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THE DETERMINANTS OF SUSTAINABLE TRANSPORTATION IN EAST ASIAN COUNTRIES: DOES THE MODERATING ROLE OF INSTITUTIONAL QUALITY MATTER

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ABSTRACT

Transportation profoundly affects the environment, aggravating air pollution, climate change, and natural resource depletion. Additionally, the construction and maintenance of transportation infrastructure contribute to deforestation and habitat loss. Therefore, this research aims to investigate the correlation between c02 emissions, natural resource depletion, trade, FDI inflow, and transportation in a chosen number of Eastern Asian countries, with a unique perspective of examining the influence of institutional qualities as a moderator among these factors. The analysis involves using CS-ARDL and the dumitrescu-hurlin causality test to examine the data. The findings suggest that institutional qualities positively impact the relationship between CO2 emissions and transportation, reversing the negative association. Additionally, trade negatively correlates with transportation; this can be explained by poor institutional quality, leading to corruption and a lack of transparency, discouraging foreign investment and trade in the transportation sector. On the other hand, resource depletion and FDI inflows negatively affect transportation services in East Asian countries. Therefore, the study highlights the significance of effective governance, regulation, and management of institutions in promoting better transportation planning and coordination, ultimately leading to sustainable transportation services.

Keywords: *Sustainable Transportation, Institutional Quality, CO2 Emission, FDI, CS-ARDL*

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Introduction

Transportation is crucial to the growth of a country's economy and urban areas. Nonetheless, excessive infrastructure construction might strain the ecology significantly due to satisfying the demands of social advancement and economic growth (Muller et al., 2015). The fundamental prerequisites for economic performance to reach a decent pinnacle are provided by transportation infrastructure, although some negative spillover could occur at such expenses (Laurance et al., 2014). Such as CO2 emissions from domestic and international production chains (Meng et al., 2013), ecosystem destruction as a consequence of ecological habitat fragmentation (Laurance et al., 2009), and altered water flow and deteriorating water quality (Palmer, 2010). This creates a subtle detrimental effect in which the transportation system can materialize as an ecological degradation factor. The myriad effects of transportation on the environment have drawn much interest (see Sayyadi & Awasthi, 2020; Wu & Madni, 2021), and they are unequivocally paradoxical. However, the macro-economic forces are still the most significant and well-known issue, ignoring the social and environmental implications under institutional implications.

Recent empirical research indicates that improvements in institutional strength, infrastructure, and transportation efficiency can significantly impact a country's ability to conduct commerce. For instance, Francois & Manchin (2013) contend that infrastructural and institutional standards indices impact trade patterns. They do this by using the gravity model. They did not, however, specify markers for border and transportation efficiency, and the scope of their study was only confined to specified time frames. Having adequate transportation networks and operating at their best are necessary for successful mobility. These systems comprise complex subsystems like transportation networks, cars, and machinery. They are there to facilitate both automobile and pedestrian traffic movement. This is accomplished by integrated control systems that monitor the movement of people and goods (Zergawu et al., 2020). The responsibilities of governments and people are crucial to transportation and mobility. Since they participate in transportation as drivers, passengers, or pedestrians, actively or inactively impacting traffic flow, they also play the roles of prospective service providers, consumers, and manufacturers of things. Demands for commodities and passenger transportation are shaped, directly or indirectly, by people's transit habits, pursuits, and socioeconomic standing. Their decisions ultimately determine the operational efficiency of demand fulfillment-related transportation activities. Shahbaz et al. (2021) also looked into the effect of transportation on foreign direct investment. The results showed that both transportation and FDI are cointegrated.

In the context of sustainability, transportation systems, which consist of a network of vehicular and infrastructural elements, play a crucial role in determining sustainable trajectories. They have a crucial function in enabling the flow of people and things, which supports social connections and economic activity. However, because transportation is a significant source of greenhouse gas emissions, air pollution, and resource consumption, its utility is deeply related to environmental implications (Erdogan et al., 2020; Saleem et al., 2018). Moreover, ostensibly, the rising urbanization and the need for more interest from international investors in such industries make it difficult to achieve sustainable transportation. However, all these research studies investigated the direct effect of the mentioned variables (environmental and macroeconomic factors) on transportation.

Therefore, this paper analyzes how trade, foreign direct investment, and environmental factors, measured by carbon emissions and net resource depletion, impact East Asia's transportation sector. Both the selected ecological indicators provide insight into the environmental health of the countries being studied. The variable of net resource depletion indicates the exploitation of natural resources. It represents the depletion of these resources over time, while CO2 is a general trendy factor used in many studies as an environmental performance indicator. In addition, this investigation aims to enhance the existing body of knowledge by demonstrating how institutional quality can play a moderating role in achieving sustainable transportation.

The study focuses on several selected East Asian nations. East Asia is recognized for its favorable institutional quality, which has played a crucial role in the region's remarkable economic progress and advancement over the last few years. This area has established efficient policies and institutions that support economic efficacy, stability, and openness. For example, countries like Japan, South Korea, and Singapore have robust legal systems that protect property rights, enforce contracts, and promote fair competition. These nations also have well-functioning bureaucracies and practical regulatory frameworks facilitating business activities and investment (Zhuang et al., 2010). Notably, to the authors' best estimation, prior research has yet to explore the interactive function of institutional indicators as a moderating factor in the transportation sector, highlighting the urgent need for such research in the current context. Likewise, literature on the evaluation of sustainable transport is scarce, and there are even fewer studies evaluating its combined performance, with most studies relying on subjective data. Therefore, the central inquiry of this study revolves around how environmental factors and trade contribute to the advancement of sustainable transportation, mainly when the moderating role of institutional qualities influences their impact. We also take into consideration the direct effect of foreign direct inflows. To answer the proposed question, the paper aims to address these challenges by utilizing the CS-ARDL method, which is well-suited for analyzing data with limited sample sizes, a challenge that traditional cointegration methods need help to handle. Using subsampling in the CS-ARDL method allows for more precise estimates of long-run coefficients and error correction terms, even with small sample sizes.

The remaining sections in this paper are as follows: Section 2 elucidates the relevant literature and theoretical framework underpinning the empirical analysis. Moving on to Section 3, we delve into the details of the data and empirical methodology employed. The results of our analysis are presented in Section 4. Section 5 is dedicated to a comprehensive discussion of these results, and finally, in Section 6, the paper concludes and highlights relevant policy implications.

Literature Review

The Path Toward Sustainable Transportation

First, exploring the viability of the transportation network (broadly speaking) while concentrating on the present and anticipated external impacts and values of traffic and transportation can enhance our knowledge of sustainable transportation. Hence, governments have historically utilized these indicators to evaluate whether the transportation sector is progressing toward sustainable development (low CO_2 emissions, adopting green energy, and adhering to domestic environmental legislation) and to set sustainable transportation targets. Several attempts have been made to catalog sustainable transportation indicators (e.g., Heath & Gifford, 2002; Steg & Sievers, 2000; Tertoolen et al., 1998). Examples include energy consumption, carbon intensity, hazardous and poisonous substance emissions, soil use, destruction and marginalization of natural areas, waste, traffic control, pollutants, the health effects of travel, accident costs, the input of the transportation industry to economic welfare, and availability.

According to research by (Anwar et al., 2020), increased industrialization and transportation lead to long-term declines in environmental quality. Granger causality analyses for the short-term suggested a one-sided positive causality flowing from Industrial output value per resident to carbon dioxide. However, the relationship between transporting shipments and CO_2 emissions is reciprocal. The article stressed the need for the industrial and transportation sectors to develop environmentally friendly regulations. Other prominent researchers also delve into the so-called sustainable transportation. The results of a panel data analysis by Saidi & Hammami (2017) show that globalization, economic growth, energy usage, and freight transportation may accelerate ecological degradation in the nations studied. Andres & Padilla (2018) findings support the idea that transportation indices and GHG emissions are positively correlated. They demonstrate that mobility and volume energy consumption substantially add to GHG emissions. Airplanes also contribute to global warming by releasing hydrocarbons, carbon dioxide, and nitrogen oxide into the atmosphere during takeoff and landing.

Using robust panel estimators and yearly time series data for a panel of the countries with the most significant air travel markets from 1995 to 2014, Erdogan et al. (2020) investigate the impacts of aerial and rail transportation on ecological degradation. According to their calculations, air travel increases emissions, whereas urban expansion and rail travel reduce them throughout the research period. They underline the importance of operating in the fresh air sector. Saleem et al. (2018) discovered that air travel hurt the rents for natural resources while significantly influencing emissions. While others propose substantial solutions, for instance, to increase freight transportation's environmental sustainability, Vachon (2007) highlights initiatives toward Carbon dioxide reduction, enhancement in car fleet operability, support for circular logistics, and waste handling. According to Sureeyatanapas et al. (2018), adopting green standards in logistic transportation is primarily influenced by state legislation and regulations, business rivalry from competing transport companies, and sustainable driving behaviors. Likewise, Eng-Larsson & Kohn (2012) highlight that switching from the road method to the intermodal mode would improve the sustainability of the freight supply network. According to Lammgrd (2012), using mixed-mode freight services for large distances effectively lowers carbon emissions and enhances green performance.

Juxtaposing İnstitutional And Transportation Sector

Transportation services and airports are essential element of urban areas, which plays crucial roles in the transmission of goods and the movement of population growth and spread in urban areas. (Holl, 2004; Durango-Cohen, 2007). Nevertheless, sustained, well-structured transportation systems that could, in return, have potential benefits for the economy would require more significant state intervention, not in the sense of imposing constraints but by allocating investment in domestic infrastructure sectors. Iwanow & Kirkpatrick (2009) examine the reduction of transaction costs related to compliance, rule-making, and trade regulation using a panel method of several newly under-industrialization nations from 2003–2004. Their findings suggest that reducing trade mismanagement and other institutionalized commerce-related restrictions on industrial export efficiency might help improve export performance in Africa. In order to minimize import/export fees in the Asia Pacific Economic Cooperation area, Abe & Wilson (2008) conducted research using a computational general equilibrium model to explore the effects of enhancing institutional framework through minimizing corruption and increasing transparency. According to their conclusions, the area will benefit from increased commerce and welfare benefits due to more openness and less corruption. Francois & Manchin (2013) also explore the impact of institutions and infrastructural standards on commerce activities between nations, considering zero-valued trade observations and cooperative trade accords. They reveal that the strength of institutions has a significant role in determining how well commerce flows across nations. In a similar vein, Seck (2017) uses various commerce optimization indicators, namely frontier effectiveness, infrastructural facilities, legal frameworks, technology for communication, and logistics performance, to examine how various components of the sub-Saharan African trade cost landscape could have been a factor into shaping trade flows both internally and externally.

Fu et al. (2020) examines the present level of ecological consciousness and climate-conscious attitudes among China's RFT drivers defined by four fundamental constituents — ecological responsibility, ecological attitude, climate awareness, and self-directed behavior— in spurring pro-environmental RFT behavior. The author further tests the link between awareness and conduct for the moderating impact of believed regulation efficacy. The findings point to an awareness-behavior gap regarding the environment. As a result, a high degree of perceived policy efficacy makes it easier for awareness to become behavior and closes the awareness-behavior gap. Wu & Madni (2021) research examines how well institutions preserve the environment in the chosen One Belt One Road (OBOR) economies. The article's primary objective was to find the cutoff point of institutional effectiveness that may reduce atmospheric CO2 emissions due to broad industrialization and transportation. According to the study's findings, the cutoff of institutional quality in the OBOR partner nations that have been chosen is 2.315. Hence, despite increasing industry and transportation, CO2 emissions do not significantly contribute to ecological deterioration if institutional quality exceeds the threshold level.

Methodology

Variables and Data Description

The current study examines the factors influencing sustainable transportation services in East Asian countries. The paper employs panel data from seven selected countries, namely China, South Korea, Japan, Indonesia, Philippines, Malaysia, and Singapore from 1997 to 2021. The reason behind considering these countries is that the transportation sector is a crucial driver of economic growth in East Asia, accounting for a significant portion of GDP and providing employment opportunities. Bastiaanssen et al. (2020) note that the recent development of transportation in Asian countries has substantiated the sector's capacity to foster job creation directly and indirectly. The transportation sector generated employment across various remote regions and industries by facilitating efficient logistics, enabling trade connectivity, and underpinning urban mobility. Additionally, it stimulated demand for specialized roles in infrastructure development, operations, maintenance, and ancillary services.

Investigating this sector can provide insights into how it can be further developed to promote economic growth and prosperity. Additionally, the transportation sector is a significant source of East Asia's greenhouse gas emissions and air pollution (Huang, 2021; Khan, 2019). Investigating this sector can provide insights into how it can be made more sustainable, such as using electric vehicles, active transportation, and improved public transportation. Within this context, the study uses transportation services as a dependent variable. Further, several indicators, such as CO2 emission, trade, FDI, and natural resources, are nominated as regressors. Notably, governance quality was used as a moderating factor to affect the strength or direction of the relationship between the independent and dependent variables. The data are extracted from World Development Indicators. To proceed with the study, the paper performed the Common Correlated Effects of Augmented Autoregressive Distributed Lag mode (CS-ARDL). The model is helpful because it accounts for common factors or cross-sectional dependence across different units (Baltagi & Hashem, 2007), such as countries or regions. This is achieved by including additional variables in the model known as common factors or common correlated effects. Next, the Dumitrescu and Hurlin panel causality test is performed to capture the long-run and short-run dynamic relationship among the variables. It also helps determine whether changes in one variable are likely to cause changes in another or whether the relationship is bidirectional or spurious (Wooldridge, 2010).

Table 1: Variables' Description

Variable	Abbreviation	Description	Measurement
Dependent	TP	Transportation	Transport services (% of service exports, BoP)
Moderating	IQ	Institutional Quality	Government Effectiveness: Estimate
Independent	I1	CO2 emission	CO2 emission (metric tons per capita)
	I3	Trade performance	Trade (% GDP)
	I5	Natural resource	Adjusted savings: natural resources depletion (% of GNI)
Controlling	FDI	FDI inflows	Foreign direct investment, net inflows (% of GDP)

The promotion of sustainable mobility will significantly influence the choice of sites for distribution centers and enterprises and places for people to live and work. Even the location of services for shopping and entertainment will be impacted. This strategy will meet the competing needs of promoting social cohesion and balanced spatial expansion, fostering economic growth, and improving environmental and health preservation. Providing the necessary conditions for sustainable mobility will also be a continual priority. However, for that to transpire, several factors should be considered.

Existing literature explores how institutional reforms and quality improvements can enhance transportation systems. For instance, Wilson et al. (2005) conducted a study assessing various aspects of transport facilitation, such as port facilities, customs procedures, regulatory framework, and service sector infrastructure. Their findings indicate that enhancing these aspects, particularly regulatory practices would significantly benefit import and export activities. The relationship between trade and transportation infrastructure is also established as a co-dependent variable. A well-functioning trade system can propel the advancement of the transportation sector, as highlighted by Ismail & Mahyideen (2015).

Moreover, several researchers emphasize the significance of transitioning to electric cars to expedite environmental sustainability and reduce CO2 emissions. Noteworthy studies in this context include Rojas-Rueda et al. (2017) and Loeb et al. (2018). Another study examining the connection between FDI and transportation services found that FDI inflows are crucial to the stability of the infrastructure (Akpan et al., 2014).

Hence, the present study examines the impact of environmental variables like CO2 emissions and natural resources, along with two macroeconomic indicators—trade and foreign direct investment—on transportation services. The quality of institutions further moderates the influence of the latter set of factors. The study follows the moderating model of previous studies in the context of econometrics based on interactions (Hunjra et al., 2020; Saha & Yap, 2014). The adopted conceptual model for the study can be seen in Figure 1.

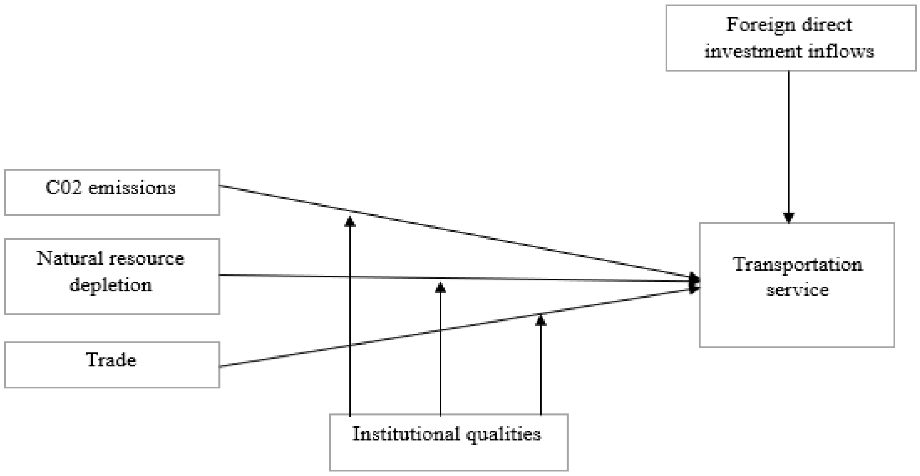

Figure 1: The Conceptual Framework of The Study

Econometric Model

In the study, co-integration and causality analyses were carried out first of all. Dumitrescu-Hurlin, Westerlund, and CS-ARDL co-integration tests were applied among the co-integration tests. The Granger non-causality causality test developed by Dumitrescu-Hurlin (2012) causality tests are included in causality. The following equation describes the study framework:

$$TP = \int (I1, I3, I5, FDI) \tag{1}$$

CS-ARDL

The second-generation cross-sectional augmented autoregressive distributed lag model was used in this study as the third co-integration test to examine both long-run and short-run models (Chudik & Pesaran, 2015). This method has a few advantages, such as providing a solid forecast, accurate results, and assessing the mean group with different slope coefficients (Usman et al., 2022). The CS-ARDL based on the mean group is an enhanced version of the ARDL model that uses average cross-sectional estimates for each cross-section as a proxy for unobserved common factors and their lags. In addition, this strategy works well when homogeneity is poor. The following equation can represent the CS-ARDL. The equation for the model is expressed as:

$$H_{i,t} = \sum_{l=0}^{Pw} \gamma_{l,i} W_{i,t-1} + \sum_{l=0}^{Pz} \beta_{l,i} Z_{i,t-l} + \varepsilon_{i,t} \tag{2}$$

The following equation belongs to autoregressive distributed lag (ARDL). By employing cross sections, Equation 2 is modified. This is created to eliminate unwarranted criticism of CD (Chudik & Pesaran, 2015).

$$H_{i,t} = \sum_{l=0}^{aw} \gamma_{l,i} H_{i,t-1} + \sum_{l=0}^{az} \beta_{l,i} Z_{i,t-l} + \sum_{l=0}^{ax} \alpha'_{i,} I\bar{X}_{t-l} + \varepsilon_{i,t} \tag{3}$$

$$TP = \alpha_{it} + \sum_{j=1}^{P} \beta_{it} TP_{i,t-j} + \sum_{j=0}^{P} \gamma_{it} X_{t-j} + \sum_{j=0}^{3} \delta \bar{Y}_{t-j} + \varepsilon_{it} \tag{4}$$

The CS-ARDL approach uses short-run values to estimate long-run values. The following are the equations for the mean-group (MG) estimator and long-run values:

$$\grave{\varphi}_{MG} = \frac{1}{N}\sum_{i=1}^{N}\grave{\varphi}_i$$
$$\hat{\varphi}_{CS-ARDL,i} = \frac{\sum_{l-0}^{pz}\rho_{I,i}^{pw}}{1-\sum_{l=0}}\widehat{\gamma_{l,l}} \tag{5}$$

The short-run equations look like this:

$$\Delta H_{i,} = s_i[H_{i,-1} - \varphi_i Z_i] - \sum_{i=1}^{a_{i-1}}\gamma_{li}\Delta_l H_{i,-1} + \sum_{i=1}^{a_{l-1}}\beta_{li}\Delta_l Z_{i,} + \sum_{i=0}^{a_i}\alpha_{i,}^{'} l\bar{X}_{t-1} + \varepsilon_{i,}$$
$$where\ \Delta_I = t-(t-1)$$
$$\hat{\delta}_i = -(1-\sum_{l=1}^{a_w}\hat{\gamma}_{I,t})$$
$$\varphi_i = \frac{\sum_{I=0}^{az}\beta_{I,i}^{aw}}{\hat{\delta}_i} \tag{6}$$
$$\grave{\bar{\varphi}}MG = \frac{1}{N}\sum_{i=1}^{N}\hat{\varphi}$$

Cross section Dependence

Recognizing the cross-sectional dependency (CD) to obtain accurate estimates from a panel data analysis is crucial. Considering the situation where a shock in one country's variable influences the same variable in other nations, we can use this example to explain the notion of CD. The findings might result in erroneous predictions if the CD is not considered in the model. Hence, appropriate econometric procedures that consider CD should be used to provide estimates that can be trusted. In this respect, the current work offers an estimating approach that may handle CD-related concerns in addition to diagnosing cross-sectional dependency. To examine the relationships between the cross-sectional units, the study used a variety of cross-sectional dependence tests, including the Breusch-Pagan LM test created by Breusch & Pagan (1980), the Pesaran scaled LM test developed by Pesaran (2007), and the Pesaran CD test proposed by Pesaran (2021). The equation below represents the model.

$$CD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{i=0}^{N-1}\sum_{j=i+1}^{N}pij\right)} \tag{7}$$

In the equation, CD stands for cross-sectional dependency, N represents the frequency of cross-sections, T indicates the approximate time, and the correlation between i and j cross-sectional error.

Westerlund Test

This study also employs the panel co-integration test developed by Westerlund in 2007. It is used since the model includes both cross-sectional dependence and heterogeneity. Using bootstrapping, this test can produce unbiased estimates even in cross-sectional dependence. The test can be used with a heterogeneous population and an unbalanced panel. Also, it has the benefit of using the error correction model instead of a residual-based estimation (Westerlund, 2007). The following model forms the basis of the Westerlund (2007). Westerlund test is expressed as follows and makes the following assumptions:

$$\Delta x_{it} = \theta_i d_i + \pi_i (x_{it} - \grave{\beta}_i y_{it-1}) \sum_{j=1}^{m} \pi_{ij} \Delta x_{it-j} + \sum_{j=0}^{m} \varphi_{ij} \Delta x_{it-j} + \mu_{it} \quad (8)$$

The error correction coefficient (π_i) is calculated using the ordinary least squares approach. G_1 and G_2 test the H_0: π_i =0 for all i against the H1: π_i <0 some i. If the H_0 is rejected, it shows the co-integrating link for at least one cross-sectional unit.

Panel Unit Root Test

Regression of non-stationary data without cointegration may provide erroneous regression. So, it is crucial to determine the correct sequence for integrating the variables. We may do a few tests to see if the panel data remains constant. For instance, Maddala & Wu (1999) and Choi (2001) modified all the first-generation panel unit root tests. Nevertheless, the fundamental drawback of these tests is their inability to account for CD faults, which is why they are sometimes referred to as first-generation panel unit root tests. So, we tested the unit root of each time series using Cross-section Augmented Dickey-Fuller (CADF) and Cross-section Im-Pesaran-Shin (CIPS) tests. The formula for the unit root is:

$$X_{it} = \delta_{it} + \vartheta_{ixit-1} + \gamma_i T + \sum_{i=1}^{n} \pi_{ij} \Delta_{xij-j} + \varepsilon_{it} \quad (9)$$

Based on equation (9) represents the regressors, is the intercept, T shows the period, Δ denotes the difference operative, and signifies the error term.

Panel Causality Test

The Dumitrescu-Hurlin panel causality test was employed in the current experiment because of its advantage over the conventional Granger causality test in the scenario of CD and slope non-linearity. Relatively homogenous non-causality is the default assumption for the Dumitrescu-Hurlin causality test. In order to dismiss the null hypothesis and conclude that the regression coefficient under consideration causes the dependent variable, a substantial p-value of the z-statistic is required (Dumitrescu & Hurlin, 2012).

$$\Delta Y_{it} = \alpha_i + \sum_{j=1}^{j} \lambda_i^{(j)} Y_{i,t} + \mu_{it} \quad (10)$$

In Equation (10), j is the ideal lag period, and X and Y are the parameters used to evaluate causality. This test was employed to determine if X produces Y or not.

The Initial Model without the Moderation Equation

TPit is the variable of interest (transportation or *TP*) for entity *i* at time *t*. *X*1*iqi,t*−*j* , *X*1*i*,*t*−*j*, *X*3*i*,*t*−*j*, *X*5*i*,*t*−*j*, and *XFDIi*,*t*−*j* represent the lagged values of IQ, 1/1, 3/3, 5/5, and *FDI* respectively for entity I at time *t*−*j*. *αi* is the entity-specific intercept. *B*iq*j*, *β*1*j*, *β*3*j*, *β*5*j* , and *βFDIj* are the coefficients associated with the lagged variables. *γk* are the coefficients associated with the lagged values of the dependent variable *TP*. *εit* is the error term for entity *i* at time *t*.

The Adopted Model with The Moderation Effect

The moderating influence of institutional qualities can be elucidated through their interactive effects on the chosen variables. Following the establishment of these interactive effects, the ultimate determination of the influence of independent variables on transportation is achieved by considering their moderation by the quality of institutions. Therefore, the equation is as follows:

$$TP_{it} = \alpha i + \sum\nolimits_{j=0} p\beta_{1j} X_i q,_{t-j} + \beta_{3j} X_{1i,t-j} + \beta_{3j} X_{3i,t-j} + \beta_{5j} X_{5i,t-j} + \beta FDI_j XFDI_{i,t-j} + \sum\nolimits_{k+1} q\gamma k TP_{i,t-k} + \varepsilon_{it} \quad (11)$$

Mit−l represents the moderation term, which is the integrated value of *TP* for entity I at time *t–l*. *IQ, 1I1, 3I3, 5I5, and FDI* denote institutional quality, CO2 emissions, trade performance, natural resource depletion, and FDI inflows. At the same time, the * presents the interaction effect of (CO2 emissions, trade performance, natural resource depletion, and FDI inflows) with institutional qualities, and TP is the dependent variable that denotes transportation.

Empirical Findings

The statistical information guided the regulators' trend analysis throughout the period and allowed them to investigate the factors that impacted the dependent variables thoroughly. The factors' statistical characteristics are shown in Table 2. The percentage of transport services varies from 49.9% to 0.07%, with an average of 22.63%. The distribution is negatively skewed, with a kurtosis of 2.07% and a standard deviation of 0.09%. In Japan, environmental taxation has an average value of 1.50%, an upper limit of 1.68%, and a lower limit of 2.03 percent.

Additionally, the findings reveal a positively skewed distribution for all the variables. The low standard deviation value for all the variables indicates that data are clustered around the mean except for I3. The correlating matrix is another critical technique for obtaining inferences between elements before being examined. In Table 2, the results indicate that all variables positively correlate with transport services. Except for the interaction effect of natural resources and institutional quality. Which demonstrated a moderate negative association with transport services.

Table 2: Overall statistics

Descriptive statistics					
	TP	**I1**	**I3**	**I5**	**FDI**
Mean	22.63533	7.139382	148.7741	0.989348	4.300793
Maximum	49.93971	22.04349	1060.967	14.64785	29.69044
Minimum	0.072721	-0.919936	-66.80299	-3.459989	-2.757440
Std. Dev.	12.90598	7.112425	264.3223	3.206959	6.763460
Skewness	0.274722	0.418901	1.916511	2.332616	2.271961
Kurtosis	2.035541	1.761258	5.202771	8.211027	7.039793
Jarque-Bera	8.983841	16.30704	142.5102	356.7024	269.5522
Observations	175	175	175	175	175
Correlation Matrix					
	TP	I1	I3	I5	FDI
TP	1.000000	0.699955	0.482532	-0.091439	0.323976
I1	0.699955	1.000000	0.738947	0.049898	0.560801
I3	0.482532	0.738947	1.000000	0.081494	0.894769
I5	-0.091439	0.049898	0.081494	1.000000	-0.018039
FDI	0.323976	0.560801	0.894769	-0.018039	1.000000

In the study, first of all, the cross-section dependency test of the panel data set was carried out. Table 4 shows the results of the Pesaran (2015) CD test. According to the table, there is a cross-section dependency for each panel data. In Table 3, the results of Pesaran & Yamagata (2008) and Blomquist & Westerlund (2013) slope homogeneity tests require rejecting the null hypothesis of slope homogeneity for the analyzed variables. Accordingly, there is heterogeneity for I1, I3, I5, and FDI in East Asian countries.

Table 3: Testing for Slope Homogeneity

Slope Homogeneity	
Delta (Pesaran and Yamagata 2008)	6.872***
Hac Delta (Blomquist and Westerlund 2013)	3.964***

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

The rejection of the null hypotheses indicates that the residuals are cross-sectionally dependent, according to the four distinct tests for cross-sectional dependence used in Table 4 (Akın, 2019). The results show that the independent cross-section null hypothesis is firmly dismissed for all variables, indicating that cross-sectional dependence exists. It implies that a disruption occurring in one of the East Asian nations might have an economic ripple effect on the other economies. From an inference process, this result enables us to carry out tests and calculations that are more suitable in the subsequent stages of the empirical investigation (Henningsen & Henningsen, 2019).

Table 4: Testing for Weak Cross-Sectional Dependence (CSD)

Variables	CD	CDw	CDw+	CD*
TP	6.220***	6.220***	55.080***	16.990***
	(0.000)	(0.000)	(0.000)	(0.000)
I1	9.000***	9.000***	68.000***	21.620***
	(0.000)	(0.000)	(0.000)	(0.000)
I3	8.320***	8.320***	64.220***	4.670***
	(0.000)	(0.000)	(0.000)	(0.000)
I5	2.140**	2.140***	38.970***	6.000***
	(0.033)	(0.033)	(0.000)	(0.000)
FDI	16.600***	5.600***	25.710***	2.530**
	(0.000)	(0.000)	(0.000)	(0.011)

p-values in parenthesis. ***, **, and * indicate significance at 1% and 5%, and 10% level respectively
CD: Pesaran (2015, 2021), CDw: Juodis, Reese (2021), CD*: Pesaran, Xie (2021)

Based on Table 5, given that the prob value suggests a 1% significant level in the standard sample, it ascertains the presence of cross-sectional dependence between the indicators evaluated in this study.

Table 5: Cross-Sectional Dependence (Csd) Test for The Common Sample

Cross-sectional dependence (CSD) tests		
Test	T-stat	Prob.
Breusch-Pagan LM	140.0606 ***	0.0000
Pesaran scaled LM	18.37146 ***	0.0000
Pesaran CD	6.078673 ***	0.0000

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

The fact that cross-sectional dependency between the panels has been confirmed shows that conventional methods for testing the unit root are invalid. As a result, we used a second-generation unit root test (CIPS and CADF) to validate the data series' integration order. Results from Table 6 show that all variables are stationary at the first difference, which both CADF and CIPS supported. As a result, we may use the cointegration approach to validate the long-term association among factors since the integration order of all the variables is the same (first difference).

Table 6: The Results of Second-Generation Panel Unit Root Tests

Variables	CIPS stats (Constant)		CADF stats (Constant)	
	Levels	First Difference	Levels	First Difference
TP	-0.384	-3.766***	-0.959	-3.245***
I1	-1.602	-4.928***	-1.289	-3.217***
I3	-1.557	-4.964***	-1.346	-3.843***
I5	-1.317	-5.042***	-0.993	-4.044***
FDI	-2.911***	-5.695***	-2.608**	-4.606***

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

Since transport services, the interaction of natural resources, CO2, and trade with institutional quality and FDI are I(1) variables, the study uses a panel cointegration test to explore the long-run relationships among these variables. The results of Table 7, where we used both the Westerlund and Kao tests for cointegration, support long-term association at less than 5%, which is a significant level. Hence, both first-generation and second-generation cointegration tests support the validity of the long-run equilibrating connections among the variables under consideration.

Table 7: Cointegration Tests

Westerlund test for cointegration		
Statistics	T-statistics	Prob
Variance ratio	2.3097**	0.0105
Kao test for cointegration		
Statistics	T-statistics	Prob
ADF	-1.665990**	0.0479

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

After confirming the long-term relationship between transport services and other independent variables in East Asian countries with Westerlund's and Kao panel co-integration tests, long-term and short-term elasticities were tried to be measured with the CS ARDL method. The significance of the co-integration vector confirms the long-term balance between the variables in the model. The findings from Table 8 are summarized below. Starting with the long-run estimates, the findings reveal that FDI inflows negatively affect transportation services in East Asian countries. For instance, a 1% increase in FDI inflows decreases transportation services by 3.7%. Next, the short-run estimates indicate that the interaction between institutional quality and CO2 positively affects transportation services. For example, in East Asian countries, a 1% increase in the variable above causes a 2.5% increase in transportation. Additionally, a 1% rise in the interaction between trade and institutional quality leads to a 0.10% decrease in transport services. Finally, the rest of the variables presented insignificant influence on transportation.

Table 8: (Dynamic) Common Correlated Effects Estimator - (CS-ARDL)

Short-Run Estimates				
Variables	Coef.	Std.Err.	z	P>z
TP	0.475**	0.196	2.420	0.016
I5	321.317	319.326	1.010	0.314
L.I1	2.586*	1.465	1.770	0.078
L.I3	-0.107**	0.052	-2.070	0.038
L.FDI	-0.461	0.668	-0.690	0.490
ECT (-1)	-0.525***	0.196	-2.680	0.007
Long-Run Estimates				
FDI	-3.780**	1.913	-1.980	0.048
I1	-2.498	10.413	-0.240	0.810
I3	-0.127	0.149	-0.860	0.392
I5	516.210	521.193	0.990	0.322
F(112, 49)	0.44	R-squared (MG)		0.65
Prob > F	1.00	Root MSE		1.87
R-squared	0.50	CD Statistic		-1.97

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

Table 9: Dumitrescu Hurlin for Causality Test

Null Hypothesis:	**W-Stat.**	**Zbar-Stat.**	**Prob.**	**Direction**
I1 does not homogeneously cause TP	3.75369	1.55938	0.1189	No Causality
TP does not homogeneously cause I1	1.38533	-0.89670	0.3699	
I3 does not homogeneously cause TP	5.05063***	2.90436	0.0037	Unidirectional
TP does not homogeneously cause I3	0.91633	-1.38306	0.1666	
I5 does not homogeneously cause TP	2.04404	-0.21359	0.8309	Unidirectional
TP does not homogeneously cause I5	4.74270***	2.58502	0.0097	
FDI does not homogeneously cause TP	2.07224	-0.18434	0.8537	Unidirectional
TP does not homogeneously cause FDI	4.80129***	2.64578	0.0082	

***, **, and * indicate significance at 1% and 5%, and 10% level respectively

The causal relationship between two indicators cannot be determined using the CS-ARDL approach despite it predicting the long-run elasticities. Consequently, the Dumitrescu-Hurlin Panel Causality test was run as part of the current investigation to examine the causative link between the variables. Moreover, due to the presence of cross-sectional dependence in the panel, Dumitrescu-Hurlin for causality is considered the most appropriate (Rahman, 2023). The findings are documented in Table 9. After observing the results, we perceive various unidirectional causality among the variables. For instance, we conclude that one-way causality runs I3 to TP, TP to I5, and TP to FDI. This suggests that FDI and the interaction between institutional quality, trade, and renewable energy depletion have a causal association with transportation. The interaction between institutional quality and CO2 revealed no prominent causal influence on transportation.

Discussion and Policy Implication

Transportation services in East Asian countries have developed significantly over the past few decades, particularly in China, Japan, South Korea, Taiwan, and Singapore. These countries have made substantial investments in their transportation infrastructure to meet the growing demand for transportation services, both domestically and internationally. In this research, we will examine the transportation services in East Asian countries, their challenges, and the measures they have taken to overcome them. One of the critical features of transportation services in East Asian countries is the high level of integration and efficiency. This has been achieved through advanced technology, such as high-speed rail, automated subways, and intelligent transportation systems. In particular, China has been a leader in developing high-speed rail, with the world's largest high-speed rail network covering over 37,000 km. Japan has also pioneered the development of automated subways, with Tokyo's world's first fully automated metro system.

However, despite the advances in transportation services, challenges still need to be addressed. One of the biggest challenges is the rapid urbanization in these countries, which has resulted in increased traffic congestion and air pollution. Many East Asian countries have implemented policies to promote public transportation and reduce the number of cars on the road (Yi & Shirk, 2018). For example, in Beijing, the government has introduced restrictions on the number of cars allowed on the road based on their license plate number. Another challenge is the aging infrastructure, particularly in Japan and South Korea, which requires significant investment to upgrade and maintain. The high cost of transportation infrastructure also poses a challenge for many countries in the region, particularly those with limited financial resources (Rojas-Rueda et al., 2017). To address this, many countries have turned to public-private partnerships to finance transportation projects.

Despite these challenges, the transportation services in East Asian countries continue to improve, with new projects and initiatives being launched regularly. For example, China is currently developing the Belt and Road Initiative. This massive infrastructure project aims to connect China with over 70 countries in Asia, Europe, and Africa through a network of roads, railways, and ports (Lai et al., 2019).

Accordingly, the paper assesses the factors influencing transportation services in selected East Asian countries. Notably, factors such as CO2 emission, trade, natural resources, and FDI are selected. Additionally, the role of institutional quality was considered a moderating factor. Based on this, the findings revealed that in the long-run, FDI inflows negatively affect the transportation services in East Asian countries. A rational justification behind this outcome could be that FDI can increase competition in the transportation sector, displacing domestic firms. Multinational corporations (MNCs) can use their size and resources to outcompete domestic firms, leading to the concentration of market share and reduced competition. This can result in higher consumer prices and reduced incentives for domestic firms to innovate and improve their services. For example, foreign airlines may have more resources and bargaining power in the airline industry to negotiate landing slots and pricing with airports, leading to less favorable conditions for domestic airlines. Samir & Mefteh (2020) also brought attention to a comparable discovery. The writer notes that communication technologies and transportation play a role in stimulating foreign direct investment, albeit primarily in developed countries. However, this correlation might not hold for emerging nations, where inadequate transportation infrastructure could undermine this connection. The attainment of sustainable development goals is linked with the investment and development of energy and transportation infrastructure. When directed towards the transportation sector, the sufficient accumulation of foreign direct inflows by relevant governing bodies has the potential to curtail CO2 emissions. This is due to the prospect of external funding mechanisms that the government can access. The results align with (Zhuang et al., 2022; Shahbaz et al., 2021).

Next, FDI can result in regulatory capture, where foreign investors use their influence to shape regulations in their favor, leading to reduced competition and lower quality of services. In some cases, foreign investors may pressure governments to relax regulations or lower standards to reduce costs, leading to lower safety standards and reduced environmental protections (Rehman et al., 2020). This can negatively affect consumers and the environment and undermine the transportation sector's long-term sustainability. Finally, FDI can result in losing local expertise and knowledge as domestic firms are displaced by foreign firms. This can negatively affect the quality and efficiency of transportation services, as foreign firms may need to be more familiar with local customs, infrastructure, or regulations. This can result in delays and increased costs as foreign firms adapt to the local market.

Moreover, the short-run estimates indicate that the interaction between institutional quality and CO2 positively affects transportation services. As an illustration, institutional quality can affect the efficiency of transportation services by improving the regulatory environment. Good institutional quality can provide a stable regulatory environment that encourages private investment, innovation, and competition in the transportation sector (Chakraborty, 2006). This, in turn, can lead to the development of more efficient transportation systems better equipped to handle the challenges of rising CO2 emissions. For example, countries with solid institutional quality may be more likely to implement policies such as congestion pricing or investment in public transportation, which can help reduce emissions while improving transportation services. Secondly, good institutional quality can encourage the development of sustainable transportation infrastructure. Institutional quality can provide the legal and regulatory framework to promote sustainable transportation infrastructure, such as low-emission vehicles, clean fuels, and renewable energy sources. This can help reduce the carbon footprint of transportation services and improve air quality while improving the efficiency and reliability of transportation services.

Lastly, adequate institutional quality can encourage the adoption of environmentally friendly transportation technologies. For example, countries with strong intellectual property rights protection and effective regulatory oversight may be more likely to adopt and develop new technologies, such as electric or hybrid vehicles, that reduce carbon emissions. This can help improve transportation services' sustainability while promoting innovation and technological development. However, research like Hussain et al.(2023) found that transport expenditures increase transport–carbon intensity by 45% in the long-run. Indeed, the positive effect of investment in transportation on economic growth is non-negotiable Banister & Berechman (2017), but its retrospective negative effect on the environment is also undeniable (Tuzkaya, 2009; Saidi & Hammami, 2017). Anwar et al.,2020 Nevertheless, when the institutional factor is considered about CO2 emissions, its adverse impact diminishes. To put it differently, the substantial emissions from the transportation sector could be mitigated by establishing robust institutional frameworks that advocate for the advancement of sustainable mobility as a priority (Stead, 2008).

Furthermore, the short-run estimates uncovered that the interaction between trade and institutional quality leads to a 0.10% decrease in transport services. This can be explained by poor institutional quality leading to corruption and a lack of transparency, discouraging foreign investment and trade in the transportation sector (Abe & Wilson, 2008). This can reduce competition and innovation in the sector, leading to lower quality and higher consumer prices. In addition, poor institutional quality can result in limited access to financing and technology, further limiting the ability of domestic firms to compete with foreign firms. Moreover, better institutional quality can lead to effective regulation and enforcement, particularly regarding safety and environmental standards. This can result in lower quality and reliability of transportation services, as firms may need to pay more attention to safety and environmental regulations to reduce costs and gain a competitive advantage. In addition, weak regulation and enforcement can lead to a lack of accountability and responsibility, making it challenging to hold firms accountable for poor performance or environmental damage. The current findings are in contrast to vein (Seck, 2017). Governmental bodies and competent authorities may temporarily set aside sustainability objectives in favor of trade endeavors, mainly focusing on boosting exports. While this approach could have implications for the maritime environment, it could slow a nation's progress toward sustainable transportation goals, driven by the heightened emphasis on trade reliance.

Finally, the findings for causal relationships documented various unidirectional causality among the variables. For instance, we concluded the presence of a one-way causality between FDI and the interaction between institutional quality, trade, and renewable energy depletion with transportation. The interaction between institutional quality and CO2 revealed no prominent causal influence on transportation.

East Asia faces significant challenges in improving its sustainable transportation system. However, several policy implications can help to address these challenges and improve sustainability in the region's transportation sector. As a starting point, East Asian countries can promote investment in sustainable transportation infrastructure, such as mass transit systems, bike lanes, and pedestrian walkways. This will help to reduce the reliance on private cars and promote sustainable modes of transportation, thereby reducing greenhouse gas emissions and improving air quality. Second, East Asian countries can encourage using electric vehicles (EVs) by providing incentives such as tax exemptions, subsidies, and charging infrastructure (Wu et al., 2019). This will help to reduce the reliance on fossil-fuel-based vehicles, thereby reducing greenhouse gas emissions and improving air quality. Third, East Asian countries can promote public-private partnerships to develop and implement sustainable transportation initiatives (Yushi & Borojo, 2019). This will help leverage the private sector's resources and expertise to promote sustainable transportation and create economic opportunities. Fourth, East Asian countries can strengthen regulatory frameworks to promote sustainable transportation, including safety and environmental standards. This will help ensure that transportation services are provided safely, efficiently, and environmentally sustainable. Finally, considering the case of the Netherlands, East Asian countries can promote active transportation, such as walking and cycling, by providing infrastructure such as bike lanes and pedestrian walkways. This will help to reduce congestion, improve air quality, and promote physical activity. Encouraging telecommuting: East Asian countries can encourage telecommuting, or remote work, to reduce the need for commuting and promote sustainable transportation. This will help to reduce traffic congestion, improve air quality, and promote work-life balance.

Conclusion

Achieving sustainable transportation by governments is critical to addressing the challenges of climate change, air pollution, and energy security. Governments are responsible for providing safe, affordable, and accessible transportation for their citizens while minimizing the negative impacts on the environment and public health. Sustainable transportation policies and investments can help reduce greenhouse gas emissions, improve air quality, promote public health, and support local economic development and social equity. By the following statement, the current paper aims to examine the relationship between several factors, namely, c02 emission, natural resource depletion, trade, foreign direct investment inflows, and transportation services. The study included institutional qualities as a moderating variable among these relationships. In order to explore the data, the study used a CS-ARDL method and the dumitrescu-hurlin causality test.

According to the findings, the interaction between institutional qualities and CO2 emission positively affects transportation services, implying that the negative ad-hoc impact of CO2 emission coming from transportation sectors is reversed by the level of institutional performance by adopting green policies. On the other hand, the interactive relation between institutional qualities and trade is negatively associated with transportation services, whereas natural resource depletion and FDI inflows project negative results. However, for the causality test, a direct effect going from trade to transportation services has been recorded; similarly, transportation is unidirectionally related to the level of natural resource depletion and trade. Some prominent implications can be noted from these findings. First, effective institutions can provide policy frameworks, regulations, and incentives to encourage sustainable transportation practices, such as promoting low-emission vehicles and alternative transportation modes. They can also encourage investment in sustainable transportation infrastructure, such as bike lanes, public transit systems, and charging stations for electric vehicles. Strong institutional qualities, such as transparency, accountability, and public participation, can also facilitate the implementation of sustainable transportation policies and ensure that they benefit all members of society, especially those most vulnerable to climate change and air pollution.

Additionally, it is recommended that a green solution be proposed for national resource depletion due to the increase of over-usage to attain sustainable transportation and overcome the traditional transportation system that degrades the environment. Finally, foreign direct investment should be directed toward environmentally friendly transportation activities by providing attractive portfolios for investors to invest in green transportation. However, it is essential to acknowledge certain constraints within the scope of this paper. Initially, our study employs a limited set of variables, specifically focusing on environmental and sustainability aspects. Future research endeavors could enrich the analysis by incorporating a broader spectrum of environmental indicators, such as ecological footprint measurements and metrics related to renewable energy consumption.

Additionally, adopting a country-level viewpoint is a possible direction to go. This method acknowledges the diversity of environmental problems and infrastructural development among various Asian countries. Third, neither the theoretical model nor the empirical estimation addresses the issue of transportation sustainability because the study needs to distinguish between private and public transportation ownership capital. Due to the limitations of the currently available data, our study is forced to use the Transport services (% of service exports, BoP) variable as a stand-in for transportation sustainability while ignoring other vital industries like water, irrigation, and other transportation-related characteristics. A more sophisticated representation of sustainability factors may be produced in further research using larger datasets covering various areas. Finally, our empirical models are based on the CS-ARDL model; therefore, future research could employ other models to overcome the econometric limitation.

Declaration

The article is based on the author's view supported by available data.

Conflict of Interest

There is no conflict of interest.

Availability of Data and Materials

All data are publicly available from the original source and online.

Authors' Contribution

Both authors contributed to the development of the article.

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