*sustainability*

MDPI

*Article*

# The Dynamic Simulation Analysis of the Impact of Urbanization and Globalization on Environmental Quality

**Ilhan Ozturk [1,2,3], Buket Savranlar [4], Alper Aslan [5], Usama Al-mulali [6,*] and Seyfettin Artan [7]**

[1] College of Business Administration, University of Sharjah, Sharjah 27272, United Arab Emirates; iozturk@sharjah.ac.ae
[2] Faculty of Economics, Administrative and Social Sciences, Nisantasi University, Istanbul 34100, Turkey
[3] Department of Medical Research, China Medical University Hospital, China Medical University, Taichung 40402, Taiwan
[4] Vocational School, Nisantasi University, İstanbul 34100, Turkey; buket.altinoz@nisantasi.edu.tr
[5] Faculty of Aeronautics and Astronautics, Erciyes University, Kayseri 38020, Turkey; alperaslan@erciyes.edu.tr
[6] Faculty of Business, Sohar University, Sohar 311, Oman
[7] Department of Economics, Faculty of Economics and Administrative Sciences, Karadeniz Technical University, Trabzon 61080, Turkey; artan@ktu.edu.tr
* Correspondence: umulali@su.edu.om

**Abstract:** This study aims to analyze the effect of urban population and economic globalization on air quality in Turkey for the period 1970–2017, including GDP and electricity consumption as control variables. This paper is the first attempt to apply the dynamic autoregressive-distributed lag (DARDL) approach to explore the association between carbon emissions, urbanization, economic globalization, GDP, and electricity consumption in Turkey. The analysis results suggested the existence of a cointegration relationship between all series in the long run. DARDL results revealed that while urbanization has a statistically significant effect on carbon emissions in the short or long run, economic globalization has a positive impact in the long run. That is, economic globalization increases carbon emissions by about 0.15 percent. Thus, it can be said that globalization is more critical than urbanization in terms of environmental costs. In addition, it was determined that GDP and electricity consumption increase carbon emissions in both the long and short run. Also, the response of $CO_2$ emissions to all shocks in the explanatories was determined. All future shocks of electricity consumption lead to no change in $CO_2$ emissions. The negative shocks of both urbanization and globalization decrease $CO_2$ emissions in the short run, but the response of $CO_2$ is stable in the long run. The effects of a shock in GDP are exactly the opposite.

**Keywords:** $CO_2$ emissions; urbanization; globalization; dynamic ARDL simulation; Turkey

check for updates

**Citation:** Ozturk, I.; Savranlar, B.; Aslan, A.; Al-mulali, U.; Artan, S. The Dynamic Simulation Analysis of the Impact of Urbanization and Globalization on Environmental Quality. *Sustainability* **2023**, *15*, 11764. https://doi.org/10.3390/su151511764

Academic Editor: Pallav Purohit

Received: 6 July 2023
Revised: 25 July 2023
Accepted: 27 July 2023
Published: 31 July 2023

**Copyright:** © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

## 1. Introduction

Environmental problems constitute one of the most important fields of struggle for many nations today. One of these problems can be described as the gradual deterioration of air quality. $CO_2$ emissions, which express the carbon released into the atmosphere, are an important air quality indicator, and the increasing $CO_2$ emissions due to many human activities lead to the atmospheric temperature reaching high levels that cause climate change. In line with this vital importance, studies on the causes of carbon emissions have a large place in the economic literature. The environmental Kuznets curve (EKC) hypothesis is one of the most studied hypotheses in this area. In addition to the studies conducted to test this hypothesis, which focus on the association between GDP and environmental destruction [1,2], various variables such as energy consumption [3–6], financial development [7,8], foreign direct investment [9–11], and urbanization [12–14] are included in the overtime.

Urbanization, which is defined as the population density in cities, is a demographic indicator. According to 2018 statistics from the United Nations, 55 percent of the global

population resides in urban areas, and this rate is expected to increase to 68 percent in 2050. In fact, urbanization can be perceived as the transition of individuals from rural areas to urban areas in order to improve economic and social conditions. It is a known fact that urbanization increases productivity, provides an economic opportunity advantage, increases income levels, and thus increases welfare [15]. However, the rapid production and consumption processes caused by urban life inevitably have environmental costs. There are many approaches that form the basis of the link between urbanization and environmental problems. First, it can be said that industrial establishments around cities that mostly use fossil fuels increase emissions. Secondly, due to the rapid urbanization rate, there may be problems with the infrastructure and sewerage system. In relation to this, a clean water shortage occurs. Thirdly, attempts to solve the settlement problems of the growing population result in the destruction of forest areas. Fourthly, using artificial ways to increase agricultural production to meet the food demand of the urban population makes the soil inefficient [16]. These are major problems brought about by urban life, and they are also important sources of an increase in carbon emissions.

Another issue that has been recently investigated for its connection to environmental issues is globalization. In the most general sense, globalization is the integration of countries around the world on economic, social, and political levels. Especially as a result of economic globalization, countries have started to shift their production to developing countries due to cheap labor and raw materials. Although this may seem to be an advantage in providing investment-saving equality for developing countries, it comes with environmental costs. Thus, globalization causes an increase in emissions with increased foreign trade and foreign investment [17]. This issue is also associated with income level. According to Shahbaz et al. [18], people with low incomes tend to compromise the environment to increase their consumption. However, as living standards increase, the importance given to the environment increases again. Therefore, it is not surprising that developing countries ignore the environmental costs of foreign investments to at least some degree.

It is known that developing countries are faced with intensive environmental problems due to their nature. In other words, it is quite possible that factors such as population growth, urbanization, and industrialization in these countries cause environmental problems [19]. Due to the rapid development process, Turkey faces some environmental problems. According to statistics, carbon emissions in Turkey, which were approximately 276 million metric tons in 2008, reached approximately 370 million metric tons in 2020. Therefore, while urbanization, energy consumption, and globalization developments in the development processes remain current in the context of sustainability, they also have critical importance for Turkey. The development that brought Turkey to the fore in this context was the adoption of an open growth target in economic policies in the 1980s. This new strategy is also considered a new stage in the urban development process. In the process of increasing liberalization and globalization after 1980, developments such as metropolitanization, internalization of cities, and the prominence of being a world city emerged in Turkey. At this point, the impact of globalization on the country's policies and the related shaping of the urbanization process emphasize the critical importance of Turkey in terms of both dynamics and bring up the study of its impact on the environmental conditions in the country.

This paper aims to explore the nexus between urban populations, economic globalization, and environmental pollution in Turkey. In this paper, the relationship between pollution and urbanization in Turkey is discussed for the first time in the context of globalization. There are many empirical studies examining the EKC hypothesis. Over time, it has been seen that urbanization is also commonly included in the models used in these studies. However, globalization is a newer factor in the EKC literature. Even so, the number of studies in which both urbanization and globalization are used as the main explanatory variables in the EKC model is quite limited. This gap identified in the literature is trying to be filled. Thus, an up-to-date contribution is made to the EKC literature. The continuation of Turkey's globalization and urbanization has increased the importance of this study. In

addition, considering the rapid development processes of urbanization and globalization in Turkey at similar times, revealing the environmental effects of these two dynamics comparatively constitutes the main contribution of this study. The process in question brings up intense energy consumption, especially in a developing country like Turkey. At this point, it is a fact that electricity consumption in Turkey increases every year. Since this increase is an important result of globalization and urbanization, it is inevitable that it should be included in the adopted model. Another contribution to the literature is the application of the dynamic autoregressive distributed lag (ARDL) simulations developed by Jordan and Philips [20]. This method eliminated the problems of the ARDL method developed by Pesaran et al. [21]. Therefore, the novelty of the dynamic ARDL approach, its ability to eliminate the traditional ARDL method, and its use for the first time in this study to investigate the environmental impact of urbanization, globalization, electricity consumption, and growth in Turkey can be considered a methodological contribution to the relevant literature.

This paper consists of five sections. The second part presents related literature. In the third section, the model, data set, and methodology are introduced. In the fourth section, findings are evaluated, and in the fifth section, the conclusion title is included.

## 2. Literature Review

In this section, selected up-to-five-year studies examining urbanization-$CO_2$ and globalization-$CO_2$ are presented under two titles.

### *2.1. Nexus between Urbanization and $CO_2$*

Li and Lin [22] studied 73 countries over the period 1971–2010. They found that urbanization causes an increase in pollution levels in low- and middle-income countries and in high- and low-income countries. The same relationship is found by Wang et al. [23] for China. Also, Quyang and Lin [24] found the same positive relationship between urbanization level and environmental pollution in both Japan and China for the period from 1978 to 2011. Liu and Bae [25] investigated the nexus between urbanization, industrialization, and pollution in China by using the ARDL testing approach. Empirical findings suggest that urbanization causes environmental pollution. This positive effect was found by Pata [12] for Turkey during 1974–2014. Wang et al. [26] tested the link among urbanization, income, energy consumption, and air pollution in 170 countries with different income levels. They revealed a statistically significant positive link between the variables. Ali et al. [27] explored the role of urbanization processes on emissions levels in Pakistan for the 1972–2014 data period. They used the ARDL boundary testing approach and found that urbanization enhances $CO_2$ emissions in both the long and short run. Bai et al. [28] reinvestigated the relationship in China using residential $CO_2$ emissions and revealed the positive impact. In addition, according to Wang et al. [29], urbanization enhances environmental pollution in APEC realms. Mahmood et al. [30] studied Saudi Arabia. Their study illustrated that urbanization has a positive impact on emissions. According to Rahman and Alam [31], in addition to population density and economic growth, urbanization also harms the environment in Bangladesh. Similarly, Sufyanullah et al. [32] revealed the positive link between urbanization and emissions in Pakistan.

Xu and Lin [33] analyzed the effect of industrialization and urbanization on air quality by using nonparametric additive regression models for Chinese provinces. They revealed that there is an inverted U-shaped relationship between urbanization and $CO_2$ in the eastern region, but there is a U-shaped relationship in the central region. Another study that found a U-shaped relationship among two variables was Shahbaz et al. [34]. They used the STIRPAT model for Malaysia. On the other hand, for Malaysia, an inverted U-shaped relationship between urbanization and $CO_2$ was confirmed by Bekhet and Othman [35]. An inverted U-shaped relationship was found by Zi et al. [36]. This study adopted a threshold analysis for China over the period of 1979–2013. Chen et al. [37] examined the effect of urbanization on $CO_2$ emissions and energy consumption using panel data

analysis for Chinese prefecture-level cities. Their results illustrated that there is an Inverted U-shaped relationship between these variables in the western region. Muhammad et al. [14] analyzed the effect of urbanization and international trade on emissions in 65 countries for the 2000–2016 data period. They suggested an inverted U-shaped relationship between urbanization and $CO_2$ in countries with high development levels. The same threshold effect between urbanization and pollution was obtained by Chen et al. [38] for China.

Although there is usually a positive or inverted U-shaped relationship between two variables, there are also studies with different results. One of these studies examining the relationship between urbanization and carbon dioxide emissions is Chikaraishi et al. [39]. Their findings suggested that the urbanization process in a country with a developed service sector and a high GDP per capita does not harm the environment. Ahmed et al. [40] analyzed whether urbanization has an impact on pollution in Indonesia using a threshold model, and they demonstrated that urbanization after a threshold level mitigates emissions. Li and Haneklaus [41] found a negative impact of urbanization on $CO_2$ emissions in G7 economies by using the panel ARDL approach. A different result was obtained by Xu et al. [42]. They used a current approach, the hybrid spatial model, to reveal the spatial spillover effects of urbanization on pollution. The results suggested that the spatial spread effect of urbanization on $CO_2$ emissions is negative and tends to increase first and decrease second.

### *2.2. Nexus between Globalization and $CO_2$*

The studies investigating the globalization-environment link are quite limited in the literature. However, it can be seen that focusing on trade openness in studies is a proxy for globalization. According to Shahbaz et al. [43], trade openness causes environmental destruction in high-, middle-, and low-income countries. A similar result was obtained by Shahzad et al. [44]. They explored the nexus between carbon emissions, energy consumption, trade openness, and financial development in Pakistan for the period from 1971 to 2011. They found that trade openness increased carbon emissions. Hasanov et al. [45] studied oil-exporting countries. They found that exports and imports cause an increase in consumption-based $CO_2$ emissions. Acheampong [46] considered both foreign direct investment and trade openness as proxies of globalization and reached the same results.

Unlike positive and statistically significant relationships, Mutascu [47] revealed the validity of the neutral hypothesis among trade openness and pollution in the short run. Haung and Ucal [48] suggested that exports reduce $CO_2$ emissions, but imports increase them. Also, Essandoh et al. [49] confirmed the negative long-run relationship between $CO_2$ and trade openness in developed countries with high income levels. Wasti and Zaidi [50] focused on the causal relationship between environmental pollution, energy consumption, trade liberalization, and economic growth in Kuwait. They found a unidirectional causality from $CO_2$ emissions to trade liberalization.

One of the few studies that literally investigates the globalization-$CO_2$ connection is You and Lv [51]. They used a spatial panel approach for 83 countries in the 1985–2013 data period and found that globalization positively affects environmental performance. Khan et al. [52] examined the effect of globalization, economic determinants, and energy consumption on air pollution in Pakistan using an economic, social, and political globalization index. Their results illustrated that all globalization indexes cause environmental pollution. Zhu and Jiang [53] investigated the globalization and global emissions nexus and concluded that globalization caused a net increase of 202 Mt. in global $CO_2$ emissions. Salahuddin et al. [17] analyzed the effect of both urbanization and globalization on $CO_2$ emissions in South Africa for the period from 1980 to 2017. They used the ARDL testing approach and found that urbanization increases $CO_2$ emissions in the short and long run, but globalization has a positive impact on emissions only in long run. Also, a positive relationship between globalization and emissions was found by Aslam et al. [54]. According to Liu et al. [13], there is an inverted U-shaped relationship between globalization and pollution. However, Farooq et al. [55] reached a different result. They analyzed

the globalization-environment nexus in 180 countries for the period from 1980 to 2016. Their findings support the existence of a positive impact of globalization on environmental quality. Danish et al. [56] tested the effects of nuclear energy and globalization on consumption-based and production-based $CO_2$ emissions in OECD countries and found the negative impact of globalization on both types of $CO_2$ emissions. Gaies et al. [57] studied MENA countries. Their study focused on 17 MENA countries over the 1980–2018 data period by using ARDL and NARDL models. The results of the analysis illustrated that globalization has a positive impact on emissions. The opposite result was obtained by Patel and Mehta [58]. They used the NARDL approach for India. Test results demonstrated that globalization reduces emissions.

## 3. Data and Methodology

This paper analyzes the link between urbanization, economic globalization, and environmental pollution in Turkey. We focused on annual data for the period from 1970 to 2017. Time period selection is based on data availability. Our model is inspired by Ali et al. [27], Ali et al. [16], Salahuddin et al. [17], and Farooq et al. [55], taking into consideration the following functions in the model:

$$\text{CO2} = \text{f(URB, GLOB, ELC, GDP,)} \tag{1}$$

$$\log_co2_t = \beta_0 + \beta_1 \log_urb_t + \beta_2 \log_glob_t + \beta_3 \log_elc_t + \beta_4 gdp_1 + \mu_t \tag{2}$$

where CO2 denotes $CO_2$ emissions (metric tons per capita) and is used as the dependent variable. Explanatory variables are electric power consumption (ELC), urban population growth (*URB*), GDP per capita with a constant 2010 USD (*GDP*), and the economic globalization index (*GLOB*). *GDP* and *ELC* are used as control variables. The globalization indicator is obtained from the KOF Swiss Economic Institute, and this variable is verified between 0 and 100. Other variables are obtained from the World Bank database. Since the logarithmic transformation is a tool for stabilizing the variance of the series [59], all variables are logarithmically analyzed.

The dynamic ARDL model is adopted in this paper. It is possible to list some important reasons for choosing the dynamic ARDL method. While the traditional ARDL approach reveals the short- and long-run dynamics, the dynamic ARDL method is more effective in revealing the actual changes in the dependent variable affected by the independent variables. Also, this approach graphically presents the effect of the shocks that each independent variable brings on the predicted value of the dependent variable. Moreover, since this approach is an algorithm that works with 5000 simulations, it gives reliable and robust results even if the sample is small.

The main equation is as follows [20]:

$$\begin{aligned}\Delta(y)_t = \alpha_0 + \theta_0(y)_{t-1} + \theta_1(x_1)_{t-1} + \ldots + \theta_k(x_k)_{t-1} + \sum_{i=1}^{p} \alpha_i \Delta(y)_{t-1} \\ + \sum_{j=0}^{q_1} \beta_{1j} \Delta(x_1)_{t-j} + \ldots + \sum_{j=0}^{q_k} \beta_{kj} \Delta(x_k)_{t-j} + \varepsilon_t\end{aligned} \tag{3}$$

where $y$ is the change in the dependent variable, which is $CO_2$ emissions, $\alpha_0$ is constant term, and $t-1$ displays the explanatory variables' maximum level of $p$, with lags $q_k$ in the difference operator with the error term ($\varepsilon$) in time $t$. Whether there is a cointegration relationship in the equation is determined by the F statistic. This statistical value is used to test the following null hypothesis:

$$H_0 = \theta_0 + \theta_1 + \ldots + \theta_k = 0 \tag{4}$$

To adopt the DARDL method, the series must be stationary in the first order. Phillips–Perron (PP), developed by Phillips and Perron [60], and Dickey–Fuller/GLS (DF-GLS),

developed by Elliott et al. [61], unit root tests are performed as preliminary tests for the method to be applied because stationarity of the series is an important prerequisite. The dynamic ARDL approach provides the opportunity to visually obtain the asymmetric effects of independent variables on the dependent variable. It clearly presents the effect of all shocks in the explanatory variables on the dependent variable. Based on the mathematical specification illustrated in Equation (4), the error correction model of the ARDL bounds test is implied as follows:

$$\begin{aligned}\Delta\log_co2_t = {} & \alpha_0\log_co2_{t-1} + \beta_1\Delta\log_urb_t + \theta_1\Delta\log_urb_{t-1} \\ & + \beta_2\Delta\log_glob_t + \theta_2\Delta\log_glob_{t-1} + \beta_3\Delta\log_elc_t \\ & + \theta_3\Delta\log_elc_{t-1} + \beta_4 gdp_t + \theta_4 gdp_{t-1}\end{aligned} \quad (5)$$

## 4. Empirical Results

To apply the dynamic ARDL method, the integration degree of the series is expected to be 1. Jordan and Phillips [20] emphasize that this criterion is a requirement for the dependent variable; they state that the integration degree of the other series should be at most 1. This study followed the test procedures in Jordan and Phillips [20], and therefore the Phillips–Perron and DF-GLS stationarity tests were applied. Related results are demonstrated in Table 1. Accordingly, the null hypothesis expressing stationarity is rejected for all variables, so the integration level of all variables is I(1).

**Table 1.** Stationarity test results.

| | **Phillips-Perron** | | **DF-GLS** | |
|---|---|---|---|---|
| **Series** | **q** | **q, t** | **Q** | **q, t** |
| log_co2 | −1.687696 | −0.843328 | −1.327961 | −1.208010 |
| log_urb | −1.288450 | −2.065490 | −1.162013 | −2.499231 |
| log_elc | −0.921240 | −0.852619 | −0.999016 | −1.256535 |
| log_gdp | 0.592277 | −1.922926 | 2.242819 | −1.937376 |
| log_glob | −1.122601 | −1.560529 | 0.257211 | −1.638771 |
| Δlog_co2 | −6.760997 * | −7.149062 * | −6.569985 * | −7.273851 * |
| Δlog_urb | −4.546972 * | −4.493285 * | −8.086175 * | −8.303381 * |
| Δlog_elc | −6.718319 * | −7.134450 * | −6.733743 * | −7.162171 * |
| Δlog_gdp | −6.596940 * | −6.749892 * | −6.389240 * | −6.562759 * |
| Δlog_glob | −7.148520 * | −7.113523 * | −6.985939 * | −6.960389 * |

* denotes 1% statistical significance level. q, and q and t are deterministic components. q implies model with intercept, q and t implies model with intercept and trend.

It is a fact that the series satisfy the proposed condition for stationarity. So, it is possible to test for cointegration via dynamic ARDL simulations. Before the cointegration test, it is investigated whether there is an econometric problem in the model. For this, both autocorrelation and varying variance problems are investigated, and it is decided that there is no problem. Cointegration and coefficient estimation results are summarized in Table 2. Firstly, cointegration results indicated that both F-statistic and t-statistic values are statistically significant at the 5% significance level. After detecting the existence of a cointegration relationship between variables in the long run, both short- and long-run coefficient estimation results are examined. The urbanization coefficient, which is one of the main independent variables, is positive in the long run. However, this positive impact is statistically insignificant. Many studies, such as Li and Lin [22], Wang et al. [23], Pata [12], Ali et al. [16], Rahman and Alam [31], and Sufyanullah et al. [32], argue that urbanization causes carbon emissions. Our result is incompatible with current literature. While globalization does not have a significant effect on carbon emissions in the short run, it

increases $CO_2$ emissions in the long run. Although the results differ from the literature, they are actually quite reasonable in the Turkish sample. In other words, globalization in Turkey may be considered a concept that has been affecting the country, especially for the last half century. Therefore, the effects of globalization have spread rapidly in the field in terms of both economic activities and lifestyle. This rapid transformation process inevitably has environmental impacts. In this process, it would be right to consider urbanization as well. On the other hand, it should not be forgotten that the urbanization process in Turkey is also shaped around the axis of globalization. It is possible to observe the effects of this global transformation in all areas, from the lifestyle of households in cities to economic activities.

**Table 2.** Dynamic ARDL results (dependent variable: Δlog_co2).

| **ARDL Bound Test Results** | | | | | | |
|---|---|---|---|---|---|---|
| | **10%** | | **5%** | | **1%** | |
| | **I(0)** | **I(1)** | **I(0)** | **I(1)** | **I(0)** | **I(1)** |
| F-stat: 4.780 ** | 2.61 | 3.74 | 3.13 | 4.41 | 4.30 | 5.87 |
| t-stat: −4.410 ** | −2.57 | −3.66 | −2.86 | −3.99 | −3.43 | −4.60 |
| Dynamic Stimulated ARDL Results | | | | | | |
| Variables | Coefficient | | | Standard Error | | |
| L.log_co2 | 4.382615 * | | | 1.27291 | | |
| Δlog_urb | −0.812678 | | | 0.502797 | | |
| L.log_urb | 0.138707 | | | 0.229853 | | |
| Δlog_elc | 1.935034 * | | | 0.042653 | | |
| L.log_elc | 1.116431 * | | | 0.253822 | | |
| Δlog_gdp | 5.920043 * | | | 1.112318 | | |
| L.log_gdp | 2.429281 * | | | 0.693777 | | |
| Δlog_glob | 1.315638 | | | 0.983954 | | |
| L.log_glob | 1.489802 * | | | 0.502131 | | |
| constant | −1.282251 * | | | 3.182778 | | |
| Obs. | 47 | | | | | |
| R2 | 0.99 | | | | | |
| sims | 5000 | | | | | |
| Prob > F | 0.0000 * | | | | | |
| Diagnostic tests | Chi-square[Prob.] | | | | | |
| Breusch-Godfrey Serial Correlation LM Test | 0.048[0.8274] | | | | | |
| Heteroskedasticity Test: Breusch-Pagan-Godfrey | 0.41[0.5232] | | | | | |

* and ** denotes 1% and 5% statistical significance level; Sims implies the number of simulations.

The results obtained regarding the effects of globalization are compatible with Khan et al. [52], Zhu and Jiang [53], and incompatible with Liu et al. [13]. In addition, the results showed that globalization, like Salahuddin [17]'s results, increased emissions only in the long run, but unlike Salahuddin [17], urbanization has an impact in neither the long nor short run. GDP and electric consumption included in the model as control variables cause an increase in emissions both in the short and long run, and the positive effect of GDP is greater than that of electricity consumption. All results considered together, the existence of a case against Turkey's environmental performance draws attention. While the results regarding GDP and electrical energy consumption are not different than expected, the effect

of globalization on environmental quality is remarkable. In particular, it is understood that the prevention of the environmental costs of economic globalization should not be ignored in possible policies. On the other hand, the fact that a statistically significant effect of urbanization could not be detected does not mean that this factor should be neglected. The fact that a positive coefficient has been obtained in the long run emphasizes that the urbanization rate is also a potential threat to the environment in Turkey.

Figures 1–4 contain a visualization of the negative and positive shocks of urbanization, electrical consumption, GDP, and economic globalization on emissions. Figure 1 implies how future negative and positive shocks in urban populations will have an impact on carbon dioxide emissions. In other words, a negative shock to urbanization decreases pollution, while a positive shock increases it. Although the meaningless effect of urbanization on pollution is observed from the results in Table 2, it is a fact that the rapid continuation of the urbanization process poses an environmental risk for Turkey in the future. However, a reverse urbanization shock results in an equally positive environmental externality. The same effects are true for economic globalization. Therefore, Turkey is likely to face an environmental disadvantage due to the factors of urbanization and globalization, which are components of the development process. The effects of a shock in GDP are exactly the opposite. Also, all future shocks of electrical consumption lead to no change in air pollution.

It is clearly understood from the results obtained that Turkey's adoption of an outwardly open economic policy has an environmental cost. Therefore, it is possible to talk about an environment in which globalization causes polluting factors to be ignored, especially in production processes. It is a fact that this negative environmental impact is also a result of the urbanization process, which is almost a complement to globalization. These effects become more meaningful in graphs showing future shocks. Therefore, the direct production and trade-oriented approach in the industry and the application of traditional production methods instead of new technologies make these effects inevitable. In addition, the realization of urbanization in this industrialization axis causes urban life to include environmental neglect in terms of both households and all economic activities.

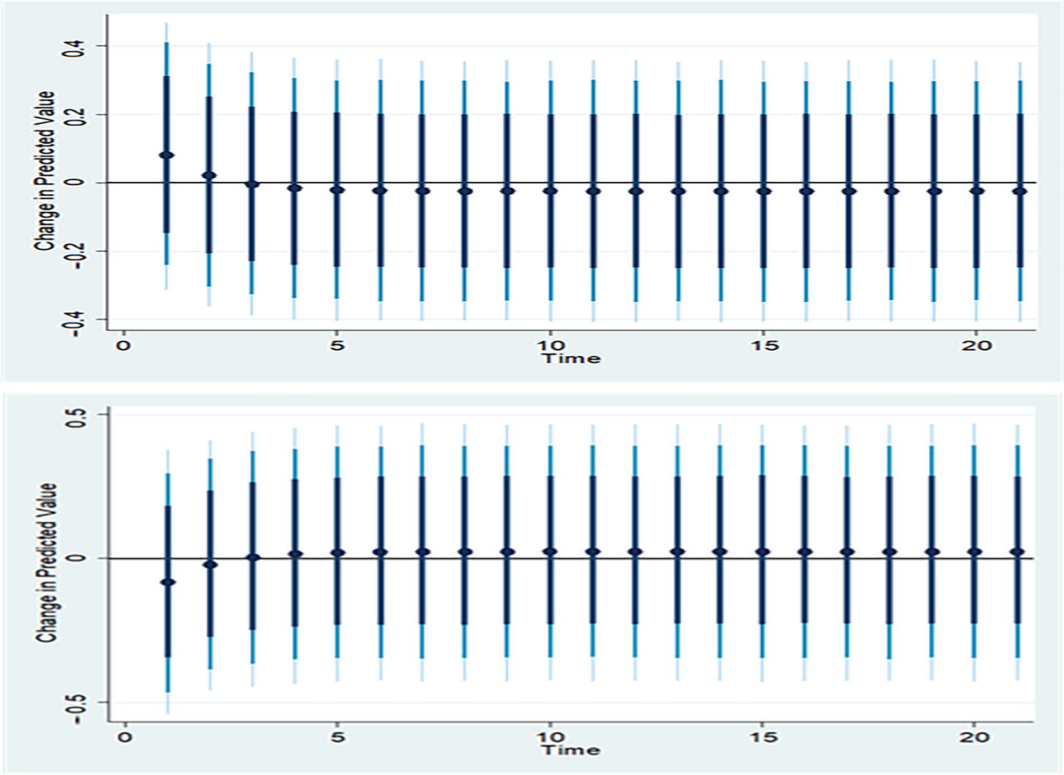



**Figure 1.** (−/+1%) changes in predicted urbanization on $CO_2$ emissions.

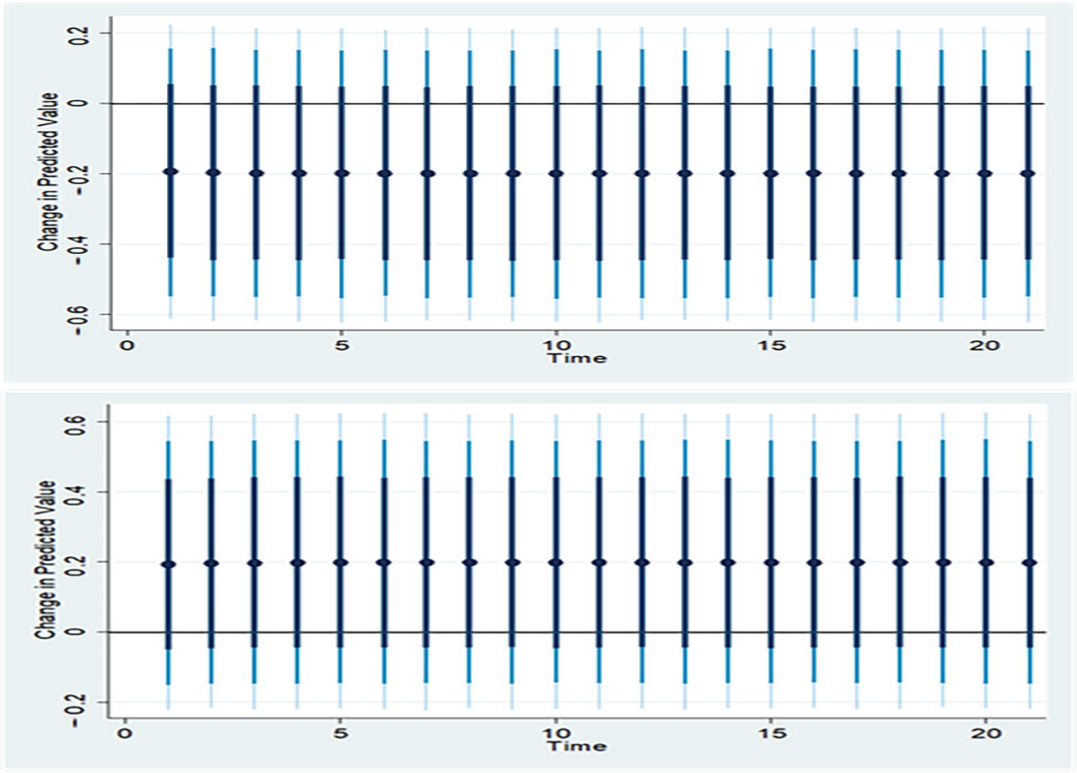



**Figure 2.** (−/+1%) changes in predicted electrical consumption on $CO_2$ emissions.

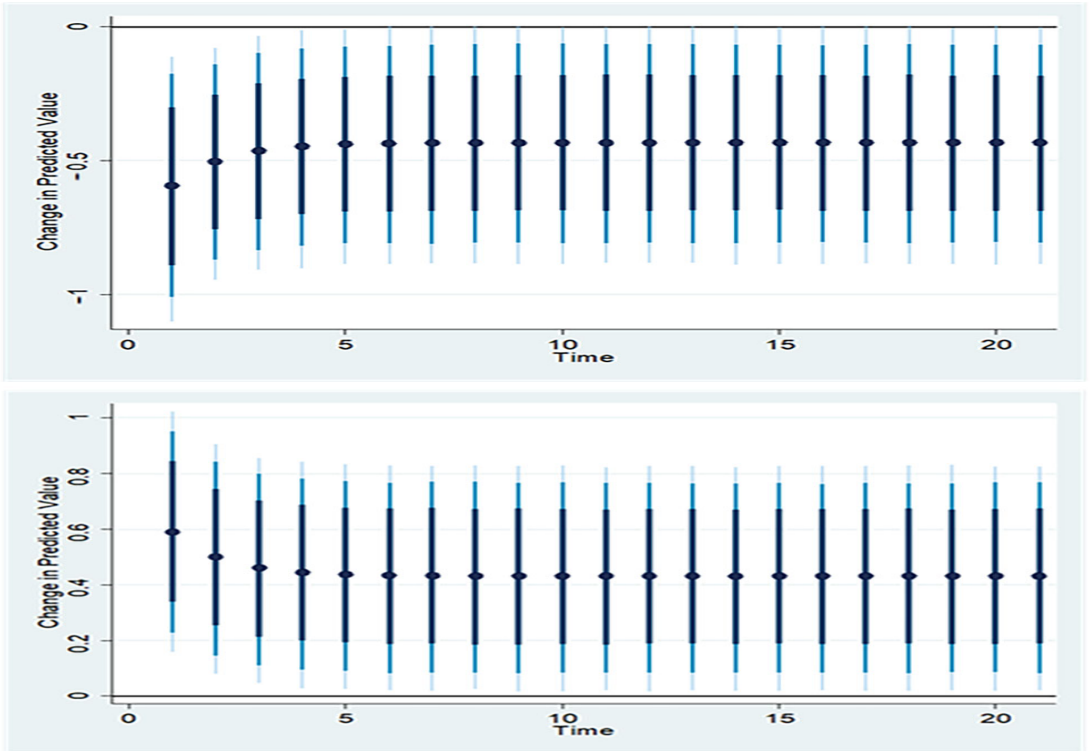



**Figure 3.** (−/+1%) changes in predicted Gross Domestic product on $CO_2$ emissions.

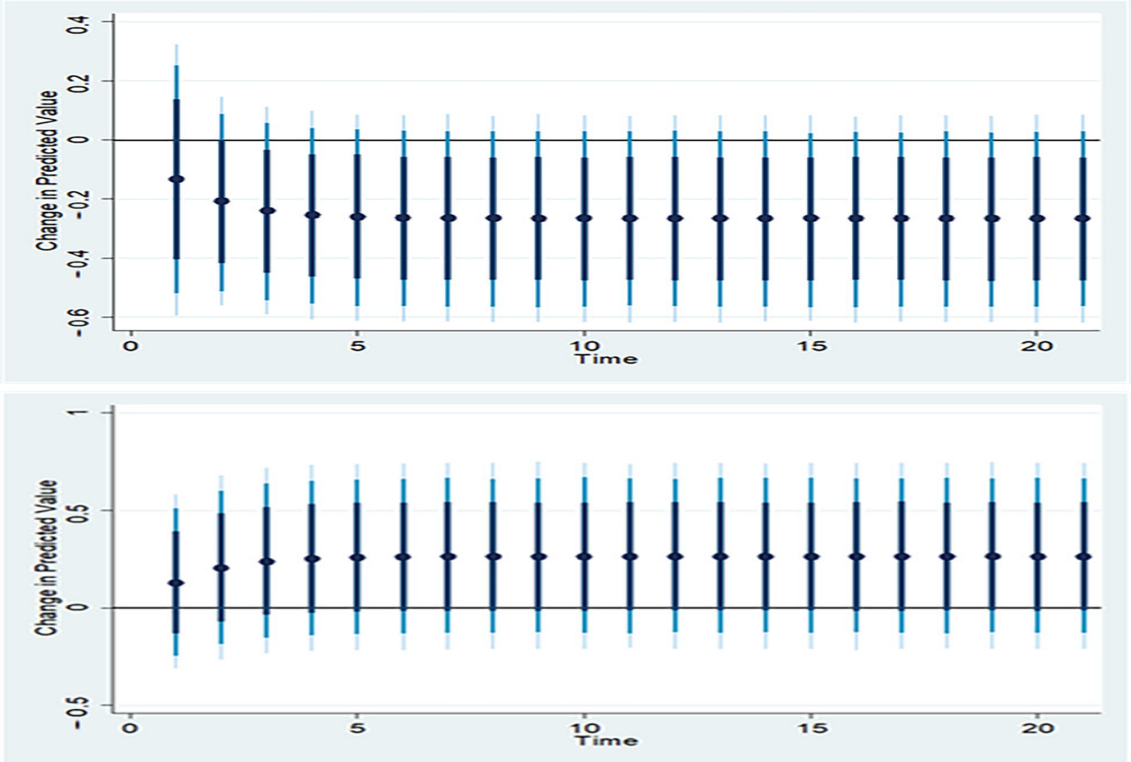



**Figure 4.** (−/+1%) changes in predicted economic globalization index on $CO_2$ emissions.

## 5. Conclusions and Policy Implications

In this study, we focus on the rapid urbanization and globalization processes in Turkey and the environmental impact of these processes. According to the Turkish Statistical Office, the urban population, which was 18.5% in 1950, reached 25.2% in 1960, 35.7% in 1970, 53.6% in 1985, and 56.3% in 1990. Between 1980 and 1990, the population living in urban areas exceeded 33 million. Between 1990 and 2000, the ratio of the urban population to the general population reached 65%, and the population living in urban areas approached 45 million. The rate of people living in urban areas was 74.4% in 2017. In addition, Turkey is exposed largely to the effects of globalization because this country is located at the intersection of east-west and north-south and is in the center of Eurasia. This geopolitical location prevents it from isolating itself from developments in the world. Hence, both urbanization and globalization in terms of Turkey's status imply that environmental sustainability cannot be independent of these factors.

While the results show that urbanization does not have a significant effect on $CO_2$, it has been confirmed that globalization increases pollution in the long run. Also, GDP and electricity consumption increase pollution, both in the short and long run. The results are a guide for the potential economic and environmental policies to be implemented in Turkey. Firstly, it can be said that there are problems with the sustainability of economic growth. Accordingly, it is understood that economic growth is the primary goal in line with the development level of the country, and environmental quality is ignored for this purpose. Therefore, environmentally friendly policies should be rapidly implemented in production processes. With various institutional arrangements, an incentive structure should be created for companies that tend to use renewable energy sources in production and do not harm the environment. In addition, an appropriate sanction and incentive system should be developed for production facilities established through foreign direct investment. Considering the emission-increasing effect of electricity consumption, it is another policy to save energy in production. At the same time, it is essential to use environmentally friendly technologies as much as possible in electricity generation to reduce the emissions caused by electricity consumption. Because of increasing urban life, it is almost impossible to limit

electricity consumption. Although no statistically significant results can be obtained, the rate of urbanization is an enemy for the environment. The fact that the coefficient of the variable is positive in the long run is also a hint at this. However, at least in the period under consideration, this emission-increasing effect of urbanization has not been observed. As the source of the optimism, it can be said that with urbanization, the enrollment rate increases, environmental awareness is created, and there is an opportunity to follow the developments in the world more closely. Therefore, despite all the disadvantages, capturing the sociocultural quality of urban life also serves to combat climate change.

The increasing role of economic globalization on pollution levels is one of the main problems that need to be focused on. Globalization has caused a rapid production and consumption process in all countries. As a result of this process, while resources are used for today's needs, future generations are compromised. Economic globalization is influenced, in particular, by trade and multinational companies in Turkey. In this context, some environmental sanctions that multinational companies will be subject to should be renewed continuously by policy makers, and an audit mechanism should be established.

This study may be an inspiration for future work. This paper may be based on a new model with different globalization and energy consumption data. With the newly developed methods, it may open new horizons for the climate change problem discussed in the literature.

**Author Contributions:** Conceptualization, I.O. and A.A.; methodology, B.S.; software, B.S.; validation, I.O., U.A.-m. and A.A.; formal analysis, B.S.; investigation, U.A.-m.; resources, A.A.; data curation, A.A.; writing—original draft preparation, A.A.; writing—review and editing, S.A.; visualization, I.O. and U.A.-m.; supervision, I.O., U.A.-m. and A.A.; project administration, I.O.; funding acquisition, I.O. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data is accessible from the corresponding author upon request.

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

## References

1. Grossman, G.; Kreuger, A. *Environmental Impacts of a North American Free Trade Agreement*; Working Paper 1991, No. 3; NBER: Cambridge, MA, USA, 1991.
2. Suri, V.; Chapman, D. Economic Growth, Trade and Energy: Implications for the Environmental Kuznets Curve. *Ecol. Econ.* **1988**, *25*, 195–208. [CrossRef]
3. Payne, J.E. Survey of the International Evidence on the Causal Relationship Between Energy Consumption and Growth. *J. Econ. Stud.* **2010**, *37*, 53–95. [CrossRef]
4. Wang, S.S.; Zhou, D.Q.; Zhou, P.; Wang, Q.W. $CO_2$ Emissions, Energy Consumption and Economic Growth in China: A Panel Data Analysis. *Energy Policy* **2011**, *39*, 4870–4875. [CrossRef]
5. Jebli, M.B.; Youssef, S.B.; Ozturk, I. Testing environmental Kuznets curve hypothesis: The role of renewable and non-renewable energy consumption and trade in OECD countries. *Ecol. Indic.* **2016**, *60*, 824–831. [CrossRef]
6. Munir, Q.; Lean, H.H.; Smyth, R. $CO_2$ emissions, energy consumption and economic growth in the ASEAN-5 countries: A cross-sectional dependence approach. *Energy Econ.* **2020**, *85*, 104571. [CrossRef]
7. 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]
8. Abokyi, E.; Appiah-Konadu, P.; Abokyi, F.; Oteng-Abayie, E.F. Industrial growth and emissions of $CO_2$ in Ghana: The role of financial development and fossil fuel consumption. *Energy Rep.* **2019**, *5*, 1339–1353. [CrossRef]
9. Hanif, I.; Raza, S.M.F.; Gago-de-Santos, P.; Abbas, Q. Fossil fuels, foreign direct investment, and economic growth have triggered $CO_2$ emissions in emerging Asian economies: Some empirical evidence. *Energy* **2019**, *171*, 493–501. [CrossRef]
10. Nasir, M.A.; Huynh, T.L.D.; Tram, H.T.X. Role of financial development, economic growth & foreign direct investment in driving climate change: A case of emerging ASEAN. *J. Environ. Manag.* **2019**, *242*, 131–141.
11. Xie, Q.; Wang, X.; Cong, X. How does foreign direct investment affect $CO_2$ emissions in emerging countries: New findings from a nonlinear panel analysis. *J. Clean. Prod.* **2020**, *249*, 119422. [CrossRef]

12. Pata, U.K. Renewable energy consumption, urbanization, financial development, income and $CO_2$ emissions in Turkey: Testing EKC hypothesis with structural breaks. *J. Clean. Prod.* **2018**, *187*, 770–779. [CrossRef]
13. Liu, X.; Sun, T.; Feng, Q. Dynamic spillover effect of urbanization on environmental pollution in China considering the inertia characteristics of environmental pollution. *Sustain. Cities Soc.* **2020**, *53*, 101903. [CrossRef]
14. Muhammad, S.; Long, X.; Salman, M.; Dauda, L. Effect of urbanization and international trade on $CO_2$ emissions across 65 belt and road initiative countries. *Energy* **2020**, *196*, 117102. [CrossRef]
15. Barido, D.P.L.; Marshall, J.D. Relationship between urbanization and $CO_2$ emissions depends on income level and policy. *Environ. Sci. Technol.* **2014**, *48*, 3632–3639. [CrossRef]
16. Ali, R.; Bakhsh, K.; Yasin, M.A. Impact of urbanization on $CO_2$ emissions in emerging economy: Evidence from Pakistan. *Sustain. Cities Soc.* **2019**, *48*, 101553. [CrossRef]
17. Salahuddin, M.; Gow, J.; Ali, M.I.; Hossain, M.R.; Al-Azami, K.S.; Akbar, D.; Gedikli, A. Urbanization-globalization-$CO_2$ emissions nexus revisited: Empirical evidence from South Africa. *Heliyon* **2019**, *5*, e01974. [CrossRef]
18. Shahbaz, M.; Khan, S.; Ali, A.; Bhattacharya, M. *The Impact of Globalization on $CO_2$ Emissions in China*; MPRA: Munich, Germany, 2015.
19. Bowonder, B. Environmental problems in developing countries. *Prog. Phys. Geogr. Earth Environ.* **1987**, *11*, 246–259. [CrossRef]
20. Jordan, S.; Philips, A.Q. Cointegration testing and dynamic simulations of autoregressive distributed lag models. *Stata J.* **2018**, *18*, 902–923. [CrossRef]
21. Pesaran, N.H.; Shin, Y.; Smith, R.J. Bounds testing approaches to the analysis of level relationships. *J. Appl. Econom.* **2001**, *16*, 289–326. [CrossRef]
22. Li, K.; Lin, B. Impacts of urbanization and industrialization on energy consumption/$CO_2$ emissions: Does the level of development matter? *Renew. Sustain. Energy Rev.* **2015**, *52*, 1107–1122. [CrossRef]
23. Wang, Q.; Wu, S.; Zeng, Y.; Wu, B. Exploring the relationship between urbanization, energy consumption and $CO_2$ emissions in different provinces of China. *Renew. Sustain. Energy Rev.* **2016**, *54*, 1563–1579. [CrossRef]
24. Ouyang, X.; Lin, B. Carbon dioxide ($CO_2$) emissions during urbanization: A comparative study between China and Japan. *J. Clean. Prod.* **2017**, *143*, 356–368. [CrossRef]
25. Liu, X.; Bae, J. Urbanization and industrialization impact of $CO_2$ emissions in China. *J. Clean. Prod.* **2018**, *172*, 178–186. [CrossRef]
26. Wang, S.; Li, G.; Fang, C. Urbanization, economic growth, energy consumption, and $CO_2$ emissions: Empirical evidence from countries with different income levels. *Renew. Sustain. Energy Rev.* **2018**, *81*, 2144–2159. [CrossRef]
27. Ali, H.S.; Abdul-Rahim, A.S.; Ribadu, M.B. Urbanization and carbon dioxide emissions in Singapore: Evidence from the ARDL approach. *Environ. Sci. Pollut. Res.* **2017**, *24*, 1967–1974. [CrossRef]
28. Bai, Y.; Deng, X.; Gibson, J.; Zhao, Z.; Xu, H. How does urbanization affect residential $CO_2$ emissions? An analysis on urban agglomerations of China. *J. Clean. Prod.* **2019**, *209*, 876–885. [CrossRef]
29. Wang, Z.; Rasool, Y.; Zhang, B.; Ahmed, Z.; Wang, B. Dynamic linkage among industrialization, urbanisation, and $CO_2$ emissions in APEC realms: Evidence based on DSUR estimation. *Struct. Chang. Econ. Dyn.* **2020**, *52*, 382–389. [CrossRef]
30. Mahmood, H.; Alkhateeb, T.T.Y.; Furqan, M. Industrialization, urbanization and $CO_2$ emissions in Saudi Arabia: Asymmetry analysis. *Energy Rep.* **2020**, *6*, 1553–1560. [CrossRef]
31. Rahman, M.M.; Alam, K. Clean energy, population density, urbanization and environmental pollution nexus: Evidence from Bangladesh. *Renew. Energy* **2021**, *172*, 1063–1072. [CrossRef]
32. Sufyanullah, K.; Ahmad, K.A.; Ali, M.A.S. Does emission of carbon dioxide is impacted by urbanization? An empirical study of urbanization, energy consumption, economic growth and carbon emissions—Using ARDL bound testing approach. *Energy Policy* **2022**, *164*, 112908. [CrossRef]
33. Xu, B.; Lin, B. How industrialization and urbanization process impact on $CO_2$ emissions in China: Evidence from nonparametric additive regression models. *Energy Econ.* **2015**, *48*, 188–202. [CrossRef]
34. Shahbaz, M.; Loganathan, N.; Muzaffar, A.T.; Ahmed, K.; Jabran, M.A. How urbanization affects $CO_2$ emissions in Malaysia? The application of STIRPAT model. *Renew. Sustain. Energy Rev.* **2016**, *57*, 83–93. [CrossRef]
35. Bekhet, H.A.; Othman, N.S. Impact of urbanization growth on Malaysia $CO_2$ emissions: Evidence from the dynamic relationship. *J. Clean. Prod.* **2017**, *154*, 374–388. [CrossRef]
36. Zi, C.; Jie, W.; Hong-Bo, C. $CO_2$ emissions and urbanization correlation in China based on threshold analysis. *Ecol. Indic.* **2016**, *61*, 193–201. [CrossRef]
37. Chen, S.; Jin, H.; Lu, Y. Impact of urbanization on $CO_2$ emissions and energy consumption stracture: A panel data analysis for Chinese prefecture-level cities. *Struct. Chang. Econ. Dyn.* **2019**, *49*, 107–119. [CrossRef]
38. Chen, C.; Qin, Y.; Gao, Y. Does new urbanization affect $CO_2$ emissions in China: A spatial econometric analysis. *Sustain. Cities Soc.* **2023**, *96*, 104687. [CrossRef]
39. Chikaraishi, M.; Fujiwara, A.; Kaneko, S.; Poumanyvong, P.; Komatsu, S.; Kalugin, A. The moderating effects of urbanization on carbon dioxide emissions: A latent class modelling approach. *Technol. Forecast. Soc. Chang.* **2015**, *90*, 302–317. [CrossRef]
40. Ahmed, Z.; Wang, Z.; Ali, S. Investigating the non-linear relationship between urbanization and $CO_2$ emissions: An empirical analysis. *Air Quality, Atmos. Health* **2019**, *12*, 945–953. [CrossRef]
41. Li, B.; Haneklaus, N. Reducing $CO_2$ emissions in G7 countries: The role of clean energy consumption, trade openness and urbanization. *Energy Rep.* **2022**, *8*, 704–713. [CrossRef]

42. Xu, J.; Wang, J.; Li, R.; Yang, X. Spatio-temporal effects of urbanization on $CO_2$ emissions: Evidences from 268 Chinese cities. *Energy Policy* **2023**, *177*, 113569. [CrossRef]
43. Shahbaz, M.; Nasreen, S.; Ahmed, K.; Hammoudeh, S. Trade openness-carbon emissions nexus: The importance of turning points of trade openness for country panels. *Energy Econ.* **2017**, *61*, 221–232. [CrossRef]
44. Shahzad, S.J.H.; Kumar, R.R.; Zakaria, M.; Hurr, M. Carbon emission, energy consumption, trade openness and financial development in Pakistan: A revisit. *Renew. Sustain. Energy Rev.* **2017**, *70*, 185–192. [CrossRef]
45. Hasanov, F.J.; Liddle, B.; Mikayilov, J.I. The impact of international trade on $CO_2$ emissions in oil exporting countries: Territory vs consumption emissions accounting. *Energy Econ.* **2018**, *74*, 343–350. [CrossRef]
46. Acheampong, A.O.; Adams, S.; Boateng, E. Do globalization and renewable energy contribute to carbon emissions mitigation in Sub-Saharan Africa? *Sci. Total Environ.* **2019**, *677*, 436–446. [CrossRef]
47. Mutascu, M. A time-frequency analysis of trade openness and $CO_2$ emissions in France. *Energy Policy* **2018**, *115*, 443–455. [CrossRef]
48. Haug, A.A.; Ucal, M. The role of trade and FDI for $CO_2$ emissions in Turkey: Nonlinear relationships. *Energy Econ.* **2019**, *81*, 297–307. [CrossRef]
49. Essandoh, O.K.; Islam, M.; Kakinaka, M. Linking international trade and foreign direct investment to $CO_2$ emissions: Any differences between developed and developing countries? *Sci. Total Environ.* **2020**, *712*, 136437. [CrossRef] [PubMed]
50. Wasti, S.K.A.; Zaidi, S.W. An empirical investigation between $CO_2$ emissions, energy consumption, trade liberalization and economic growth: A case of Kuwait. *J. Build. Eng.* **2020**, *28*, 101104. [CrossRef]
51. You, W.; Lv, Z. Spillover effects of economic globalization on $CO_2$ emissions: A spatial panel approach. *Energy Econ.* **2018**, *73*, 248–257. [CrossRef]
52. Khan, M.K.; Teng, J.Z.; Khan, M.I.; Khan, M.O. Impact of globalization, economic factors and energy consumption on $CO_2$ emissions in Pakistan. *Sci. Total Environ.* **2019**, *688*, 424–436. [CrossRef]
53. Zhu, K.; Jiang, X. Slowing down of globalization and global $CO_2$ emissions—A causal or causal association? *Energy Econ.* **2019**, *84*, 104483. [CrossRef]
54. Aslam, B.; Hu, J.; Hafeez, M.; Ma, D.; AlGarni, T.S.; Saeed, M.; Abdullah, M.A.; Hussain, S. Applying environmental Kuznets curve framework to assess the nexus of industry, globalization, and $CO_2$ emissions. *Environ. Technol. Innov.* **2021**, *21*, 101377. [CrossRef]
55. Farooq, S.; Ozturk, I.; Majeed, M.T.; Akram, R. Globalization and $CO_2$ emissions in the presence of EKC: A global panel data analysis. *Gondwana Res.* **2022**, *106*, 367–378. [CrossRef]
56. Khan, D.; Ulucak, R.; Erdogan, S. The effect of nuclear energy on the environment in the context of globalization: Consumption vs production-based $CO_2$ emissions. *Nucl. Eng. Technol.* **2022**, *54*, 1312–1320.
57. Gaies, B.; Nakhli, M.S.; Sahut, J.-M. What are the effects of economic globalization on $CO_2$ emissions in MENA countries. *Econ. Model.* **2022**, *116*, 106022. [CrossRef]
58. Patel, N.; Mehta, D. The asymmetry effect of industrialization, financial development and globalization on $CO_2$ emissions in India. *Int. J. Thermofluids* **2023**, *20*, 100397. [CrossRef]
59. Wakyereza, R.K.S. *Foreign Direct Investment as A Tool for Poverty Reduction in Developing Countries: A study on Uganda*; Cambridge Scholars Publishing: Cambridge, UK, 2019.
60. Phillips, P.C.; Perron, P. Testing for a unit root in time series regression. *Biometrika* **1988**, *75*, 335–346. [CrossRef]
61. Elliot, G.; Rothenberg, T.J.; Stock, J.H. Efficient tests for an autoregressive unit root. *Econometrica* **1996**, *64*, 813–836. [CrossRef]


**Disclaimer/Publisher's Note:** The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.