Transportation, Environmental Degradation, and Health Dynamics in the United States and China: Evidence From Bootstrap ARDL With a Fourier Function

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Transportation and environmental degradation, with indirect and direct effects, play a significant role in determining the health of a nation’s citizens. This study uses bootstrap ARDL with a Fourier function to examine transportation, environmental degradation, and health dynamics in the United States and China. In the long run, the results support the cointegration relationship between transportation, environmental degradation, and health in both countries. The results show the contingency of the causality where a negative impact of transportation on environmental degradation exists in the United States while a positive impact exists in China. The effect of environmental degradation on health is negative in the United States while a positive effect exists in China. Regarding the causal direction between the variables of interest, the implications provide policymakers in developing strategy and policy for sustainable development.

Keywords: bootstrap ARDL approach, Fourier function approximation, transportation, environmental degradation, health, environmental Kuznets curve (EKC)

INTRODUCTION

Human health has become an ad hoc topic and development strategy for a country to improve the quality of human capital since previous studies emphasized that human capital accumulation related to production factors affects the growth of an economy (1, 2). To have better human health in a country, there has been a growing trend to assess the impact of environmental aspects on a regular basis (3, 4). In fact, transportation as an engine of economic growth directly affects the environment through the lens of the environmental Kuznets curve (EKC) (5–7). Therefore, relentlessly reviewing the dynamic relationship between transportation, environment, and health is very crucial to enhancing the growth of an economy.

With the expansion in economic development and international trade, global transport services have experienced a growth in delivery services, such as freight and passenger. Access to adequate transportation services in a supply chain is an essential determinant of progress and expansion for society and economics in a country (8). Transportation is viewed as one of the fundamentals for supporting the development of a nation since transportation shows its added value in a supply chain and is beneficial to economic growth. As a large component of the transportation sector, air transport not only allows quick mobility for freight service but also increases social connectedness...
for passenger service, and contributes to considerable outputs in economics (9). According to the International Air Transport Association, air cargo delivers about one-third of global trade value annually, making it a critical contribution to the supply chain solution (10). Nevertheless, within the globalization context, transport activities extend to the problem that a negative effect of the activities influences the environment in human society. The business activities related to freight transport as a major cause of air pollution generate vast CO2 emissions in the environment (11). The growth in the amount of CO2 emissions in the environment leads to harmful effects on human health (4, 12) and results in climate change (13).

The quality of the environment varies depending on the development of a country. The EKC theory has been highlighted as a helpful theoretical fundamental to identify the impact of environments (14, 15). In the framework of the EKC, an economy in the early stage of economic development leads to environmental degradation. Specifically, transportation activities as an engine of economics eject harmful gas into the environment. However, the development of the economy steps to the next stage where human beings with higher income request a better quality of life. Thus, humans in society and enterprises in economic activities pursue a better environment triggered by the decarbonization policy. Investigating the transport-induced EKC hypothesis, Erdogan et al. (16) affirmed that the connection between transportation and the deterioration in environmental quality since transportation is an important manner of the growth of an economy. The quality of the environment will deteriorate at the beginning where the industrial sector relying on transportation is the major contributor to the economic development; however, with the growth of an economy, the condition of the environment is improved since the wealth of the residents is improved and they focus on their environmental quality for a better quality of life.

According to a study by Mujtaba and Shahzad (17), the effect of the environment on health is discussed within the aspects of healthcare expenditure and health status. Polluted environments could decrease the immune system of humans and generate various diseases, such as respiratory diseases and lung cancer (18–20). Thus, humans in society pay the price for polluted environments through healthcare expenditure (19) and health status (20). Based on the foundation of the EKC theory, Moosa and Pham (21) and Moosa et al. (22) proposed a stylized representation regarding the association between healthcare expenditures and environmental degradation. They showed that income in an economy is an important connection when discussing the association between the deterioration in environmental quality and healthcare expenditure. Additionally, human beings would perform defensive behavior through activities where they aim to avoid, prevent, and mitigate the negative effect of the environment when facing the challenge of environmental pollution. Williams et al. (23) addressed the definition of health expenditures as follows: “health expenditures include the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health”. Human beings with abundant income demand better nutrition, medical care, and medicines since human beings in society have more consciousness of better quality of life along with the growth of the economy (24).

Moreover, human beings with a better quality of life could increase preventive health expenditures to strengthen their health itself. Thus, the effect of the environment could positively or negatively alter health expenditures.

Previous studies have investigated the transport-induced EKC hypothesis (25–27) in a stream and the nexus between environment and health in another stream (3, 4). However, limited studies combine the transport-induced EKC with the nexus between environment and health to examine the health effect. Since firms provide time value in the competitive priorities to customers, air transportation is an important driver for the performance of a supply chain. Also, air freight contributes to a large part of trade value worldwide (10). Thus, this study collects air freight as the proxy variable of transportation. Within the field of social science including economics (28–33), environment (14, 34–37), and transportation (38–42) categories, the indicators perform the attributes of smooth and sharp shifts in the trend of time series. Smooth and sharp breaks are important and considered in previous studies since any effects of shocks on the indicators would affect the results of a model (43). Thus, without considering structural breaks in a model, the results may show bias and conclude with a misleading implication (44).

To the best of our knowledge, this is the first study that investigates the dynamics between transportation, environment, and health in the United States and China by using the bootstrap autoregressive-distributed lag test with a Fourier function. This study contributes to the existing literature in the following aspects. First, rather than simply measuring environmental indicators or health effects, this study concerns the transport-induced EKC and the environment-health nexus to examine how transportation and environmental degradation, with indirect and direct effects, play a significant role in determining health in a country. Second, the model employs a Fourier function that allows for capturing structural breaks. The effect of structural breaks is usually ignored in causality and unit root tests (43, 44). A Fourier function is used to consider multiple structural changes where the number, location, or forms (45). Third, two major countries that contribute to economic development and inject major CO2 emissions into the world are investigated in this study and this paper offers policy recommendations and motivates the government to be concerned about the development of a healthy and productive economy. The rest of the work is organized in the following manner: Section Data and Method includes data and method. Results are covered in Section Results. Discussion and conclusion are included in Section Discussion and Conclusion.

DATA AND METHOD

Previous researchers considered transportation as the engine of the growth of an economy to investigate the transport-environment nexus (6, 16, 39). Moreover, prior studies considered environmental degradation as a major indicator resulting in health expenditures (21, 22, 46, 47). Thus, this
The United States TR 10.296 10.669 9.580 0.350
metric tons times kilometers traveled. Regrading the data source, the volume of cargo carried on each flight stage, measured in emissions per unit of GDP based on 2010 prices. Air freight is and health. CO2 emissions are measured in carbon dioxide (GDP) as the proxies to measure transportation, environment, health expenditure as a share of the gross domestic product to health indicators. The study uses air freight, CO2 emissions, and this study follows the two streams of literature and bridges them to contribute to the literature. This study collected time-series data from 1990 to 2018 in the United States and China to investigate the associations from transportation to environment to health indicators. The study uses air freight, CO2 emissions, health expenditure as a share of the gross domestic product (GDP) as the proxies to measure transportation, environment, and health. CO2 emissions are measured in carbon dioxide emissions per unit of GDP based on 2010 prices. Air freight is the volume of cargo carried on each flight stage, measured in metric tons times kilometers traveled. Regrading the data source, the air freight and CO2 emissions are retrieved from the World Bank; the health expenditure as a share of the gross domestic product is retrieved from the Organization for Economic Co-operation and Development and the China Health Database for the United States and China, respectively. The time series of air freight has been processed by Logarithm as Logarithmic transformation reduces the effect of the heterogeneous problem where the dynamic range of a variable exists. Table 1 reports the summary statistics of the variables examined in this study. Jarque-Bera statistics indicate that air freight, CO2 emissions, and health expenditure for the two countries are normally distributed.

This study visits the long-run cointegration and causal relationship between transportation, the environment, and health, the following model is used in this study.

\[
\Delta y_t = c + \gamma_1 \sin \left( \frac{2\pi kt}{T} \right) + \gamma_2 \cos \left( \frac{2\pi kt}{T} \right) + \delta_1 y_{t-1} + \delta_2 x_{t-1} + \delta_3 z_{t-1} + \sum_{i=1}^{p-1} \lambda_1 \Delta y_{t-i} + \sum_{i=1}^{p-1} \lambda_2 \Delta x_{t-i} + \sum_{i=1}^{p-1} \lambda_3 \Delta z_{t-i} + \epsilon_t
\]

where c is a constant, \( \Delta \) is the operator for forwarding difference; \( p \) indicates the lag order; \( i \) represents the lag index; \( t \) stands for the periods; \( \epsilon_t \) is the disturbance term; \( x \) and \( z \) are the independent variables; \( y \) denotes the dependent variable; \( \lambda_1, \lambda_2, \lambda_3, \delta_1, \delta_2, \delta_3 \) are coefficients of the lagged variables, and \( T \) represents the sample size.

The setting regarding the Fourier approximation procedure follows the study of (50). For more details on the evolution of the equations, please refer to the supplementary material.

**RESULTS**

**The Unit Root Tests**

Three common procedures for testing unit root tests, that is, KPSS, ADF, and PP, were conducted to test the variables for stationarity. The null hypothesis for the first and second ones state that a time series has a unit root. If the null hypothesis is rejected, the time series is stationary. Otherwise, it is not stationary. In Table 2, the results indicate that the three variables, air freight, CO2 emissions, and health expenditure are integrated at I (1) order in both China and the United States. A study by (49) suggests that the bootstrap ARDL model is appropriate for testing the co-integration relation between the variables if all the variables are not at I (2) order or above.

**Cointegration Test**

This study applies the bootstrap ARDL model with a Fourier function test to explore the long-run relationship between transportation, environment, and health in China and the United States. The model was built based on error-correction models without restrictions where the optimal order of the lags for the variables was determined according to the Akaike and
Schwarz information criteria used in other empirical studies (48, 51). The test statistics generated in the bootstrapping process determine whether the cointegration between variables exists or not. As shown in Table 3, \( F_a \) is the calculated F test statics for the coefficients of \( y_{t-1} \), \( x_{t-1} \), and \( z_{t-1} \). Additionally, \( t_{dev} \) denotes the \( t \)-test statistics for the dependent variable, and \( F_{indev} \) is the F-test statistics for the independent variables. \( F_a \), \( t_{dev} \), and \( F_{indev} \) statistics are checked to see whether the statistic values exceed their corresponding critical values. The null hypothesis of no-cointegration was rejected since all three tests are statistically significant. In Table 3, we find the values of \( F_a \), \( t_{dev} \), and \( F_{indev} \) statistics exceed corresponding critical values in both China and the United States when health expenditure is taken as the dependent variable while air freight and CO2 emissions are taken as independent variables.

### Granger Causality Test

Table 4 reports the results of granger causality test. In the case of China, the positive causality between air freight and CO2 emissions runs from the former to the latter, implying that the growth of transportation leads to environmental degradation, which is in line with major empirical findings (5−7). The results also show a positive causality running from CO2 emissions to healthcare expenditure, indicating that environmental degradation causes increased healthcare expenditure, which is in line with major empirical findings (3). Regarding the case in the United States, the negative causality runs from air freight to CO2 emissions, which implies that the development of transportation improves the quality of the environment, which is in line with previous empirical findings (52). We also find the results that CO2 emissions negatively impact healthcare expenditure, indicating that as the quality of the environment is improved, the spending on healthcare increases, which is in line with major empirical findings (21, 22).

### DISCUSSION AND CONCLUSION

The study examines the transportation, environment, and health dynamics in China and the United States for the time period 1990–2018. To do this, we applied the bootstrap ARDL with a Fourier function procedure to test cointegration and confirm the presence of the long-term relationship between transportation, environment, and health. This study enriches current literature by providing new evidence where we apply the relatively rigorous method to confirm the long- and short-term transportation, environment, and health dynamics. Such relationships of cointegration in transportation, environment, and health dynamics provide useful insights for making proper strategies to develop a healthy and productive economy in the long term. Furthermore, the directions of the causal relationships among the variables are identified, which provides useful insights for policymakers to propose better policies to mitigate...
environmental degradation and accumulate human capital in the process of economic growth.

Our results confirm the existence of transport-induced EKC phenomenon where the effect of transportation on the quality of environments is different depending on the stage of development in an economy. Within the different stages of development, human beings in society and business activities have various consciousness of environment and health. Our empirical findings provide important implications for policymakers. First, in the context of China, the positive causality between transportation and CO2 emissions indicates that augmenting the development of transportation increases environmental degradation. The findings imply that the process of economic growth is responsible for environmental pollution in China as transportation is the engine of economic growth. Residents pursue an improved quality of life that is suggestively dependent on efficient transportation as a result of the improvement in their economic circumstances. Apart from that, the logistic system, which plays a critical role in the expansion of the economic system, needs an effective transportation system, which raises the demand for passenger and freight transportation services. Thus, one of the causes of environmental degradation is the growth of vehicular traffic flow in urban areas and congestion commonly happens in most major cities in China. The massive growth in the number of vehicles on the road has led to a surge in oil consumption and ejection of harmful gases such as carbon dioxide. On the other hand, the manufacturing and industrial sectors contribute major output to Chinese economics. Specifically, the logistic industry contributing to important added value in transferring products in supply chains has witnessed significant expansion since the logistic industry is a supporting, crucial, and leading industry of economic development. Thus, the increased demand for passenger and freight transportation services both leads to increase in transport-related infrastructure and activities and generates more CO2 emissions in the environment. Another finding for China is that environmental degradation leads to boosting the demand for care of health. Specifically, air pollution has a negative influence on health as the poor environment quality causes illnesses. Previous studies (53, 54) indicated that air pollution is one of the main causes that increase the mortality and morbidity of cardiovascular disease. Thus, the worse the quality of the environment, the more tangible and intangible costs that residents should pay, including healthcare expenditure and health outcomes.

Second, in the context of the United States, the negative causality between transportation and CO2 emissions. The findings imply that the growth of the economy comes up with a better environment in the society in the United States. Specifically, economic growth increases the demand for freight and passenger service in transport since residents with higher income pursue a better quality of life. In recent decades, citizens have grown more aware and concerned about air pollution. This has led to an increasing consciousness that we can no longer disregard the environment in the process of economic development. (55) indicated that the problem of air pollution has been a concern by the broader communities in urban areas such as Pittsburgh. The government in the United States put effort into advanced renewable energy that is more eco-friendly on the environment rather than traditional energy generation. International Energy Agency (56) reported that renewable energy accounts for 12% of transport fuel demand growth from 2018 to 2023 in the world. Specifically, the United States produce biofuel energy of about 65 billion in 2020 liters, which is the major part of the sum worldwide (International Energy Agency, 2021). In the transport sector energy demand, biofuels still hold an almost 90% share of total renewable energy in 2023 (56). The effort in the development and use of advanced renewable energy rather than traditional energy generation supports a better quality of the environment in the United States. Another finding for the United States is that improved quality of environment leads to increased healthcare expenditure. The results align with previous research (21, 22). The EKC links economic growth to the environment, which has been identified as a primary factor justifying the evidence that improved quality of environment leads to more spending on healthcare. For the United States as a developed country, the residents with relatively high per capita income and quality of life could demand better nutrition, medical care, and medicines. Additionally, the residents could increase preventive health expenditures to strengthen their health itself since health expenditures include preventive and curative health services. Kamal and Hudman (57) reported that preventive care spending is higher in the United States than in many comparably wealthy countries.

We recommend that the Chinese government should enhance its transportation system and encourage the auto industry to introduce more hybrid-type cars. With a better transportation system, the residents could rely less on private vehicles for moving, and thus, congestion could decrease. The improved environmental quality in a region not only benefits the humans who live there but also promotes the development of the region where skilled workforces preferring better quality of life commonly move. The United States government should continue to put effort into investment in advanced renewable energy and support the use of hybrid or energy-efficient automobiles. The government is suggested to deliver the residents and enterprises the knowledge regarding a variety of initiatives, such as disaster preparedness, nutrition and education programs, disease prevention programs, and epidemiological surveillance to promote population health and wellbeing. This study takes the environment as the factor impacting health; however, other factors are considered to validate related theory where health could be influenced by other factors. In the future, it is suggested to investigate more issues such as energy consumption that would influence the environment. Moreover, a more deep understanding of the relationship between healthcare expenditure and health status would be investigated.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://data.worldbank.org/.
AUTHOR CONTRIBUTIONS

C-FW and M-CL contributed to the research topic, research model, and the statistical analysis and writing. All authors contributed to the article and approved the submitted version.

REFERENCES

1. Yan W, Yudong Y. Sources of China’s economic growth 1952–1999: incorporating human capital accumulation. China Econ Rev. (2003) 14:32–32. doi: 10.1016/S1043-951X(02)00084-6
2. Ogbeifun I, Shobande OA. A reevaluation of human capital accumulation and economic growth in OECD. J Public Aff. (2021) e2602. doi: 10.1002/2pa.2602
3. Akbar M, Hussain A, Akbar A, Ullah I. The dynamic association between healthcare spending, CO2 emissions, and human development index in OECD countries: evidence from panel VAR model. Environ Dev Sustain. (2021) 23:10470–89. doi: 10.1007/s11356-020-01066-5
4. Barua S, Adeleye BN, Akam D, Ogunrinola I, Shafiq MM. Modeling mortality rates and environmental degradation in Asia and the Pacific: does income group matter? Environ Sci Pollut Res. (2022) 1–20. doi: 10.1007/s11356-021-17686-x
5. Sharif A, Afzhan S, Chehra S, Amel A, Khan SAR. The role of tourism, transportation and globalization in testing environmental Kuznets curve in Malaysia: new insights from quantile ARDL approach. Environ Dev Sustain. (2020) 27:25494–509. doi: 10.1017/s11356-020-08782-5
6. Hassan SA, Nosheen M, Rafaz N, Haq I. Exploring the existence of aviation Kuznets curve in the context of environmental pollution for OECD nations. Environ Dev Sustain. (2021) 23:15266–89. doi: 10.1007/s11356-021-01297-0
7. Gyamf BA, Bekun FV, Balsalobre-Lorente D, Onifade ST, Ampomah AB. Beyond the environmental Kuznets curve: Do combined impacts of air transport and rail transport matter for environmental sustainability amidst energy use in E7 economies?. Environ Dev Sustain. (2022) 1–19. doi: 10.1007/s11356-021-01944-6
8. Sharif A, Shabbaz M, Hille E. The transportation-growth nexus in USA: fresh insights from pre-post global crisis period. Transp Res A: Policy Pract. (2019) 121:108–21. doi: 10.1016/j.tra.2019.01.011
9. Habib Y, Xia E, Hashmi SH, Yousaf AU. Testing the heterogeneous effect of air transport intensity on CO2 emissions in G20 countries: an advanced empirical analysis. Environ Sci Pollut Res. (2022) 1–22. doi: 10.1007/s11356-022-18904-w
10. Tan D, Tsui K. Investigating causality in international air freight and business travel: the case of Australia. Urban Studies. (2017) 9:41778–93. doi: 10.1177/0042098015620520
11. McKinnon A. Green logistics: the carbon agenda. Int J Logist Manag. (2010) 6.
12. Kelle P, Song J, Jin M, Schneider H, Claypool C. Evaluation of operational and environmental sustainability tradeoffs in multimodal freight transportation planning. Int J Product Econ. (2019) 209:411–20. doi: 10.1016/j.ijpe.2018.08.011
13. Aidedoyin F, Ozturk I, Abubakar I, Kumea T, Folarin O, Bekun FV. Structural breaks in CO2 emissions: are they caused by climate change protests or other factors?. J Environ Manage. (2020) 266:110628. doi: 10.1016/j.jenvman.2020.110628
14. Anwar MA, Nasreen S, Tiwari AK. Forestation, renewable energy and environmental quality: empirical evidence from Belt and Road Initiative economies. J Environ Manage. (2021) 291:112684. doi: 10.1016/j.jenvman.2021.112684
15. Sharma GD, Tiwari AK, Erkut B, Mundi HS. Exploring the nexus between non-renewable and renewable energy consumptions and economic development: Evidence from panel estimations. Renew Sust Energ Rev. (2021) 146:111152. doi: 10.1016/j.rser.2021.111152
16. Erdogan S, Agedoyin FF, Bekun FV, Sarkodie SA. Testing the transport-induced environmental Kuznets curve hypothesis: The role of air and railway transport. J Air Transp Manag. (2020) 89:101935. doi: 10.1016/j.jairtraman.2020.101935
17. Mujtaba G, Shahzad SJH. Air pollutants, economic growth and public health: implications for sustainable development in OECD countries. Environ Sci Pollut Res. (2021) 28:12686–98. doi: 10.1007/s11356-020-11212-1
18. Bilici GP, Ranocevanni RM, Tudosarch E, Motfi R, Oancea C. Air pollution exposure—the (in) visible risk factor for respiratory diseases. Environ Sci Pollut Res. (2021) 28:19615–28. doi: 10.1007/s11356-021-13208-x
19. Chen F, Chen Z. Cost of economic growth: air pollution and health expenditure. Sci Total Environ. (2021) 755:142543. doi: 10.1016/j.scitotenv.2021.142543
20. Taghizadeh-Hesary F, Rasoulinezhad E, Yoshino N, Chang Y, Taghizadeh-Hesary F, Morgan PJ. The energy–pollution–health nexus: a panel data analysis of low-and middle-income Asian countries. SIngap Econ Rev. (2021) 66:435–55. doi: 10.1108/155759020430040
21. Moosa N, Pham HN. The effect of environmental degradation on the financing of healthcare. Emerg Mark Finance Trade. (2019) 55:237–50. doi: 10.1007/s10663-019-09867-2
22. Moosa N, Ramiah V, Pereira V. A plausible explanation for the negative correlation between environmental degradation and healthcare expenditure. Appl Econ Lett. (2021) 28:1377–81. doi: 10.1080/10504851.2020.1817843
23. Williams R, Karuranga S, Malanda B, Saeedi P, Basit A, Besancon S, et al. Global and regional estimates and projections of diabetes-related health expenditure: Results from the International Diabetes Federation Diabetes Atlas. Diabetes Res Clin Pract. (2020) 162:108072. doi: 10.1016/j.diabres.2020.108072
24. Varvarigos D. Environmental degradation, longevity, and the dynamics of economic development. Environ Res Econ. (2010) 46:59–73. doi: 10.1016/j.eurev.2009.09-934-0
25. Balsalobre-Lorente D, Driha OM, Leitão NC, Murshed M. The carbon dioxide operational and environmental sustainability tradeoffs in multimodal freight transportation planning. Int J Product Econ. (2019) 28:12686–98. doi: 10.1007/s11356-020-11212-1
26. Zhuang Y, Yang S, Razzaq A, Khan Z. Environmental impact of infrastructure-led Chinese outward FDI, tourism development and technology innovation: A regional country analysis. J Environ Plan Manag. (2021) 1–33. doi: 10.1080/09640568.2021.1999672
27. Zhang H, Razzaq A, Pelet I, Irmak E. Does freight and passenger transportation industries are sustainable in BRICS countries? Evidence from advance panel estimations. Econ Res.-Ekonomска istraživanja. (2021) 1–21. doi: 10.1007/s1131677X.2021.002708
28. Solarin SA, Hammoudeh S, Shabaz M. Influence of economic factors on disaggregated Islamic banking deposits: Evidence with structural breaks in Malaysia. J Int Financial Mark Inst Money. (2018) 55:13–28. doi: 10.1016/j.intfin.2018.02.007
29. Shabaz M, Ahmed K, Tiwari AK, Jiao Z. Resource curse hypothesis and role of oil prices in USA. Res Policy. (2019) 64:101514. doi: 10.1016/j.respol.2019.101514
30. Khoshnevis Yazdi S. Structural breaks, international tourism development and economic growth. Economic Res.-Ekonomска istraživanja. (2019) 32:1765–76. doi: 10.1007/s1131677X.2019.1638279
31. Malik MA, Masood T, Ozturk I. Identifying structural breaks and growth regimes in middle eastern economies. Int Rev Econ Finance. (2020) 27:224–36. doi: 10.1016/j.ijie.2148
32. Dimitraki O, Win S. Military expenditure economic growth nexus in Jordan: An application of ARDL Bound test analysis in the presence of breaks. Def Peace Econ. (2021) 32:864–81. doi: 10.1007/s10649-020-17301-3
33. Okere KI, Muoneke OR, Onuoha FC. Symmetric and asymmetric effects of crude oil price and exchange rate on stock market performance in Nigeria: FUNDING

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Pata UK. Environmental Kuznets curve and trade openness in Turkey: bootstrap ARDL approach with a structural break. *Environ Sci Pollut Res.* (2019) 26:20264–76. doi: 10.1007/s11356-019-05266-x

Tiwari AK, Nasreen S, Shabbaz M, Hammoudeh S. Time-frequency causality and connectedness between international prices of energy, food, industry, agriculture and metals. *Energy Economics.* (2020) 85:104529. doi: 10.1016/j.eneco.2019.104529

Pata UK. Renewable and non-renewable energy consumption, economic complexity, CO2 emissions, and ecological footprint in the USA: testing the EKC hypothesis with a structural break. *Environ Sci Pollut Res.* (2021) 28:846–61. doi: 10.1007/s11356-020-10446-3

Pata UK, Caglar AE. Investigating the EKC hypothesis with renewable energy consumption, human capital, globalization and trade openness for China: evidence from augmented ARDL approach with a structural break. *Energy.* (2021) 216:119220. doi: 10.1016/j.energy.2020.119220

Stamolampros P, Korfiatis N. Airline service quality and economic factors: An ARDL approach on US airlines. *J Air Transp Manag.* (2019) 77:24–31. doi: 10.1016/j.jairtraman.2019.03.002

Shafique M, Azam A, Raﬁq M, Luo X. Investigating the nexus among transport, economic growth and environmental degradation: Evidence from panel ARDL approach. *Transport Policy.* (2021) 109:61–71. doi: 10.1016/j.tranpol.2021.04.014

Oţer M, Canbay S, Kirca M. The impact of container transport on economic growth in Turkey: An ARDL bounds testing approach. *Res Transp Econ.* (2021) 88:101002. doi: 10.1016/j.retrec.2020.101002

Magazzino C, Giolli L. The relationship among railway networks, energy consumption, and real added value in Italy. Evidence form ARDL and Wavelet analysis. *Res Transp Econ.* (2021) 90:101126. doi: 10.1016/j.retrec.2021.101126

Alam KM, Li X, Baig S, Ghanem O, Hanif S. Causality between transportation infrastructure and economic development in Pakistan: An ARDL analysis. *Res Transp Econ.* (2021) 88:100974. doi: 10.1016/j.retrec.2020.100974

Bozoklu S, Yi lançi V, Gorus MS. Persistence in per capita energy consumption: A fractional integration approach with a Fourier function. *Energy Economics.* (2020) 91:104926. doi: 10.1016/j.eneco.2020.104926

Cai Y, Chang T, Inglesi-Lotz R. Asymmetric persistence in convergence for carbon dioxide emissions based on quantile unit root test with Fourier function. *Energy.* (2018) 161:470–81. doi: 10.1016/j.energy.2018.07.125

Enders W, Jones P. Grain prices, oil prices, and multiple smooth breaks in a VAR. *Stud Nonlin Dynam Econ.* (2016) 20:399–419. doi: 10.1515/snde-2014-0101

Jerrett M, Eyles J, Dufournard C, Birch S. Environmental inﬂuences on healthcare expenditures: an exploratory analysis from Ontario, Canada. *J Epidemic Community Health.* (2003) 57:334–8. doi: 10.1136/jech.57.5.334

Apergis N, Gupta R, Lau CKM, Mukherjee Z. US state-level carbon dioxide emissions: does it affect health care expenditure? *Renew Sust Energ Rev.* (2018) 91:521–30. doi: 10.1016/j.rser.2018.03.035

Pesaran MH, Shin Y, Smith RJ. Bounds testing approaches to the analysis of level relationships. *J Appl Econ.* (2001) 16:289–326. doi: 10.1002/jae.616

McNown R, Sam CY, Goh SK. Bootstrapping the autoregressive distributed lag test for cointegration. *Appl Econ.* (2018) 50:1509–21. doi: 10.1080/00036846.2017.1366643

Yilanci V, Bozoklu S, Gorus MS. Are BRICS countries pollution havens? Evidence from a bootstrap ARDL bounds testing approach with a Fourier function. *Sustain Cities Soc.* (2020) 55:102035. doi: 10.1016/j.scs.2020.102035

Lin FL, Inglesi-Lotz R, Chang T. Revisit coal consumption, CO2 emissions and economic growth nexus in China and India using a newly developed bootstrap ARDL bound test. *Energy Explor Exploit.* (2018) 36:450–63. doi: 10.1177/0144598717741031

Godil DI, Yu Z, Sharif A, Usman R, Khan SAR. Investigate the role of technology innovation and renewable energy in reducing transport sector CO2 emission in China: a path toward sustainable development. *Sust Dev.* (2021) 29:694–707. doi: 10.1002/sd.2167

Liang F, Liu F, Huang K, Yang X, Li J, Xiao Q, et al. Long-term exposure to ﬁne particulate matter and cardiovascular disease in China. *J Am Coll Cardiol.* (2020) 75:707–17. doi: 10.1016/j.jacc.2019.12.031

Du X, Zhang Y, Liu C, Fang J, Zhao F, Chen C, et al. Fine particulate matter constituents and sub-clinical outcomes of cardiovascular diseases: A multi-center study in China. *Sci Total Environ.* (2021) 759:143555. doi: 10.1016/j.scitotenv.2020.143555

Rickenbacker H, Brown F, Bilec M. Creating environmental consciousness in underserved communities: Implementation and outcomes of community-based environmental justice and air pollution research. *Sustain Cities Soc.* (2019) 47:101473. doi: 10.1016/j.scs.2019.101473

International Energy Agency. *Renewables.* (2018). Available online at: https://www.iea.org/reports/renewables-2018/transport

Kamal, R. and Hudman, J. (2020). What do we know about spending related to public health in the U.S. and comparable countries? https://www.healthsystemtracker.org/chart-collection/what-do-we-know-about-spending-related-to-public-health-in-the-u-s-and-comparable-countries

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