerging Markets Finance and Trade*	2000–2014	30 provinces	FE, RE	PM2.5	Yes
Zhao et al. [114]	*Energy Economics*	2000–2015	30 provinces	SYS-GMM method	CO_2	Yes
Jiang et al. [115]	*Energy Economics*	1997–2015	30 provinces	CD- techniques, FMOLS	Gas consumption	Yes

Table 3. *Cont.*

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Hao et al. [116]	*Environment and Development Economics*	1995–2015	29 provinces	GMM	SO_2, CO_2	Yes in the relationship between emissions and fiscal decentralization
Shahbaz et al. [117]	*Energy Economics*	1980–2018	30 provinces	Nonparametric panel cointegration	Energy consumption	Yes
Shao [118]	*Marine Policy*	2000–2016	11 coastal regions in China	Panel threshold model	Marine pollution	Yes
Zhao et al. [119]	*Energy Economics*	1999–2017	30 provinces	SDM	SO_2, solid waste	Yes
Bonnefond et al. [120]	*Post-Communist Economies*	2000–2012	30 provinces	Semiparametric panel techniques	CO_2, SO_2, soot, AN, COD	Yes
Ahmad et al. [121]	*Resource Policy*	1995–2017	5 provinces	FMOLS	CO_2	Yes
Wang et al. [122]	*Energy Economics*	2004–2016	30 provinces	GMM	CO_2	Yes
Hao et al. [123]	*Environment, Development and Sustainability*	2000–2017	30 provinces in China and 16 states in Germany	GMM	CO_2, SO_2, NOx, sewerage	Yes
Xu et al. [124]	*Environment, Development and Sustainability*	2006–2015	30 provinces	GMM	NOx	Yes
Cheng and Yao [125]	*Environment, Development and Sustainability*	2008–2020	31 provinces	Factor decomposition model	CO_2	Yes
Qu et al. [126]	*Frontiers in Energy Research*	2000–2015	30 provinces	Regression	CO_2	Yes
Liu et al. [127]	*Applied Economics*	1997–2019	6 regions	FMOLS, augmented mean group (AMG), panel causality	CO_2	Yes
Geng et al. [128]	*Resources Policy*	2007–2021	30 provinces	Panel regression	Green economic efficiency	Yes between green economic efficiency and green finance

Wang et al. [89] investigated 30 Chinese provinces from 1984 to 2003 and validated the EKC between per capita GDP and forest cover, which referred to the policy implications for forest resource management in the country. Using 30 provinces' data on waste gas emissions from China during 1985–2004, Auffhammer and Carson [90] conducted a spatial analysis. In dynamic models, it was shown that the EKC did not hold in China. Moreover, population density increased emissions. Song et al. [91] used 29 provinces' data from China from 1985 to 2005. Waste gas, wastewater, and solid waste were used as proxies for pollution. DOLS estimators were used, and the results corroborated the EKC in China in the cases of waste gas and wastewater. However, the EKC was not validated in the case of solid waste. Jiang et al. [92] analyzed 31 provinces from 1985 to 2005 to test the EKC, and the EKC was validated for waste gas and wastewater as pollutants but not for solid waste. Song et al. [93] investigated Chinese provinces from 1993 to 2010. They found five provinces in the second stage of the EKC and five others in the first stage.

He [94] investigated and validated the EKC in 26 provinces in China from 1991 to 2001 by using SO_2 emissions as a pollution proxy. A significant negative impact of economic growth was seen at an EKC turning point for China at 10,000 yuan. Additionally, the capital–labor abundance ratio also had an indirect effect on the provincial income level in China. On the other hand, He [95] examined 29 provinces from 1991 to 2001 to test the EKC hypothesis. The 3SLS and decomposition methods were used to test the rich panel data and SO_2 emissions were used as a proxy for emissions. Scale, composition, and technical effects were calculated, and the analysis showed that trade openness increased SO_2 emissions and the EKC was also validated. Taguchi and Murofushi [96] used the EKC framework by using wastewater, waste gas, and solid waste as proxies for pollution. The EKC was validated using data from 29 provinces from 1988 to 2007. Du [97] tested the EKC in three major economic zones in China from 1991 to 2005 and used industrial wastewater, industrial SO_2, and industrial effluent as pollution indicators. The EKC was validated for all pollution indicators.

Jayanthakumaran and Liu [98] used data from 30 Chinese provinces from 1990 to 2007 on SO_2 emissions and chemical oxygen demand (COD). The results validated the EKC. Secondly, using SEM, they determined that the scale effects were initially stronger than the technical ones. With increasing provincial income, their emission rates declined. Nevertheless, technical effects led to a negative relationship between COD and international trade. Jiang et al. [99] used energy intensity data from 29 Chinese provinces from 2003 to 2011 and showed the existence of the EKC. Yang et al. [100] used the extreme bound analysis, spatial regression, and bootstrap approaches to test the EKC in 29 Chinese provinces from 1995 to 2010 in the case of seven pollution proxies. They found that the EKC was not validated in China for any of the emissions' proxies. Chen and Chen [101] explored 31 provinces in China from 1985 to 2010 to test the EKC. Industrial CO_2 was used as an indicator of environmental pollution and GDP was used as a proxy for economic development. The EKC was corroborated.

Lee and Oh [102] examined and found the quadratic and cubic EKCs by applying an FE model in 30 provinces on data from 2003 to 2010. Using air pollution data from 27 Chinese provinces from 2004 to 2013, Shostya [103] showed that the EKC existed in these provinces, but its trend seemed to be different for different types of pollution including particulate matter, SO_2, and NOx. These air pollutants were major contributors to air environmental degradation in the country. With increasing income, their trends could be altered to alleviate the negative effects. Using data from 30 Chinese provinces, Guilhot et al. [104] showed the effects of several different variables, including urbanization and regulatory measures on SO_2 and particulate emissions. They validated the EKC for all emissions models. Shimizu [105] showed that income growth resulted in the release of higher emissions and hence degraded the environment even more. They used data from 29 provinces from 1995 to 2010 to test the effect of income on CO_2, NOx, and SO_2 and could not validate the EKC. They suggested that emission abatement programs would be crucial to reducing these degrading effects of subsequent pollution.

Liao et al. [106] investigated 29 provinces from 1990 to 2012 and validated the EKC, which showed that income growth over two decades had eventually brought down SO_2 emissions in China. According to Xu et al. [107], the EKC existed in the context of China, and they proved this using data from 30 provinces in the country from 2000 to 2012. They applied spatial models to identify the relationship between the variables and showed that at a 279.91 million yuan/km^2 income level, pollution started to backtrack. Dong et al. [108] explored 30 provinces from 1998 to 2012 by utilizing GMM and found that urbanization and CO_2 intensity had an inverted U-shaped relationship. Thus, increasing urbanization eventually reduced pollution, which validated the EKC.

Cohen et al. [109] analyzed 30 provinces from 1990 to 2012 to test the EKC and revealed that the curve had an elasticity of 0.6 and production-based emissions had a more elastic EKC than consumption-based ones. The EKC was validated. However, they showed that its trend had changed over the years. Additionally, richer provinces had a less elastic

EKC. Zeng et al. [110] examined 30 provinces from 2004 to 2006 and validated the EKC in the country. Zhang et al. [111] analyzed a handful of emission indicators including NOx, PM2.5, PM10, volatile organic compounds (VOC), and SO_2. Using data from 31 provinces in China, they conducted a spatial analysis, and the results of the analysis validated the EKC. They said that the results for China were similar to those for developed countries including the UK, the USA, Canada, and Denmark. Furthermore, technology investment increased emissions, which was contradictory to the existing theory of innovation.

Qiao et al. [112] used data from 2000 to 2016 across 30 provinces in China and tested the coal EKC. The idea was to test whether China had reached a coal peak. In some areas, a downward trend was seen between income and coal consumption, which indicated that the coal peak had been achieved. In other provinces and regions, however, there was still an upward trend. Thus, the peak had not arrived yet in these areas. Hence, the results indicated the EKC in some parts of China and not in others, which indicated that a "one size fits all" approach could not be worked in China. Thus, policymakers needed to understand that coal consumption policies needed to take this regional diversity into consideration. Wang et al. [113] showed that in the EKC discussion, several other factors including population, energy consumption patterns, FDI, and industrialization could matter to a great extent in changing PM2.5 emissions. In 30 Chinese provinces, using data from 2000 to 2014, they showed the prevalence of the EKC. However, the results also indicated that there was a difference in terms of the trend in the EKC across regions.

Zhao et al. [114] investigated 30 provinces from 2000 to 2015 and reported that the EKC existed in China by using a proxy of CO_2 emissions. Moreover, the environmental regulatory structure could influence emissions and energy consumption patterns. Jiang et al. [115] examined 30 provinces in China from 1997 to 2015 and showed that economic growth in China accelerated natural gas use while other variables, including energy intensity and urbanization, also had a positive impact. On the other hand, factors such as long-run energy consumption structures could negatively affect the trend. They proved the EKC hypothesis in the gas consumption model. Hao et al. [116] explored 29 provinces from 1995 to 2015 and mentioned that an inverted U-shaped effect of fiscal decentralization existed for SO_2 and CO_2 emissions. Shahbaz et al. [117] tested and corroborated the EKC in 30 Chinese provinces from 1980 to 2018 and found that there was a nonparametric relationship between growth and energy usage. For most of these provinces, a decoupling of energy consumption was needed so that environmentally degrading effects of income growth could be avoided by achieving higher energy efficiency.

Shao [118] conducted an analysis on 11 coastal regions in China to test the EKC over the period of 2000–2016, and the EKC was validated in the model of marine pollution. Zhao et al. [119] tested the EKC in 30 provinces from 2000 to 2016 by using SO_2, solid waste, and wastewater as the indicators of pollution. The results from a spatial analysis showed that energy consumption and FMD released higher pollution levels. However, the EKC was also corroborated with an N-shape. Bonnefond et al. [120] conducted a semiparametric analysis of 30 provinces in China from 2000 to 2012 by using pollution proxies of SO_2, COD, wastewater, CO_2, soot, and ammonia nitrogen (AN). They found that income inequality raised emissions. They also argued that urban inequality was responsible for rising soot emissions and water pollution. However, rural inequality did not contribute to pollution. Moreover, the EKC was corroborated in the models of CO_2, SO_2, and wastewater and could not be verified in the AN, COD, or soot models.

Using data from five northwestern provinces in China, Ahmad et al. [121] conducted a panel data analysis from 1995 to 2017 to understand how natural resources could affect CO_2 emissions. The results showed that for some regions, greater natural resource availability could lead to lower emissions. Additionally, renewable sources of energy could contribute to better environmental consequences, which should be considered in long-term policymaking for sustainable growth. Wang et al. [122] examined the EKC in the model of CO_2 emissions in 30 Chinese provinces from 2004 to 2016 by using the GMM approach, and the EKC was corroborated for the relationship between emissions and FDI. Hao et al. [123]

used data from over the period of 2000–2017 from 30 Chinese provinces and 16 German states in models of CO_2, SO_2, NOx, and sewerage. The results validated the EKC for all pollution proxies. Xu et al. [124] analyzed 30 provinces from 2006 to 2015 by using the FE, RE, and GMM approaches. They tested the effects of energy consumption and nitrogen fertilizer on NOx. The EKC was corroborated in all cases.

Cheng and Yao [125] examined the EKC in 31 Chinese provinces from 2008 to 2020 with the CO_2 emissions model and showed the EKC's prevalence in China. In their research, Qu et al. [126] investigated 30 provinces from 2000 to 2015 and validated the EKC. Moreover, they suggested that technological advancement should be encouraged, which could support emission reduction policies in a sustainable way. This could have purification effects on the environment as renewable energy is used to achieve these environmental goals. They argued that dirty technology needed to be replaced with cleaner options so that the energy structure could be transformed at large, ensuring environmental quality improvement. Liu et al. [127] used the FMOLS and augmented mean group (AMG) techniques on regional data from 1997 to 2019 in the six Chinese regions. The results showed that the EKC was validated in five of the investigated regions but not in Western China. Geng et al. [128] tested the EKC in 30 provinces from 2007 to 2021. In their analysis, they showed that the EKC was validated in the relationship between green economic efficiency and green finance.

3.4. Studies on Testing the EKC by Analyzing a Single Province in China

Some studies tested the EKC in a single region/province of China, as presented in Table 4. For instance, Liu et al. [129] investigated Shenzhen from 1989 to 2003 to test the EKC and used pollutant concentration in ambient air, main rivers, and near-shore waters as the proxies for pollution. Production-induced pollution validated the prevalence of the EKC, which was not the case for consumption-induced pollution. Jia et al. [130] analyzed Henan from 1983 to 2006 to identify ecological footprint intensity. They found that the EKC did not exist in the province, as the parameters of GDP and its square were positive. Zhao et al. [131] collected forest cover data from Sichuan for the years 1988, 1990, and 2000, and found a U-shaped relationship between forest cover and economic growth. Thus, increasing economic growth after a cut-off point may increase forest cover, which would be pleasant for the environment. However, the high turning point of the U-shaped curve suggested that the EKC between forest cover and economic growth was not confirmed. Zhang and Gangopadhyay [132] investigated the Yangtze River Delta from 2003 to 2009 by using the pollution proxies of SO_2, dust, and sewage water. They mentioned that increasing economic growth raised technological advancements and financial incentives to reduce environmental emissions. Moreover, they validated the EKC between GDP and SO_2. However, the EKC was not validated in the cases of dust and sewage water.

Table 4. EKC testing in a single province or a region.

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Liu et al. [129]	*Ecological Economics*	1989–2003	Shenzhen, China	Regressions	Pollution index based on the Nemerow index	Yes for production-induced pollution. No for consumption-induced pollutants
Jia et al. [130]	*Ecological Economics*	1983–2006	Henan, China	Partial least squares	Ecological footprint	No
Zhao et al. [131]	*Environmental and Resource Economics*	1988, 1990, 2000	Sichuan, China	Spatial lag and error models	Forest cover	No
Zhang and Gangopadhyay [132]	*Applied Economics*	2003–2009	Yangtze River Delta, China	FE	SO_2, dust, sewage water	Yes for SO_2. No for dust and sewage water

Table 4. *Cont.*

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Li et al. [133]	*Forum Scientiae Oeconomia*	1990–2012	Shaanxi provinces, China	VAR	CO_2	Yes
Agboola and Alola [134]	*Journal of Environmental Economics and Policy*	1995–2018	Hong Kong, China	ARDL	CO_2	Yes
To and Lam [135]	*Chinese Journal of Urban and Environmental Studies*	1985–2020	Macao, China	Kaya decomposition	GHG	Yes

Li et al. [133] investigated the EKC in Shaanxi from 1990 to 2012 by using a CO_2 emissions proxy and validated the EKC. Agboola and Alola [134] examined the EKC in Hong Kong from 1995 to 2018 by using a CO_2 emissions proxy and corroborated the EKC between growth and CO_2 emissions. To and Lam [135] analyzed GHG emissions in Macao from 1985 to 2020. Over the selected period, the energy use and GDP of Macao increased dramatically, leading to higher GHG emissions. However, GHG emissions declined after reaching a threshold of GDP. Thus, the EKC was corroborated.

3.5. Studies on Testing the EKC by Using Data from Chinese Cities

Table 5 displays a summary of studies on testing the EKC by using city-level data. Brajer et al. [136] analyzed SO_2 emissions in 128 Chinese cities from 1990 to 2004 to test the EKC, and their results corroborated an inverted U-shaped and an N-shaped EKC. Shaw et al. [137] used data from 99 cities from 1992 to 2004 to identify if the EKC existed in the relationship of SO_2, deposited particles, NOx, and economic growth. The FE results confirmed the EKC in the models of SO_2 and deposited particles. The EKC was not validated in the NOx model. In their study, Brajer et al. [138] investigated the EKC in 139 Chinese cities from 1990 to 2006 in the models of SO_2, NO_2, and suspended particulates. They validated the EKC with an inverted U-shaped relationship in the model of NO_2 and with an N-shaped relationship in the models of SO_2 and suspended particulates. He and Wang [139] analyzed 74 cities from 1991 to 2001 to study the EKC in the models of NOx, SO_2, and suspended particulates. Applying RE models, the EKC was corroborated in all models. Using 2001–2011 data from 225 Chinese cities, He et al. [140] examined and corroborated the EKC in the model of the air quality index. With more regulations, environmental and specifically air quality increased. However, the results seemed to differ across cities. With more resistance to the regulatory mechanisms, air quality was aggravated.

Table 5. EKC testing using city-level data.

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Brajer et al. [136]	*Ecological Economics*	1990–2004	128 cities	RE	SO_2	Yes
Shaw et al. [137]	*Environmental Economics and Policy Studies*	1992–2004	99 cities	FE	SO_2, deposited particles, NOx	Yes for SO_2 emissions and deposited particles.No for NOx
Brajer et al. [138]	*China Economic Review*	1990–2006	139 cities	RE	SO_2, NO_2, suspended particulates	Yes

Table 5. *Cont.*

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
He and Wang [139]	*Ecological Economics*	1991–2001	74 cities	FE, RE	NOx, SO_2, suspended particulates	Yes
He et al. [140]	*Eurasian Geography and Economics*	2001–2011	225 cities	Simultaneous equations	Air pollution index	Yes
Sun and Yuan [141]	*Pacific Economic Review*	2003–2008	287 cities	FE, instrumental variable technique	CO_2	Yes
Stern and Zha [142]	*Environmental Economics and Policy Studies*	2013–2014	50 cities	FE, growth equations	PM2.5, PM10	Yes
Jiang and Zheng [143]	*Emerging Markets Finance and Trade*	2007–2015	30 cities in the Yangtze River Delta, China	FE, RE	Regional pollution intensity	Yes
Meng and Huang [144]	*Environmental and Resource Economics*	1995–2012	331 cities	SDM	CO_2	Yes
Fang et al. [145]	*The World Economy*	2004–2013	261 cities	FMOLS, panel cointegration	Industrial waste pollution, SO_2	Yes
Zhang Y. [146]	*Environment and Development Economics*	1998–2007	287 cities	FE, RE	PM2.5	Yes in the relationship between emissions and wages
Wang et al. [147]	*Journal of Systems Science and Information*	2003–2017	289 cities	3SLS	SO_2, soot	Yes
Song et al. [148]	*Energy Economics*	2004–2016	277 cities	Spatial analysis	Pollution index	Yes
Kang et al. [149]	*Chinese Journal of Urban and Environmental Studies*	2000–2017	264 cities	Tapio decoupling index	CO_2	Yes
Chang et al. [150]	*Energy Economics*	2004–2015	284 cities	Spatial dynamic panel model	CO_2	Yes
Hu et al. [151]	*Environmental and Resource Economics*	2000–2011	240 cities	Instrumental variables technique	SO_2, wastewater emissions	Yes
Yang et al. [152]	*Environment, Development and Sustainability*	2018	120 cities	Multilinear regression	Environmental information transparency	Yes
Kahn et al. [153]	*Ecological Economics*	2015–2019	144 cities	OLS	PM2.5	Yes
Wu and Zhang [154]	*Letters in Spatial and Resource Sciences*	2006–2018	265 cities	SDM	SO_2, solid waste, water pollution	No

Sun and Yuan [141] analyzed CO_2 emissions in 287 cities from 2003 to 2008 and tested the prevalence of the EKC in the country. The results showed that more industrial agglomeration could lead to higher environmental degradation. However, the EKC was confirmed. Their results also showed that the type of industrial activities could also have an impact on the shape of the EKC. Stern and Zha [142] analyzed 50 Chinese cities from 2013 to 2014 to test the relationship between income and air quality and corroborated the EKC in the models of PM2.5 and PM10. Jiang and Zheng [143] investigated and confirmed the EKC in the regional pollution intensity model in 30 cities located in the Yangtze River Delta.

They also argued that intercity government regulations and environmental protection checks had a role in determining this relationship as well. Meng and Huang [144] examined 331 Chinese cities from 1995 to 2012 by using the spatial Durbin model (SDM) as the model of CO_2 emissions. The EKC existed and environmental governance and regulations helped to flatten the curve. Fang et al. [145] examined 261 cities from 2004 to 2013 to test the EKC in the models of industrial waste pollution and SO_2. The analysis validated the EKC.

Zhang [146] investigated 287 Chinese cities from 1998 to 2007 and showed that the EKC was validated between wages and PM2.5 emissions in China, and trade openness had a large role in that picture. Wang et al. [147] used 2SLS to investigate 289 Chinese cities from 2003 to 2017 in the models of soot and SO_2 and validated the EKC for both models. Song et al. [148] worked on the pollution index in spatial analyses of 277 cities from 2004 to 2016 and validated the EKC in China. They argued that the EKC was confirmed after using pollution reduction technology. Kang et al. [149] used the Tapio decoupling method and analyzed 264 cities from 2000 to 2017. Over the years, a decoupling trend was seen in cities. With more investment and economic growth, these growth trends seemed to become decoupled from emissions, and emission levels started to decline. This result validated the EKC in the selected cities in China. Chang et al. [150] examined 284 Chinese cities from 2004 to 2015 and also validated the EKC in the model of CO_2 emissions. Hu et al. [151] explored 240 Chinese cities from 2000 to 2011 by utilizing instrumental variables in the models of SO_2 and wastewater emissions and validated the EKC for both models.

Yang et al. [152] examined 120 cities using data from the year 2018 to test the relationship between government–business relations and environmental information transparency. They corroborated the EKC with an inverted U-shaped relationship between variables. The results also showed a similar pattern between GDP and transparency. Kahn et al. [153] examined and corroborated the EKC in 144 Chinese cities from 2015 to 2019 for the model of PM2.5 emissions. They also talked about how COVID-19 led to a decline in urban pollution in China. This opened a discussion around "blue sky" regulation, which could lead to clear policymaking in order to keep pollution below a certain level. Wu and Zhang [154] explored 265 Chinese cities from 2006 to 2018 in the models of SO_2, solid waste, and water pollution. In all models, the EKC was supported in China.

3.6. Studies on Testing the EKC at the Industrial/Sectoral Level

Some studies explored the EKC at the industrial/sectoral level in China, as presented in Table 6. For instance, Ren et al. [155] explored 18 industrial sectors in China from 2000 to 2010 by using the GMM technique. The results showed that more trade surpluses and FDI were leading to higher CO_2 emissions in China. The EKC was also validated with an inverted U-shaped curve. Zhang et al. [156] investigated Chinese-listed heavily polluted companies from 2004 to 2014. A combination of difference-in-difference and FE approaches was utilized on data on industrial effluent, SO_2, and smoke emissions. The authors found that environmental courts and environmental justice efforts could help reduce emissions and help achieve the turnaround point of the EKC in the cities. However, an inverted N-shaped relationship was validated in the models of industrial effluent, SO_2, and smoke emissions. Thus, the EKC was not corroborated.

Table 6. EKC testing using industrial/sectoral data from China.

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Ren et al. [155]	*China Economic Review*	2000–2010	18 industrial sectors	GMM	CO_2	Yes
Zhang et al. [156]	*Journal of Environmental Economics and Management*	2004–2014	Chinese-listed heavily polluted companies	FE, difference-in-difference (DID)	Industrial effluent, SO_2, smoke emissions	No
Zhu et al. [157]	*The Chinese Economy*	1993–2011	35 industrial sectors	FE	misallocation index	No

Table 6. *Cont.*

Authors	Journal	Time Sample	Area	Technique	Pollution Proxy	The EKC Is Validated or Not
Zhang et al. [158]	*Energy Economics*	2012–2016	Household consumption data	The difference in mean decomposition	Household CO_2 emissions	Yes
Shahzad et al. [159]	*International Journal of Finance and Economics*	1990–2018	Industrial data from 621 firms	Binomial regression modeling, Pearson correlation	Radical innovation	Yes in the relationship between pollution proxy and FMD
Wang et al. [160]	*Environment, Development and Sustainability*	2014–2018 Monthly	Chinese stock market	Multilinear regression model	Air quality index	Yes
Sun et al. [161]	*Environment, Development and Sustainability*	2003–2016	Industrial data from all provinces of China	Spatial models	CO_2	Yes

Zhu et al. [157] examined 35 industrial sectors in China and covered the period of 1993–2011 for the panel data analysis. Although the analysis was not directly about the EKC, the outcomes did inform the EKC in the industrial sector in China. For instance, the results showed that more technology-oriented industries had a higher chance of resource misallocation. This idea contradicted the EKC hypothesis that a shift in the production factor from less to more efficient industries occurred, which would essentially require appropriate resource allocation. These results contradicted the underlying argument of the EKC that with more income and investment in industry, countries could lower their emission rates due to technical advancement and performance efficiency. Zhang et al. [158] used data from 2012 to 2016 for a household survey in China and used the difference-in-difference approach to test the EKC between household CO_2 emissions and income. The EKC was corroborated, and the results showed that household lifestyle changes could play a significant role in shaping the EKC. Shahzad et al. [159] examined the EKC by using data from 621 firms from 1990 to 2018 and validated the EKC in the relationship between debt financing and radical innovations. Wang et al. [160] used monthly data from the Chinese stock market over the period of 2014–2018 to test the impact of the stock market and investor sentiments on air quality and validated the EKC. Sun et al. [161] examined the industrial CO_2 emissions data from all provinces in China from 2003 to 2016 by using spatial techniques and validated the EKC in the service industry. To reduce emissions even more, they suggested ensuring technological advancement on a progressive level.

4. Summary of the Validity of the EKC in China

We have reviewed a total of 117 empirical studies that have tested the EKC hypothesis in China. Some of the studies investigated both global and local pollution proxies in their analyses. Moreover, some studies performed analyses of more than one local pollution proxy. Table 7 shows the summary of the EKC studies using global and local pollution proxies. In total, 64 studies investigated the EKC by using global pollution proxies and 54 studies corroborated the EKC hypothesis in China. Nevertheless, 10 studies could not validate the EKC using global pollution proxies. Thus, 84.38% of the sample studies using a global pollution proxy validated the EKC in China. In the case of local pollution proxies, 49 studies validated the EKC, and 19 studies could not validate the EKC. Hence, 72.06% of the sample studies using local pollution proxies substantiated the EKC in China. Surprisingly, the nonexistence of the EKC is more visible in the 19 studies using local pollution proxies (27.94%) compared with the 10 studies using global pollution proxies (15.62%). Conversely, Shafik and Bandyopadhyay [162] argued that increasing economic growth could achieve a better reduction in local pollution than in global pollution by adopting government environmental policies on the demand for cleaner air and water, and a cleaner overall environment. Considering this argument, the Chinese EKC literature has used more local pollution proxies compared with global pollution proxies. However, the results of our sample studies corroborate that global pollution proxies are found to be more helpful in validating the EKC in China compared with local pollution proxies.

Table 7. Validity of the EKC using global and local pollution proxies.

Pollution Proxy	The Validity of the EKC	Number of Studies	Percentage
Global	Yes	54	84.38%
	No	10	15.62%
Local	Yes	49	72.06%
	No	19	27.94%

Table 8 displays the studies using different sample areas. Using aggregate country data, 20 studies validated the EKC in China, and 8 studies did not validate the EKC. Moreover, 12 studies corroborated the EKC by using a panel dataset of different countries including China in analyses. Using data from Chinese provinces, 35 studies validated the EKC. However, four studies did not validate the EKC, and five studies found mixed evidence for the presence or absence of the EKC using different pollution proxies. Using data from a single province/region, three studies validated the EKC. However, two studies did not validate the EKC, and two other studies reported mixed evidence of the existence and nonexistence of the EKC by using different pollution proxies. Using Chinese cities' data, 17 studies corroborated the EKC. However, one study did not find the EKC, and another reported mixed evidence of the presence or absence of the EKC. Using industrial/sectoral data, five studies corroborated the EKC, and two studies could not validate the EKC. Overall, 92 studies corroborated the EKC hypothesis in China and 17 studies could not validate the EKC hypothesis. Moreover, eight studies found mixed evidence by using different pollution proxies.

Table 8. Validity of the EKC using different sample areas.

Sample Area	The Validity of the EKC	Number of Studies	Percentage
Aggregate China	Yes	20	71.43%
	No	8	28.57%
	Mix of Yes and No	0	0%
A panel including China	Yes	12	100%
	No	0	0%
	Mix of Yes and No	0	0%
A panel of Chinese provinces	Yes	35	79.55%
	No	4	9.09%
	Mix of Yes and No	5	11.36%
Single province or region	Yes	3	42.86%
	No	2	28.57%
	Mix of Yes and No	2	28.57%
A panel of Chinese cities	Yes	17	89.48%
	No	1	5.26%
	Mix of Yes and No	1	5.26%
Chinese industries or sectors	Yes	5	71.43%
	No	2	28.57%
	Mix of Yes and No	0	0%
Total studies	Yes	92	78.63%
	No	17	14.43%
	Mix of Yes and No	8	6.84%

Table 7 shows that the existence or nonexistence of the EKC depends on local and global pollution proxies. Furthermore, Table 8 shows that the area samples may also matter for the validity of the EKC. For instance, the validity of the EKC is more consistent in the studies using provincial or city-level data. Therefore, the disaggregated provincial and city-level data are found helpful in validating the EKC in China. Based on these findings, we hypothesize that disaggregated data and global pollution proxies may help in achieving the validity of the EKC. To test these hypotheses, we applied logistic regression, and the results are presented in Table 9. The dependent variable shows the validity of the EKC. It carries a value of 1 if the EKC is corroborated and a value of 0 otherwise. If a study shows mixed findings on the existence or nonexistence of the EKC, then we divided this study into two observations in our sample. The global pollution proxy variable carries 1 if a study uses a global pollution proxy to test the EKC and 0 otherwise. If a study has used both global and local pollution proxies, then we divided this study into two observations. The disaggregated data variable carries a value of 1 if a study uses Chinese provincial, city, industrial, or sectoral data and a value of 0 otherwise.

Table 9. Logistic regression.

	Dependent Variable: The EKC Is Validated			
Independent Variables	**Coefficient**	**Standard Error**	**z-Value**	***p*-Value**
Global pollution proxy	1.6267	0.7388	2.2018	0.028
Disaggregated data	1.4949	0.6935	2.1556	0.031
Intercept	0.2064	0.6396	0.3227	0.747

The results of logistic regression show the positive coefficients of both hypothesized independent variables. Thus, using both global pollution proxies and disaggregated Chinese data helps to validate the EKC. If an empirical study uses a global pollution proxy, then the chance of the existence of the EKC is 5.08 times ($e^{1.6267}$) higher than the chance of the nonexistence of the EKC. Furthermore, if an empirical study uses Chinese provincial, city, industrial, or sectoral data, then the chance of the existence of the EKC is 4.46 times ($e^{1.4949}$) higher than the chance of the nonexistence of the EKC.

5. Conclusions

China is the largest pollution emitter economy in the world and its macroeconomic performance could cause further environmental concerns for the globe and the country itself. Considering this argument, much of the literature has tested the EKC hypothesis in China by using aggregate national data, provincial data, city-level data, and industrial/sectoral data. Moreover, different pollution proxies have been utilized, such as industrial and aggregate SO_2, industrial effluent, household and aggregate CO_2, CO_2 intensity, GHG, NOx, PM2.5, PM10, ecological footprint, wastewater, waste gas, solid waste, soot and suspended particulates, particulate concentration, dust fall, water pollution, forest cover, industrial wastewater, VOC, coal consumption, gas consumption, aggregate energy consumption, energy intensity, marine pollution, AN, COD, sewerage, sewage water, green economic efficiency, the air pollution index, smoke emissions, and the misallocation index. We reviewed the EKC empirical literature in China and found that 92 out of 117 studies found the existence of the EKC hypothesis in China. However, 17 studies could not validate the EKC hypothesis, and 8 studies reported mixed evidence of the presence or absence of the EKC by using different pollution proxies. In the comparison of pollution proxies, 54 out of 64 studies validated the EKC using a global pollution proxy. However, 10 studies could not validate the EKC using a global pollution proxy. Moreover, 49 out of 68 studies validated the EKC by using local pollution proxies, and 19 studies could not validate the EKC using a local pollution proxy. Theoretically, economic growth and environmental policies could achieve a better result in reducing local pollution compared with global pollution. However, global pollution proxies are found to be more helpful in validating the EKC hypothesis in China than local pollution proxies. In the area samples, we found that 20 out of 28 studies confirmed the EKC in China by using aggregate national data, and 8 studies could not validate the EKC. Moreover, 12 studies provided evidence of the EKC in the panel of countries including China in the analyses. In the analyses of Chinese provincial data, 35 out of 44 studies confirmed the EKC and 4 studies did not validate the EKC. Moreover, five studies reported mixed evidence of the existence or nonexistence of the EKC by using different pollution proxies. Three out of seven studies validated the EKC in the analysis of a single province/region in China, two studies could not find the EKC, and two studies reported mixed evidence of the presence or absence of the EKC by using different pollution proxies. In the analyses of city-level data, 17 out of 19 studies confirmed the EKC, 1 study could not find the EKC, and another study reported mixed evidence. In the industrial/sectoral analyses, five studies confirmed the EKC and two studies could not find the EKC. In comparison, the studies using panel data of Chinese provinces and cities show a higher proportion of the validity of the EKC compared with the studies using aggregate national data. Therefore, the use of disaggregated data is found more helpful in validating the EKC than the use of aggregate national data. In addition, some studies using disaggregated data found mixed evidence of the presence or absence of the EKC by using different pollution proxies. Thus, the importance of different pollution proxies in validating the EKC is again highlighted in the studies by using disaggregated data.

On the whole, we may conclude that a higher proportion of empirical studies have validated the EKC in China as opposed to suggesting the absence of the EKC. However, the findings of the studies are mixed in terms of the validation of the EKC due to using different pollution proxies and due to using aggregated or disaggregated data. The EKC is validated comparatively more in studies using global pollution proxies than those using local pollution proxies. In the area sample, evidence of the validity of the EKC is found more often in studies using provincial or city-level data compared with studies using aggregate national data. Thus, disaggregated data and global pollution proxies are found helpful in establishing the EKC in the relationship between pollution and economic performance. Furthermore, we applied logistic regression to empirically test the effects of using global pollution proxies and disaggregated data on the validity of the EKC in China. Our results corroborate that the chance of the existence of the EKC is 5.08 times higher than that of the absence of the EKC if an empirical study used a global pollution proxy. In addition, the chance of the existence of the EKC is 4.46 times higher than that of the absence of the EKC if an empirical study used Chinese provincial, city, industrial, or sectoral data.

The present study has reviewed the EKC studies in the largest polluter country, China, in this research. However, future research may review the literature on other top polluters in the world. Moreover, future studies may also focus on a region with a group of countries that carry a significant proportion of the emissions on the globe. In addition, we could not find any Chinese study investigating the effect of migration on emissions in the EKC model. Thus, a future empirical study may also include migration in the EKC model.

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References

1. Tisdell, C. Globalisation and sustainability: Environmental Kuznets curve and the WTO. *Ecol. Econ.* **2001**, *39*, 185–196. [CrossRef]
2. Global Carbon Atlas. 2022. Available online: http://www.globalcarbonatlas.org/en/CO2-emissions (accessed on 25 December 2022).
3. World Bank. The World Development Indicators. 2022. Available online: https://databank.worldbank.org/source/world-development-indicators (accessed on 25 December 2022).
4. BP. BP Statistical Review of World Energy 2022. Available online: https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/xlsx/energy-economics/statistical-review/bp-stats-review-2022-all-data.xlsx (accessed on 25 December 2022).
5. Pasten, R.; Figueroa, E. The environmental Kuznets curve: A survey of the theoretical literature. *Int. Rev. Environ. Resour. Econ.* **2012**, *6*, 195–224. [CrossRef]
6. Dinda, S. Environmental Kuznets curve hypothesis: A survey. *Ecol. Econom.* **2004**, *49*, 431–455. [CrossRef]
7. Shahbaz, M.; Sinha, A. Environmental Kuznets curve for CO_2 emissions: A literature survey. *J. Econ. Stud.* **2019**, *46*, 106–168. [CrossRef]
8. Saqib, M.; Benhmad, F. Updated meta-analysis of environmental Kuznets curve: Where do we stand? *Environ. Impact Assess. Rev.* **2021**, *86*, 106503. [CrossRef]
9. Bashir, M.F.; Ma, B.; Bashir, M.A.; Shahzad, L. Scientific data-driven evaluation of academic publications on environmental Kuznets curve. *Environ. Sci. Pollut. Res.* **2021**, *28*, 16982–16999. [CrossRef] [PubMed]
10. Naveed, A.; Ahmad, N.; Aghdam, R.F.; Menegaki, A.N. What have we learned from Environmental Kuznets Curve hypothesis? A citation-based systematic literature review and content analysis. *Energy Strategy Rev.* **2022**, *44*, 100946. [CrossRef]
11. Koondhar, M.A.; Shahbaz, M.; Memon, K.A.; Ozturk, I.; Kong, R. A visualization review analysis of the last two decades for environmental Kuznets curve "EKC" based on co-citation analysis theory and pathfinder network scaling algorithms. *Environ. Sci. Pollut. Res.* **2021**, *28*, 16690–16706. [CrossRef]
12. Sarkodie, S.A.; Strezov, V. A review on environmental Kuznets curve hypothesis using bibliometric and meta-analysis. *Sci. Total Environ.* **2019**, *649*, 128–145. [CrossRef]
13. Miah, M.D.; Masum, M.F.H.; Koike, M.; Akther, S. A review of the environmental Kuznets curve hypothesis for deforestation policy in Bangladesh. *iForest-Biogeosci. For.* **2011**, *4*, 16. [CrossRef]
14. AlKhars, M.A.; Alwahaishi, S.; Fallatah, M.R.; Kayal, A. A literature review of the Environmental Kuznets Curve in GCC for 2010–2020. *Environ. Sustain. Indic.* **2022**, *14*, 100181. [CrossRef]
15. Grossman, G.M.; Krueger, A.B. *Environmental Impacts of the North American Free Trade Agreement*; Working paper 3914; NBER: Cambridge, MA, USA, 1991.
16. Panayotou, T. *Empirical Tests and Policy Analysis of Environmental Degradation at Different Stages of Economic Development*, *ILO*; Technology and Employment Programme: Geneva, Switzerland, 1993.
17. Kuznets, P.; Simon, P. Economic growth and income inequality. *Am. Econ. Rev.* **1955**, *45*, 1–28.
18. Sadik-Zada, E.R.; Gatto, A. Grow First, Clean Up Later? Dropping Old Paradigms and Opening Up New Horizons of Sustainable Development. *Sustainability* **2023**, *15*, 3595. [CrossRef]
19. Dasgupta, S.; Laplante, B.; Wang, H.; Wheeler, D. Confronting the Environmental Kuznets Curve. *J. Econ. Perspect.* **2022**, *16*, 147–168. [CrossRef]
20. Selden, T.; Song, D. 1994. Environmental quality and development: Is there a Kuznets Curve for air pollution emissions? *J. Environ. Econ. Manag.* **1994**, *27*, 147–162. [CrossRef]
21. Arrow, K.; Bolin, B.; Costanza, R.; Folke, C.; Holling, C.S.; Janson, B.; Levin, S.; Maler, K.; Perrings, C.; Pimental, D. Economic growth, carrying capacity, and the environment. *Science* **1995**, *15*, 91–95.
22. Komen, R.; Gerking, S.; Folmer, H. Income and environmental R&D: Empirical evidence from OECD countries. *Environ. Dev. Econ.* **1997**, *2*, 505–515.
23. Bai, C.; Du, K.; Yu, Y.; Feng, C. 2019. Understanding the trend of total factor carbon productivity in the world: Insights from convergence analysis. *Energy Econ.* **2019**, *81*, 698–708. [CrossRef]
24. Sadik-Zada, E.R.; Gatto, A. The puzzle of greenhouse gas footprints of oil abundance. *Socio-Econ. Plan. Sci.* **2021**, *75*, 100936. [CrossRef]
25. Verma, S.; Kandpal, D. Green economy and sustainable development: A macroeconomic perspective. In *Environmental Sustainability and Economy*; Elsevier: Amsterdam, The Netherlands, 2021; pp. 325–343.
26. Lindmark, M. An EKC-pattern in historical perspective: Carbon dioxide emissions, technology, fuel prices and growth in Sweden 1870–1997. *Ecol. Econ.* **2002**, *42*, 333–347. [CrossRef]
27. Murphy, R. The emerging hyper carbon reality, technological and post-carbon utopias, and social innovation to low-carbon societies. *Curr. Sociol.* **2015**, *63*, 317–338. [CrossRef]
28. Smulder, S.; Bretschger, L. *Explaining Environmental Kuznets Curves: How Pollution Induces Policy and New Technologies*; Center for Economic Research working paper No. 2000-95, Tilburg University: Tilburg, The Netherlands, 2000.
29. Mahmood, H.; Maalel, N.; Zarrad, O. Trade Openness and CO_2 Emissions: Evidence from Tunisia. *Sustainability* **2019**, *11*, 3295. [CrossRef]
30. Jaffe, A.; Peterson, S.; Portney, P.; Stavins, R. Environmental regulation and the competitiveness of U.S. manufacturing: What does the evidence tell us? *J. Econ. Lit.* **1995**, *33*, 132–163.

31. Copeland, B.R.; Taylor, M.S. Trade and environment: A partial synthesis. *Am. J. Agric. Econ.* **1995**, *77*, 765–771. [CrossRef]
32. Revesz, R.L. Rehabilitating interstate competition: Rethinking the "race-to-the-bottom". Rationale for federal environmental regulation. *N. Y. Univ. Law Rev.* **1992**, *67*, 1210.
33. Agras, J.; Chapman, D. A dynamic approach to the Environmental Kuznets Curve hypothesis. *Ecol. Econ.* **1999**, *28*, 267–277. [CrossRef]
34. Suri, V.; Chapman, D. Economic growth, trade and the environment: Implications for the environmental Kuznets curve. *Ecol. Econ.* **1998**, *25*, 195–208. [CrossRef]
35. Rock, M.T. Pollution intensity of GDP and trade policy: Can the World Bank be wrong? *World Dev.* **1996**, *24*, 471–479. [CrossRef]
36. Antweiler, W.; Copeland, B.R.; Taylor, M.S. Is free trade good for the environment? *Am. Econ. Rev.* **2001**, *91*, 877–908. [CrossRef]
37. Pargal, S.; Wheeler, D. Informal regulation of industrial pollution in developing countries: Evidence from Indonesia. *J. Political Econ.* **1996**, *104*, 1314–1327. [CrossRef]
38. Lopez, R.; Mitra, S. Corruption, pollution, and the Kuznets environment curve. *J. Environ. Econ. Manag.* **2000**, *40*, 137–150. [CrossRef]
39. Reppelin-Hill, V. Trade and environment: An empirical analysis of the technology effect in the steel industry. *J. Environ. Econ. Manag.* **1999**, *38*, 283–301. [CrossRef]
40. Zhang, Y.J. The impact of financial development on carbon emissions: An empirical analysis in China. *Energy Policy* **2011**, *39*, 2197–2203. [CrossRef]
41. Tamazian, A.; Chousa, J.P.; Vadlamannati, K.C. Does higher economic and financial development lead to environmental degradation: Evidence from BRIC countries. *Energy Policy* **2009**, *37*, 246–253. [CrossRef]
42. Frankel, J.A.; Romer, D. Does trade cause growth? *Am. Econ. Rev.* **1999**, *89*, 379–399. [CrossRef]
43. Gawande, K.; Bohara, A.K.; Berrens, R.P.; Wang, P. Internal migration and the Environmental Kuznets Curve for U.S. hazardous waste sites. *Ecol. Econ.* **2000**, *33*, 151–166. [CrossRef]
44. Lucas, R.E.B.; Wheeler, D.; Hettige, H. Economic development, environmental regulation and the international migration of toxic industrial pollution: 1960–1988. In *International Trade and the Environment*; Low, P., Ed.; World Bank discussion paper 159; World Bank Publications: Washington, DC, USA, 1992; pp. 67–87.
45. Yaguchi, Y.; Sonobe, T.; Otsuka, K. Beyond the environmental Kuznets curve: A comparative study of SO_2 and CO_2 emissions between Japan and China. *Environ. Dev. Econ.* **2007**, *12*, 445–470. [CrossRef]
46. Halkos, G.E.; Tzeremes, N.G. Growth and environmental pollution: Empirical evidence from China. *J. Chin. Econ. Foreign Trade Stud.* **2011**, *4*, 144–157. [CrossRef]
47. Jalil, A.; Feridun, M. The impact of growth, energy and financial development on the environment in China: A cointegration analysis. *Energy Econ.* **2011**, *33*, 284–291. [CrossRef]
48. Guo, L. CO_2 emissions and regional income disparity: Evidence from China. *Singap. Econ. Rev.* **2014**, *59*, 1450007. [CrossRef]
49. Zhang, J. Environmental Kuznets curve hypothesis on CO2 emissions: Evidence for China. *J. Risk Financ. Manag.* **2021**, *14*, 93. [CrossRef]
50. Sarkodie, S.A.; Strezov, V. Empirical study of the environmental Kuznets curve and environmental sustainability curve hypothesis for Australia, China, Ghana and USA. *J. Clean. Prod.* **2018**, *201*, 98–110. [CrossRef]
51. Onafowora, O.A.; Owoye, O. Bounds testing approach to analysis of the environment Kuznets curve hypothesis. *Energy Econ.* **2014**, *44*, 47–62. [CrossRef]
52. Pal, D.; Mitra, S.K. The environmental Kuznets curve for carbon dioxide in India and China: Growth and pollution at crossroad. *J. Policy Model.* **2017**, *39*, 371–385. [CrossRef]
53. Moriwaki, S. Sustainable Development in Four East Asian Countries' Agricultural Sectors Post-World War II: Measuring Nutrient Balance and Estimating the Environmental Kuznets Curve. *Asia Pac. Policy Stud.* **2017**, *4*, 467–483. [CrossRef]
54. Shahbaz, M.; Khan, S.; Ali, A.; Bhattacharya, M. The impact of globalization on CO_2 emissions in China. *The Singapore Economic Review* **2017**, *62*, 929–957. [CrossRef]
55. Dogan, N. The impact of agriculture on CO_2 emissions in China. *Panoeconomicus* **2019**, *66*, 257–271. [CrossRef]
56. Mesagan, E.P.; Isola, W.A.; Ajide, K.B. The capital investment channel of environmental improvement: Evidence from BRICS. *Environ. Dev. Sustain.* **2019**, *21*, 1561–1582. [CrossRef]
57. Gessesse, A.T.; He, G. Analysis of carbon dioxide emissions, energy consumption, and economic growth in China. *Agric. Econ.* **2020**, *66*, 183–192. [CrossRef]
58. Farhani, S.; Balsalobre-Lorente, D. Comparing the role of coal to other energy resources in the environmental Kuznets curve of three large economies. *Chin. Econ.* **2020**, *53*, 82–120. [CrossRef]
59. Shahbaz, M.; Shafiullah, M.; Khalid, U.; Song, M. A nonparametric analysis of energy environmental Kuznets Curve in Chinese Provinces. *Energy Econ.* **2020**, *89*, 104814. [CrossRef]
60. Bozoklu, S.; Demir, A.O.; Ataer, S. Reassessing the environmental Kuznets curve: A summability approach for emerging market economies. *Eurasian Econ. Rev.* **2020**, *10*, 513–531. [CrossRef]
61. Hussain, M.; Mahmood, N.; Chen, F.; Khan, Z.; Usman, M. Comparative re-estimation of environmental degradation and population density in China: Evidence from the Maki's regime shift approach. *J. World Econ.* **2021**, *58*, 29–50. [CrossRef]
62. Bese, E. The effect of external debt on emissions: Evidence from China. *Int. J. Energy Econ. Policy* **2021**, *11*, 440–447. [CrossRef]

63. Pata, U.K.; Isik, C. Determinants of the load capacity factor in China: A novel dynamic ARDL approach for ecological footprint accounting. *Resour. Policy* **2021**, *74*, 102313. [CrossRef]
64. Zhu, S.; Luo, Y.; Aziz, N.; Jamal, A.; Zhang, Q. Environmental impact of the tourism industry in China: Analyses based on multiple environmental factors using novel Quantile Autoregressive Distributed Lag model. *Econ. Res.-Ekon. Istraživanja* **2021**, *35*, 3663–3689. [CrossRef]
65. Jin, C.; Razzaq, A.; Saleem, F.; Sinha, A. Asymmetric effects of eco-innovation and human capital development in realizing environmental sustainability in China: Evidence from quantile ARDL framework. *Econ. Res.-Ekon. Istraživanja* **2021**, *35*, 4947–4970. [CrossRef]
66. Liu, S.; Li, C.; Aziz, N.; Raza, A. Dynamic nexus between transportation, economic growth and environmental degradation in China: Fresh insights from the QARDL approach. *Econ. Res.-Ekon. Istraživanja* **2022**. [CrossRef]
67. Kongkuah, M.; Yao, H.; Yilanci, V. The relationship between energy consumption, economic growth, and CO_2 emissions in China: The role of urbanisation and international trade. *Environ. Dev. Sustain.* **2022**, *24*, 4684–4708. [CrossRef]
68. Hao, Y.; Cho, H.C. Research on the relationship between urban public infrastructure, CO_2 emission and economic growth in China. *Environ. Dev. Sustain.* **2022**, *24*, 7361–7376. [CrossRef]
69. Han, Y.; Liu, Y.; Liu, X. Decoupling Re-analysis of CO_2 Emissions and Economic Growth from Two Dimensions. *Front. Energy Res.* **2022**, *10*, 896529. [CrossRef]
70. Aminata, J.; Nugroho, S.B.M.; Atmanti, H.D.; Agustin, E.S.A.S.; Wibowo, A.; Smida, A. Economic growth, population, and policy strategies: Its effects on CO_2 emissions. *Int. J. Energy Econ. Policy* **2022**, *12*, 67–71. [CrossRef]
71. Hussain, M.; Wang, W.; Wang, Y. Natural resources, consumer prices and financial development in China: Measures to control carbon emissions and ecological footprints. *Resour. Policy* **2022**, *78*, 102880. [CrossRef]
72. Chen, H.; Rehman, M.A.; Luo, J.; Ali, M. Dynamic influence of natural resources, financial integration and eco-innovation on ecological sustainability in EKC framework: Fresh insights from China. *Resour. Policy* **2022**, *79*, 103043. [CrossRef]
73. Abdouli, M.; Kamoun, O.; Hamdi, B. The impact of economic growth, population density, and FDI inflows on CO_2 emissions in BRICTS countries: Does the Kuznets curve exist? *Empir. Econ.* **2018**, *54*, 1717–1742. [CrossRef]
74. Jiang, L.; He, S.; Zhong, Z.; Zhou, H.; He, L. Revisiting environmental Kuznets curve for carbon dioxide emissions: The role of trade. *Struct. Chang. Econ. Dyn.* **2019**, *50*, 245–257. [CrossRef]
75. Baloch, M.A.; Wang, B. Analyzing the role of governance in CO_2 emissions mitigation: The BRICS experience. *Struct. Chang. Econ. Dyn.* **2019**, *51*, 119–125.
76. Sahu, S.K.; Kamboj, S. Decomposition analysis of GHG emissions in emerging economies. *J. Econ. Dev.* **2019**, *44*, 20–26.
77. Mahmood, H.; Furqan, M.; Bagais, O.A. Environmental accounting of financial development and foreign investment: Spatial analyses of East Asia. *Sustainability* **2019**, *11*, 13. [CrossRef]
78. Ehigiamusoe, K.U. The drivers of environmental degradation in ASEAN+ China: Do financial development and urbanization have any moderating effect? *Singap. Econ. Rev.* **2020**. [CrossRef]
79. Awolusi, O.D.; Mbonigaba, J. Economic growth and environmental sustainability within the BRICS countries: A comparative analysis. *Int. J. Green Econ.* **2020**, *14*, 207–246. [CrossRef]
80. He, P.; Ya, Q.; Chengfeng, L.; Yuan, Y.; Xiao, C. Nexus between environmental tax, economic growth, energy consumption, and carbon dioxide emissions: Evidence from china, Finland, and Malaysia based on a Panel-ARDL approach. *Emerg. Mark. Financ. Trade* **2021**, *57*, 698–712. [CrossRef]
81. Zhang, H.; Razzaq, A.; Pelit, I.; Irmak, E. Does freight and passenger transportation industries are sustainable in BRICS countries? Evidence from advance panel estimations. *Econ. Res.-Ekon. Istraživanja* **2021**, *35*, 3690–3710. [CrossRef]
82. Adebayo, T.S.; Onifade, S.T.; Alola, A.A.; Muoneke, O.B. Does it take international integration of natural resources to ascend the ladder of environmental quality in the newly industrialized countries? *Resour. Policy* **2022**, *76*, 102616. [CrossRef]
83. Thio, E.; Tan, M.; Li, L.; Salman, M.; Long, X.; Sun, H.; Zhu, B. The estimation of influencing factors for carbon emissions based on EKC hypothesis and STIRPAT model: Evidence from top 10 countries. *Environ. Dev. Sustain.* **2022**, *24*, 11226–11259. [CrossRef]
84. Gyamfi, B.A.; Ampomah, A.B.; Bekun, F.V.; Asongu, S.A. Can information and communication technology and institutional quality help mitigate climate change in E7 economies? An environmental Kuznets curve extension. *J. Econ. Struct.* **2022**, *11*, 14. [CrossRef]
85. Dean, J.M. Does trade liberalization harm the environment? A new test. *Can. J. Econ.* **2002**, *35*, 819–842. [CrossRef]
86. De Groot, H.L.; Withagen, C.A.; Minliang, Z. Dynamics of China's regional development and pollution: An investigation into the Environmental Kuznets Curve. *Environ. Dev. Econ.* **2004**, *9*, 507–537. [CrossRef]
87. Poon, J.P.; Casas, I.; He, C. The impact of energy, transport, and trade on air pollution in China. *Eurasian Geogr. Econ.* **2006**, *47*, 568–584. [CrossRef]
88. Shen, J. A simultaneous estimation of environmental Kuznets curve: Evidence from China. *China Econ. Rev.* **2006**, *17*, 383–394. [CrossRef]
89. Wang, S.; Liu, C.; Wilson, B. Is China in a later stage of a U-shaped forest resource curve? A re-examination of empirical evidence. *For. Policy Econ.* **2007**, *10*, 1–6. [CrossRef]
90. Auffhammer, M.; Carson, R.T. Forecasting the path of China's CO_2 emissions using province-level information. *J. Environ. Econ. Manag.* **2008**, *55*, 229–247. [CrossRef]

91. Song, T.; Zheng, T.; Tong, L. An empirical test of the environmental Kuznets curve in China: A panel cointegration approach. *China Econ. Rev.* **2008**, *19*, 381–392. [CrossRef]
92. Jiang, Y.; Lin, T.; Zhuang, J. Environmental Kuznets Curves in the People's Republic of China: Turning points and regional differences. *SSRN Electron. J.* **2011**, *141*, 21252. [CrossRef]
93. Song, M.L.; Zhang, W.; Wang, S.H. Inflection point of environmental Kuznets curve in Mainland China. *Energy Policy* **2013**, *57*, 14–20. [CrossRef]
94. He, J. China's industrial SO_2 emissions and its economic determinants: EKC's reduced vs. structural model and the role of international trade. *Environ. Dev. Econ.* **2009**, *14*, 227–262. [CrossRef]
95. He, J. What is the role of openness for China's aggregate industrial SO_2 emission?: A structural analysis based on the Divisia decomposition method. *Ecol. Econ.* **2010**, *69*, 868–886. [CrossRef]
96. Taguchi, H.; Murofushi, H. Evidence on the interjurisdictional competition for polluted industries within China. *Environ. Dev. Econ.* **2010**, *15*, 363–378. [CrossRef]
97. Du, W. Empirical Study on Unbalanced Development of Regional Environmental Economy in China. *Asian Soc. Sci.* **2011**, *7*, 12–19. [CrossRef]
98. Jayanthakumaran, K.; Liu, Y. Openness and the environmental Kuznets curve: Evidence from China. *Econ. Model.* **2012**, *29*, 566–576. [CrossRef]
99. Jiang, L.; Folmer, H.; Ji, M. The drivers of energy intensity in China: A spatial panel data approach. *China Econ. Rev.* **2014**, *31*, 351–360. [CrossRef]
100. Yang, H.; He, J.; Chen, S. The fragility of the Environmental Kuznets Curve: Revisiting the hypothesis with Chinese data via an "Extreme Bound Analysis". *Ecol. Econ.* **2015**, *109*, 41–58. [CrossRef]
101. Chen, L.; Chen, S. The estimation of environmental Kuznets curve in China: Nonparametric panel approach. *Comput. Econ.* **2015**, *46*, 405–420. [CrossRef]
102. Lee, S.; Oh, D.W. Economic growth and the environment in China: Empirical evidence using prefecture level data. *China Econ. Rev.* **2015**, *36*, 73–85. [CrossRef]
103. Shostya, A. Ambient air pollution in China: Predicting a turning point. *Int. Adv. Econ. Res.* **2016**, *22*, 295–307. [CrossRef]
104. Guilhot, L.; Meunié, A.; Pouyanne, G. Growth, urban transition, and atmospheric pollution in China. *Mondes Dév.* **2017**, *45*, 53–68. [CrossRef]
105. Shimizu, M. Pollution abatement efforts: A regional analysis of the Chinese industrial sector. *J. Chin. Econ. Bus. Stud.* **2017**, *15*, 103–125. [CrossRef]
106. Liao, X.; Dogan, E.; Baek, J. Does corruption matter for the environment? Panel evidence from China. *Economics* **2017**, *11*, 1–12. [CrossRef]
107. Xu, H.; Zhang, C.; Li, W.; Zhang, W.; Yin, H. Economic growth and carbon emission in China: A spatial econometric Kuznets curve? *Zb. Rad. Ekon. Fak. U Rijeci Časopis Za Ekon. Teor. I Praksu* **2018**, *36*, 11–28. [CrossRef]
108. Dong, F.; Bian, Z.; Yu, B.; Wang, Y.; Zhang, S.; Li, J.; Su, B.; Long, R. Can land urbanization help to achieve CO_2 intensity reduction target or hinder it? Evidence from China. *Resour. Conserv. Recycl.* **2018**, *134*, 206–215. [CrossRef]
109. Cohen, G.; Jalles, J.T.; Loungani, P.; Marto, R.; Wang, G. Decoupling of emissions and GDP: Evidence from aggregate and provincial Chinese data. *Energy Econ.* **2019**, *77*, 105–118. [CrossRef]
110. Zeng, B.; Wu, T.; Guo, X. Interprovincial trade, economic development and the impact on air quality in China. *Resour. Conserv. Recycl.* **2019**, *142*, 204–214. [CrossRef]
111. Zhang, W.W.; Sharp, B.; Xu, S.C. Does economic growth and energy consumption drive environmental degradation in China's 31 provinces? New evidence from a spatial econometric perspective. *Appl. Econ.* **2019**, *51*, 4658–4671. [CrossRef]
112. Qiao, H.; Chen, S.; Dong, X.; Dong, K. Has China's coal consumption actually reached its peak? National and regional analysis considering cross-sectional dependence and heterogeneity. *Energy Econ.* **2019**, *84*, 104509. [CrossRef]
113. Wang, S.; Hua, G.; Li, C. Urbanization, air quality, and the panel threshold effect in China based on kernel density estimation. *Emerg. Mark. Financ. Trade* **2019**, *55*, 3575–3590. [CrossRef]
114. Zhao, J.; Jiang, Q.; Dong, X.; Dong, K. Would environmental regulation improve the greenhouse gas benefits of natural gas use? A Chinese case study. *Energy Econ.* **2020**, *87*, 104712. [CrossRef]
115. Jiang, H.; Dong, X.; Jiang, Q.; Dong, K. What drives China's natural gas consumption? Analysis of national and regional estimates. *Energy Econ.* **2020**, *87*, 104744. [CrossRef]
116. Hao, Y.; Chen, Y.F.; Liao, H.; Wei, Y.M. China's fiscal decentralization and environmental quality: Theory and an empirical study. *Environ. Dev. Econ.* **2020**, *25*, 159–181. [CrossRef]
117. Shahbaz, M.; Raghutla, C.; Song, M.; Zameer, H.; Jiao, Z. Public-private partnerships investment in energy as new determinant of CO_2 emissions: The role of technological innovations in China. *Energy Econ.* **2020**, *86*, 104664. [CrossRef]
118. Shao, Q. Nonlinear effects of marine economic growth and technological innovation on marine pollution: Panel threshold analysis for China's 11 coastal regions. *Mar. Policy* **2020**, *121*, 104110. [CrossRef]
119. Zhao, J.; Zhao, Z.; Zhang, H. The impact of growth, energy and financial development on environmental pollution in China: New evidence from a spatial econometric analysis. *Energy Econ.* **2021**, *93*, 104506. [CrossRef]
120. Bonnefond, C.; Clement, M.; Yan, H. Income inequality and environmental quality in China: A semi-parametric analysis applied to provincial panel data. *Post-Communist Econ.* **2021**, *33*, 541–565. [CrossRef]

121. Ahmad, F.; Draz, M.U.; Chang, W.Y.; Yang, S.C.; Su, L. More than the resource curse: Exploring the nexus of natural resource abundance and environmental quality in northwestern China. *Resour. Policy* **2021**, *70*, 101902. [CrossRef]
122. Wang, Y.; Liao, M.; Xu, L.; Malik, A. The impact of foreign direct investment on China's carbon emissions through energy intensity and emissions trading system. *Energy Econ.* **2021**, *97*, 105212. [CrossRef]
123. Hao, Y.; Gao, S.; Guo, Y.; Gai, Z.; Wu, H. Measuring the nexus between economic development and environmental quality based on environmental Kuznets curve: A comparative study between China and Germany for the period of 2000–2017. *Environ. Dev. Sustain.* **2021**, *23*, 16848–16873. [CrossRef]
124. Xu, B.; Zhong, R.; Liu, D.; Liu, Y. Investigating the impact of energy consumption and nitrogen fertilizer on NOx emissions in China based on the environmental Kuznets curve. *Environ. Dev. Sustain.* **2021**, *23*, 17590–17605. [CrossRef]
125. Cheng, M.; Yao, W. Trend Prediction of Carbon Peak in China's Animal Husbandry Based on the Empirical Analysis of 31 Provinces in China. *Environ. Dev. Sustain.* **2022**. [CrossRef]
126. Qu, F.; Xu, L.; Zheng, B. Directed Technical Change and Pollution Emission: Evidence From Fossil and Renewable Energy Technologies in China. *Front. Energy Res.* **2022**, *10*, 794104. [CrossRef]
127. Liu, X.; Liu, J.; Zhang, S. A regional analysis of the urbanization-energy-economy-emissions nexus in China: Based on the environmental Kuznets curve hypothesis. *Appl. Econ.* **2022**. [CrossRef]
128. Geng, Q.; Wang, Y.; Wang, X. The impact of natural resource endowment and green finance on green economic efficiency in the context of COP26. *Resour. Policy* **2023**, *80*, 103246. [CrossRef]
129. Liu, X.; Heilig, G.K.; Chen, J.; Heino, M. Interactions between economic growth and environmental quality in Shenzhen, China's first special economic zone. *Ecol. Econ.* **2007**, *62*, 559–570. [CrossRef]
130. Jia, J.; Deng, H.; Duan, J.; Zhao, J. Analysis of the major drivers of the ecological footprint using the STIRPAT model and the PLS method—A case study in Henan Province, China. *Ecol. Econ.* **2009**, *68*, 2818–2824. [CrossRef]
131. Zhao, H.; Uchida, E.; Deng, X.; Rozelle, S. Do trees grow with the economy? A spatial analysis of the determinants of forest cover change in Sichuan, China. *Environ. Resour. Econ.* **2011**, *50*, 61–82. [CrossRef]
132. Zhang, J.; Gangopadhyay, P. Dynamics of environmental quality and economic development: The regional experience from Yangtze River Delta of China. *Appl. Econ.* **2015**, *47*, 3113–3123. [CrossRef]
133. Li, N.; Kang, R.; Feng, C.; Wang, C.; Zhang, C. Energy structure, economic growth, and carbon emissions: Evidence from Shaanxi province of China (1990–2012). *Forum Sci. Oeconomia* **2017**, *5*, 79–93.
134. Agboola, M.O.; Alola, A.A. The energy mix-environmental aspects of income and economic freedom in Hong Kong: Cointegration and frequency domain causality evidence. *J. Environ. Econ. Policy* **2023**, *12*, 63–78. [CrossRef]
135. To, W.M.; LAM, K.H. Economic Growth, Energy Use, and Greenhouse Gases Emission in Macao SAR, China. *Chin. J. Urban Environ. Stud.* **2022**, *10*, 2250002. [CrossRef]
136. Brajer, V.; Mead, R.W.; Xiao, F. Health benefits of tunneling through the Chinese environmental Kuznets curve (EKC). *Ecol. Econ.* **2008**, *66*, 674–686. [CrossRef]
137. Shaw, D.; Pang, A.; Lin, C.C.; Hung, M.F. Economic growth and air quality in China. *Environ. Econ. Policy Stud.* **2010**, *12*, 79–96. [CrossRef]
138. Brajer, V.; Mead, R.W.; Xiao, F. Searching for an Environmental Kuznets Curve in China's air pollution. *China Econ. Rev.* **2011**, *22*, 383–397. [CrossRef]
139. He, J.; Wang, H. Economic structure, development policy and environmental quality: An empirical analysis of environmental Kuznets curves with Chinese municipal data. *Ecol. Econ.* **2012**, *76*, 49–59. [CrossRef]
140. He, C.; Zhang, T.; Rui, W. Air quality in urban China. *Eurasian Geogr. Econ.* **2012**, *53*, 750–771. [CrossRef]
141. Sun, P.; Yuan, Y. Industrial Agglomeration and Environmental Degradation: Empirical Evidence in Chinese Cities. *Pac. Econ. Rev.* **2015**, *20*, 544–568. [CrossRef]
142. Stern, D.I.; Zha, D. Economic growth and particulate pollution concentrations in China. *Environ. Econ. Policy Stud.* **2016**, *18*, 327–338. [CrossRef]
143. Jiang, Y.; Zheng, J. Economic growth or environmental sustainability? Drivers of pollution in the Yangtze River Delta urban agglomeration in China. *Emerg. Mark. Financ. Trade* **2017**, *53*, 2625–2643. [CrossRef]
144. Meng, L.; Huang, B. Shaping the relationship between economic development and carbon dioxide emissions at the local level: Evidence from spatial econometric models. *Environ. Resour. Econ.* **2018**, *71*, 127–156. [CrossRef]
145. Fang, Z.; Huang, B.; Yang, Z. Trade openness and the environmental Kuznets curve: Evidence from Chinese cities. *World Econ.* **2020**, *43*, 2622–2649. [CrossRef]
146. Zhang, Y. Free trade and the environment–evidence from Chinese cities. *Environ. Dev. Econ.* **2020**, *25*, 561–582. [CrossRef]
147. Wang, L.; Zhang, Q.; Wang, L.; Zhang, X. Air Pollution, Environmental Regulations and Economic Growth—Estimation of Simultaneous Equations Based on Panel Data of Prefecture-Level Cities. *J. Syst. Sci. Inf.* **2021**, *9*, 721–738. [CrossRef]
148. Song, Y.; Liu, D.; Wang, Q. Identifying characteristic changes in club convergence of China's urban pollution emission: A spatial-temporal feature analysis. *Energy Econ.* **2021**, *98*, 105243. [CrossRef]
149. Kang, W.; Liang, B.; Xia, K.; Xue, F.; Li, Y. Decoupling of Carbon Emissions from Economic Growth: An Empirical Analysis Based on 264 Prefecture-Level Cities in China. *Chin. J. Urban Environ. Stud.* **2021**, *9*, 2150017. [CrossRef]
150. Chang, H.Y.; Wang, W.; Yu, J. Revisiting the environmental Kuznets curve in China: A spatial dynamic panel data approach. *Energy Econ.* **2021**, *104*, 105600. [CrossRef]

151. Hu, H.; Paudel, K.P.; Tan, Y. Income, Policy, and Pollution. *Environ. Resour. Econ.* **2022**, *81*, 131–153. [CrossRef]
152. Yang, R.; Chen, Y.; Liu, Y.; Feng, Y.; Ji, J.; Wong, C.W.; Miao, X.; Tang, Y. Government–business relations, environmental information transparency, and Hu-line-related factors in China. *Environ. Dev. Sustain.* **2022**. [CrossRef]
153. Kahn, M.E.; Sun, W.; Zheng, S. Clean air as an experience good in urban China. *Ecol. Econ.* **2022**, *192*, 107254. [CrossRef]
154. Wu, S.; Zhang, H. The existence and mechanism of the domestic pollution haven hypothesis: Evidence from 265 cities in China. *Lett. Spat. Resour. Sci.* **2022**, *15*, 287–310. [CrossRef]
155. Ren, S.; Yuan, B.; Ma, X.; Chen, X. International trade, FDI (foreign direct investment) and embodied CO_2 emissions: A case study of Chinas industrial sectors. *China Econ. Rev.* **2014**, *28*, 123–134. [CrossRef]
156. Zhang, Q.; Yu, Z.; Kong, D. The real effect of legal institutions: Environmental courts and firm environmental protection expenditure. *J. Environ. Econ. Manag.* **2019**, *98*, 102254. [CrossRef]
157. Zhu, H.; Lou, D.; Song, S. Openness, Technology Spillovers, and Resource Misallocations: Evidence from China. *Chin. Econ.* **2019**, *52*, 427–448. [CrossRef]
158. Zhang, H.; Shi, X.; Wang, K.; Xue, J.; Song, L.; Sun, Y. Intertemporal lifestyle changes and carbon emissions: Evidence from a China household survey. *Energy Econ.* **2020**, *86*, 104655. [CrossRef]
159. Shahzad, U.; Luo, F.; Liu, J. Debt financing and technology investment Kuznets curve: Evidence from China. *Int. J. Financ. Econ.* **2021**, *28*, 751–765. [CrossRef]
160. Wang, S.; Yi, X.; Song, M. The interrelationship of air quality, investor sentiment, and stock market liquidity: A review of China. *Environ. Dev. Sustain.* **2022**. [CrossRef]
161. Sun, Y.; Qian, L.; Liu, Z. The carbon emissions level of China's service industry: An analysis of characteristics and influencing factors. *Environ Dev Sustain* **2022**, *24*, 13557–13582. [CrossRef]
162. Shafik, N.; Bandyopadhyay, S. *Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence*; World Bank Publications: Washington, DC, USA, 1992.