JRSSEM 2026, Vol. 5, No. 10
E-ISSN: 2807 - 6311
P-ISSN: 2807 - 6494

Correlation Analysis of the Logistic Performance Index (LPI) and Environmental Quality in Asia-Pacific Countries, 2010–2022

Agus Suhery Sinaga*, Widyono Soetjipto
Universitas Indonesia,
Email: suhery.agus@gmail.com*, widyono.soetjipto@ui.ac.id

Keywords:
ecological footprint (EF), logistic performance index (LPI), gross domestic product (GDP), foreign direct investment (FDI), trade (TRD)

Abstract
Improvements in logistics facilities and infrastructure have increased the volume of world trade transportation. On the other hand, increased trade transportation activities may have the potential to reduce environmental quality through emissions. Therefore, this study analyzes the relationship between logistics performance and environmental quality, which is approached by using the ecological footprint. Using a quantitative approach, this study employs panel data regression with a fixed effect model on data from 17 APEC member economies over the period 2010–2022. A robustness check is also conducted using quantile regression to evaluate the consistency of results across different data distribution quartiles.. The results of panel data regression with fixed effect model show that Logistic Performance Index (LPI) has a positive and significant effect on ecological footprint. These findings have important implications for sustainable development policy. Efforts to reduce environmental impact should focus on improving logistics performance in a sustainable manner that mitigates its impact to environmentally unfriendly economic growth.

INTRODUCTION

A country's economic growth is highly dependent on an efficient and well-planned logistics system. Research by Lee (2004) and Cheng-Min et al. (2006) shows that the development of logistics infrastructure plays a crucial role in increasing global trade volumes. Efficiency in logistics is not only vital for the distribution of goods and services globally but also drives economic activity by reducing costs and accelerating shipments, which ultimately contributes to industrial productivity. Countries with efficient logistics systems tend to attract more foreign investment and have greater export opportunities, thereby positively affecting patents, global competitiveness indexes, and gross domestic product (GDP) (Çelebi, 2021; Halaszovich & Kinra, 2020; Jayathilaka et al., 2022).

However, the importance of logistics is accompanied by significant environmental impacts, creating a paradox between logistics efficiency and environmental sustainability. Logistics activities generate pollutants and CO2 emissions that contribute to climate change and environmental degradation. Furthermore, the development of logistics infrastructure can damage habitats and biodiversity (Krstić et al., 2025; Lemmetty, 2024). This paradox underscores that improving logistics efficiency often increases total resource consumption, thereby requiring a more comprehensive approach to addressing the environmental impacts of logistics and achieving a balance between logistics performance and environmental sustainability.

This study proposes data from Asia-Pacific Economic Cooperation (APEC) countries as the object of the research. Based on data processed from the World Bank (2023), APEC is the dominant economic region in terms of logistics performance compared to other regional groups, as shown in Figure 1.

In addition, as a global forum, APEC countries are dominant contributors to greenhouse gas emissions, with per capita emission levels consistently much higher than the global average. Based on data for the 2011–2020 period, the per capita emissions of APEC countries ranged from approximately 7.4 to 7.9, while the global average ranged only from 4.2 to 4.7. This difference indicates that APEC's contribution to emissions exceeded the global average by more than two-thirds, reaching approximately 74.63% in 2020. This condition demonstrates that the role of APEC countries is highly significant in the dynamics of global climate change, thereby necessitating stronger commitments and policies to reduce emission levels (Tian et al., 2025; Zaidi et al., 2019; Zhang & Khan, 2024).

However, APEC has committed to achieving sustainable and inclusive economic growth, including through efforts to reduce greenhouse gas emissions. At the 27th APEC Summit held in Auckland in 2021, APEC leaders committed to achieving net-zero emissions by 2050.

This research focuses on the use of the ecological footprint as the primary indicator for comprehensively measuring environmental sustainability. Introduced by Mathis Wackernagel and William Rees in 1990, the ecological footprint measures the extent of productive land and water areas required to support human consumption relative to the availability of those resources. This concept is important for measuring and managing resource use at various levels and has received considerable attention in scientific debates related to environmental degradation. However, research related to the ecological footprint remains limited, especially studies highlighting specific environmental impacts such as CO2 emissions.

Furthermore, the primary independent variable in this study is the Logistics Performance Index (LPI). The LPI, first published in 2007, was developed to measure the efficiency of the logistics supply chain based on survey feedback from international freight forwarders and express carriers. This index and its components enable policymakers, including governments and businesses, to deepen their understanding of logistics performance and identify potential adjustments that may negatively affect competitiveness. The LPI acts as a macro-level indicator of logistics performance and its influence on national trade and economic growth. At the international level, the LPI helps countries identify challenges in trade logistics, formulate strategies, and explore opportunities for performance improvement, as described by Arvis et al. (2016).

The third variable, Foreign Direct Investment (FDI), has a diverse impact on environmental sustainability. Research by Baloch et al. (2019) showed that financial development and FDI increase the ecological footprint, while a meta-analysis by Demena et al. (2019) found that FDI can reduce environmental emissions depending on the specific conditions of each country. This signifies the complexity of the relationship between FDI and environmental sustainability, which requires in-depth analysis while accounting for influencing factors.

The relationship between Gross Domestic Product (GDP) and the ecological footprint is also an important area of research. Chen et al. (2016) found that countries with high GDP tend to have larger ecological footprints, suggesting that economic growth affects the environment

differently depending on income levels. The Environmental Kuznets Curve (EKC) hypothesis proposes an inverted U-shaped relationship between GDP and the ecological footprint, indicating that economic growth can improve environmental conditions after reaching a certain level of economic maturity.

Finally, trade openness has a significant impact on the environment, especially in the context of the ecological footprint. Research shows that trade openness can increase the ecological footprint, whereas renewable energy consumption can reduce it. This underscores the need for trade policies that consider environmental impacts to achieve a balance between economic growth and environmental sustainability, particularly in developing and emerging economies.

In the context of rapid economic growth in Asia-Pacific countries, this study critically evaluates the impact of economic progress—amplified by the expansion of logistics networks, foreign investment inflows, increases in GDP, and trade openness—on environmental balance. The primary focus is to examine the influence of the Logistics Performance Index (LPI) on the ecological footprint in Asia-Pacific Economic Cooperation (APEC) member countries using data from 2010 to 2022.

Previous studies on logistics performance and environmental indicators have largely focused on CO2 emissions rather than the more comprehensive ecological footprint, with limited research specifically targeting APEC countries—a region characterized by dominant logistics performance and high emission levels. Moreover, few studies have simultaneously analyzed LPI, FDI, GDP, and trade openness in relation to the ecological footprint (EF) using panel data and robustness checks such as quantile regression. The novelty of this study lies in its use of the ecological footprint as a holistic indicator, its focus on APEC countries during the 2010–2022 period, its application of fixed-effects panel regression with quantile regression robustness checks, and its examination of the Jevons Paradox in logistics efficiency. Accordingly, this study aims to analyze the relationship between logistics performance (LPI) and the ecological footprint in APEC countries, examine the effects of FDI, GDP, and trade openness on EF, and test whether the Jevons Paradox applies to logistics performance in the region. Theoretically, this research enriches the literature on sustainable logistics and environmental economics by integrating ecological footprint analysis with logistics performance analysis and by providing empirical evidence of the Jevons Paradox in an under-researched context. Practically, it offers policy insights for APEC governments and international organizations to design logistics improvements that mitigate environmental impacts through green logistics, renewable energy adoption, and sustainable trade policies.

RESEARCH METHOD

Based on the elaboration of the background and theoretical review, the conceptual framework in this study can be illustrated as follows

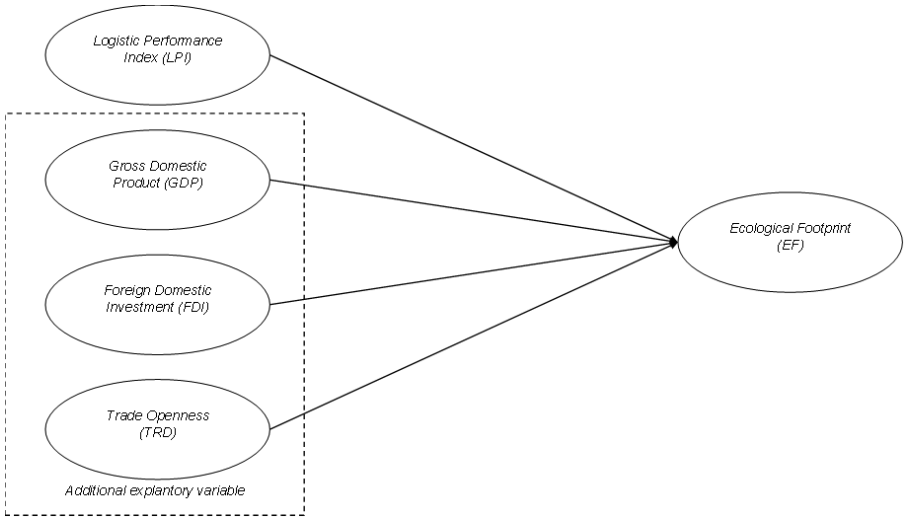

Figure 2. Research Conceptual Framework

Source: Author's data processing

Based on the conceptual framework and hypotheses that have been stated previously, the variables used in this study are as in Table 2

Table 1. Research Variable Data

Variable	Grade Categories	Units	Minimum scale	Maximum Scale	Period of project	Source
Ecological Footprint	Racing	GHA	0	∞	Annual	Open Data Platform (footprintnetwork.org)
Economic Growth	Racing	USD	0	∞	Annual	GDP Per Capita (World Bank)
Foreign Direct Investment	Racing	USD	0	∞	Annual	*Foreign Direct Investment* (World Bank)
Logistic Performance Index	Ordinal (Index)	-	1	6	Bi-Annual	Logistics Performance Index (LPI) (World Bank)
Trade Openness	Racing	Percentage	0	100	Annual	Trade (World Bank)

Source: Author's data processing

In overcoming the unavailability of Logistic Performance Index (LPI) data which is reported every two years and is not available for 2020 due to the Covid-19 pandemic, this study uses data interpolation techniques, specifically the cubic spline interpolation method, to obtain smooth annual data, following the approach of Mahpour et al. (2023). This approach was chosen based on the recommendations of McKinley et al. (1998), who suggested cubic spline interpolation as an effective method for subtly reflecting the movement of data. Further analysis using t-test and density plots between the interpolated data and the original data

showed no significant difference, confirming the validity of the interpolation technique used.

This study uses a panel data regression approach. By transforming all variables except Dummy Pandemic into a natural logarithmic form, the fixed effect mathematical model can be changed as follows:

$$\ln(EF_{\{it\}}) = \alpha_i + \beta_1 \ln(LPI_{\{it\}}) + \beta_2 \ln(FDI_{\{it\}}) + \beta_3 \ln(GDP_{\{it\}}) + \beta_4 \ln(TRD_{\{it\}}) + \beta_5 D_{PNDM\{it\}} + u_{\{it\}}$$

Where:

$\ln(EF_{\{it\}})$ is the natural logarithm of the Ecological Footprint in country i at time t; is an intercept that is specific to each cross-section, representing an unobserved fixed effect that might affect the natural logarithm of EF in addition to independent variables; is the natural logarithm of the α_i $\ln(LPI_{\{it\}})$*Logistic Performance Index* in country i at time t; is the natural logarithm of $\ln(FDI_{\{it\}})$*Foreign Direct Investment* in country i at time t; is the natural logarithm of $\ln(GDP_{\{it\}})$*the Gross Domestic Product* in country i at time t; is the natural logarithm of $\ln(TRD_{\{it\}})$*Trade Openness* in the country i at time t; is $DP_{\{it\}}$*a dummy pandemic* for country i at time t, where = 1 if period t is in a pandemic, and 0 if not; is an error term that represents other factors that affect the natural logarithm of EF that are not included in the model.$DP_{\{it\}}u_{\{it\}}$

This model assumes that the relationship between dependent and independent variables is *multiplicative* in their original form, meaning that the percentage change in the independent variable is associated with the percentage change in the dependent variable, adjusted for the fixed *effects of cross-section* and time factors. Logarithmic transformations help in normalizing the distribution of variables, reducing the impact of outliers, and facilitating the interpretation of coefficients as elasticity, i.e. the percentage change in a dependent variable to one percentage change in an independent variable.

RESULTS AND DISCUSSION

Research Results

Table 2. Descriptive Statistics

Variable	obs	Mean	Std. dev.	Min	Max
country_id	221	9	4.910	1	17
year	221	2016	3.750	2010	2022
ef	221	2.774	1.385	0.585	5.582
lpi	221	3.425	0.427	2.571	4.300
fdi *)	221	5.440	9.270	-4.000	51.100
gdp	221	24,636.910	21,895.270	1,684.012	82,807.650
trd	221	84.926	73.939	23.384	379.099
d_pndm	221	0.231	0.422	0.000	1.000
Ket. :*) in tens of billions of USD					

Source: Author's data processing results

Descriptive analysis revealed an average EF of 2,774 with a standard deviation of 1,385, indicating significant variation in resource consumption between countries, with Canada

having the highest EF in 2013, indicating excessive resource consumption, while the Philippines recorded the lowest EF, indicating sustainable resource use. For LPI, the average value was 3.425 with a standard deviation of 0.427, with Singapore recording the highest score in 2022, highlighting superior logistics performance, inversely proportional to Russia recording the lowest score in 2016. FDI showed an average of USD54.4 Billion with a standard deviation of USD92.7 Billion, with the United States recording the highest foreign investment in 2015, in contrast to the Russian Federation recording the lowest FDI value in 2022. GDP has an average of USD24.6 Billion with a standard deviation of USD21.9 Billion, where Singapore recorded the highest GDP value in 2022, while Vietnam recorded the lowest value in 2010. Lastly, the TRD has an average of 84,926 with a standard deviation of 73,939, with Singapore recording the highest TRD value in 2022, as opposed to Vietnam recording the lowest value in 2012.

In this study, the multicollinearity test was carried out by examining the correlation matrix between independent variables, which followed the guidelines of Gujarati (2006), with no indication of multicollinearity because the correlation coefficient between independent variables did not exceed the threshold of 0.90. Furthermore, the heteroscedasticity test using the Glejser method resulted in the conclusion that there were no symptoms of heteroscedasticity, reinforced by the results of the examination of p-values greater than 0.05 for each variable. For the selection of panel data regression models, the Chow test and Hausman test were carried out to determine the choice between Common Effect Model, Fixed Effect Model (FE), and Random Effect Model (RE). The results of the Chow test show a preference for the FE model based on a significant p-value, which is reinforced by the results of the Hausman test with a Prob value > chi2 = 0.0005, less than 0.05, indicating that the FE model is more suitable than the RE model for this analysis (Gujarati, 2006).

Tabel 3. ***Multicollinearity Test Result***

	ln_lpi	**ln_fdi**	**ln_trd**	**ln_gdp**	**d_pndm**
ln_lpi	1.0000				
ln_fdi	0.2705	1.0000			
ln_trd	0.1006	-0.0409	1.0000		
ln_gdp	0.7513	0.1231	-0.1055	1.0000	
d_pndm	0.0494	-0.1026	-0.0031	0.0525	1.0000

Source: Author's data processing results

Tabel 4. ***Heteroskedasticity Test Result***

abs_res	Coefficient	Std. err.	t	P>|t|	[95% conf. interval]	
ln_lpi	-0.0902592	0.0765695	-1.18	0.240	-0.2412509	0.0607325
ln_fdi	0.0024689	0.0014002	1.76	0.079	-0.0002922	0.00523
ln_trd	-0.0034043	0.0230118	-0.15	0.883	-0.0487825	0.0419739
ln_gdp	0.0223665	0.0177889	1.26	0.210	-0.0127125	0.0574455
d_pndm	0.0088813	0.0058377	1.52	0.130	-0.0026304	0.020393
_cons	-0.1092584	0.2136177	-0.51	0.610	-0.5305033	0.3119864
sigma_u	0.02865199					
sigma_e	0.03327193					
rho	0.42580622	(fraction of variance due to u_i)				
F test that all u_i=0: F(16, 199) = 3.43					Prob > F = 0.0000	

Source: Author's data processing results

Table 5. shows that the output of the heteroscedasticity test describes that there are no symptoms of heteroscedasticity because the prob. of each variable >0.05.

Tabel 5. ***Chow Test Result***

F(16, 199) = 170.20
Prob > F = 0.0000

Source: Author's data processing results

Tabel 6. ***Hausman Test Result***

chi2(5) = (b-B)'[(V_b-V_B)^(-1)](b-B)
= 21.90
Prob > chi2 = 0.0005
(V_b-V_B is not positive definite)

Source: Author's data processing results

Based on the results of *the chow test* and *hausman test*, the analysis model in this study is a *fixed effects model*, with the following estimated results:

Tabel 7. ***Sequential Estimation Results – Fixed Effect Model***

		Dependent Variable : ***Ecological Footprint***				
		(1)	(2)	(3)	(4)	(5)
(1)	ln_lpi	0.75406***	0.76073***	0.76593***	0.36898**	0.42888***
		(0.16315)	(0.16363)	(0.16401)	(0.14536)	(0.14100)
(2)	ln_fdi		-0.00221	-0.00240	0.00002	-0.00099
			(0.00312)	(0.00313)	(0.00266)	(0.00258)
(3)	ln_trd			0.03544	0.09623**	0.10592**
				(0.05130)	(0.04386)	(0.04237)
(4)	ln_gdp				0.28749***	0.33327***
					(0.03182)	(0.03276)
(5)	d_pndm					-0.04300***
						(0.01075)
Prob > F		0.0000	0.0000	0.0000	0.0000	0.0000

obs	221	221	221	221	221
R-Squared	0.37350	0.37690	0.32690	0.78700	0.79120
Standard Error is in parentheses					
p < 0.01; ** p < 0.05; * p < 0.1					

Source: Author's data processing

Estimation results from various regression models show that independent variables, including Logistic Performance Index (LPI), Foreign Direct Investment (FDI), Trade Openness (TRD), Gross Domestic Product (GDP), and Pandemic (PNDM), significantly affect the Ecological Footprint (EF), as shown by the Probability (F-statistic) which reaches a value of 0.0000 in all models. This signifies a rejection of the null hypothesis and the acceptance of an alternative hypothesis that the independent variables together have a significant effect on EF. The consistently increasing R-Squared value from model I to model V indicates that EF variation can be well explained by such independent variables.

Further analysis showed that LPI had a significant positive influence on EF in all models, confirming that an increase in LPI would increase EF. However, FDI did not show a significant effect on EF, suggesting that FDI had no significant effect on EF in all models tested. Meanwhile, GDP and TRD showed a significant positive influence on EF, stating that the increase in GDP and TRD contributed to the increase in EF. In contrast, PNDM had a significant negative influence on EF, suggesting that the existence of the pandemic contributed to the decline in EF.

This study also involves robustness check analysis using quantile regression to evaluate the consistency of regression results at various data distribution quartile points. The application of this method strengthens the validity and generalizability of the findings, by showing that the influence of independent variables on EF remains significant across various quantiles. In conclusion, these findings underscore the importance of considering LPI, GDP, and TRD variables in efforts to reduce EF, while highlighting that the impact of FDI on EF is not significant and that the presence of a pandemic has the potential to reduce EF.

Tabel 8. ***MM-QR regression results***

Variable	0.1 Coeff. (SE)	0.25 Coeff. (SE)	0.5 Coeff. (SE)	0.75 Coeff. (SE)	0.9 Coeff. (SE)
ln_lpi	.5599098** (.2472068)	.511661** (.1897808)	.4394814*** (.14538)	.3446153 (.2062709)	.2908812 (.2746232)
ln_fdi	-.0045721** (.001613)	-.0032523** (.0012434)	-.0012779 (.0009845)	.001317 (.0013442)	.0027868 (.0017764)
ln_trd	.1108657 (.0736613)	.1090459* (.0565194)	.1063235** (.0431762)	.1027455 (.0614535)	.1007188 (.0818802)
ln_gdp	.3008038*** (.0584389)	.31276*** (.0448708)	.3306463*** (.0343916)	.3541544*** (.0487668)	.3674699*** (.0649138)
d_pndm	-.0558889** (.0194601)	-.0511413*** (.0149457)	-.044039*** (.0114702)	-.0347044** (.0162405)	-.0294171 (.02161)

Source: Author's data processing

The results of the estimation using quantile regression present the influence of independent variables on the Ecological Footprint (EF) with diverse tendencies in various quantiles. The Logistic Performance Index (LPI) showed a significant positive influence on EF in quantiles I, II, III, and IV, with significance levels of 95%, 99%, 99%, and 90% respectively, confirming that increased LPI tends to increase EF. Foreign Direct Investment (FDI) positively impacted EF in quantiles I and II with a significance of 99%, indicating that FDI worsened environmental conditions at the initial level of EF distribution. Trade Openness (TRD) positively affects EF at quantiles II, III, and IV, with significance levels of 90%, 95%, and 90%, highlighting the influence of trade on EF enhancement. Gross Domestic Product (GDP) has a positive influence on EF across all quantiles with a significance rate of 99%, indicating that economic growth contributes to an overall increase in EF. Meanwhile, Pandemic (PNDM) negatively impacted EF in all quantiles tested, with significance levels of 99% in quantiles I, II, III, and 95% in quantile IV, suggesting that pandemic conditions have the potential to reduce EF.

Through robustness check analysis with quantile regression in quantitle III, the results showed consistency with the fixed effect panel data regression model, strengthening confidence in the resilience of the findings to data variations. This reinforces the validity and interpretability of the regression results, confirming that independent variables such as LPI, FDI, TRD, GDP, and PNDM have a significant influence on EF, with PNDM being the only variable that shows a negative influence.

Discussion of *Data Analysis* Output

Estimates from the fixed effect model show a consistent R-Squared increase across all proposed models, with Model 5 achieving an R-Squared of 0.79120. This indicates that the model is quite effective in explaining variations in dependent variables. Furthermore, the results of panel data analysis using the fixed effect model showed that the probability value (F-statistic) for all models was less than the alpha value (<0.05), indicating that the independent variables, namely LPI, FDI, TRD, GDP, and D_PNDM, had a collectively significant impact on EF.

LPI showed a significant positive influence on EF in APEC member countries during the period 2010 to 2022, with a positive coefficient of 0.4288835. This means that an increase in the value of LPI indicates an increase in the value of EF, which indicates that environmental damage increases as logistics performance improves. Quantile regression analysis corroborates these findings by showing the positive influence of LPI on EF in various quantiles with significance levels of 95%, 99%, 99%, and 90%, confirming that LPI has a significant impact on environmental quality in various Ecological Footprint data segments.

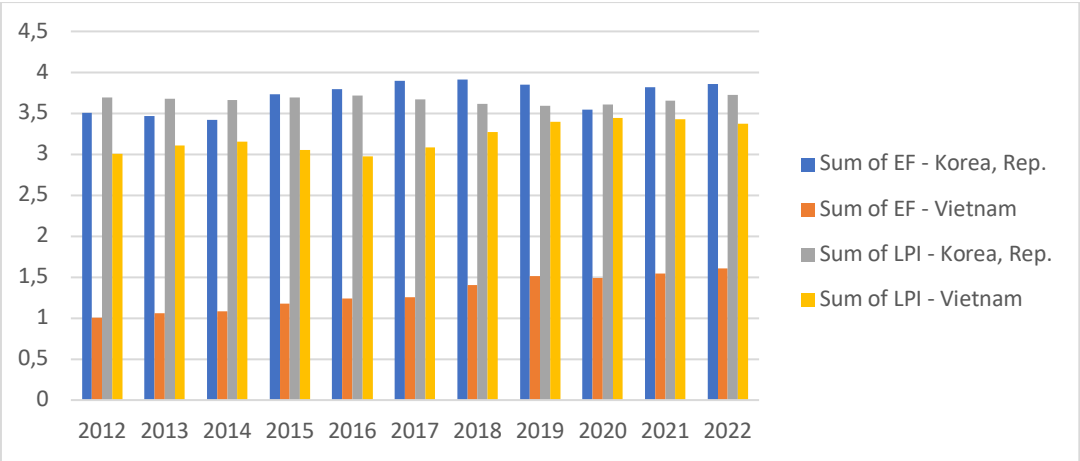

Figure 2. South Korea and Vietnam EF and LPI Value Chart

Source: Author's data processing

These findings underscore the Jevons Paradox, where improved resource use efficiency—in this case demonstrated by improved logistics performance characterized by higher LPI values—does not lead to a reduction in environmental impact. On the contrary, these efficiencies actually trigger increased resource consumption and greater environmental impact, as seen from the increase in EF value. The case study of South Korea and Vietnam illustrates this phenomenon, where South Korea with high logistics activities shows a significant ecological footprint, while increased logistics activities in Vietnam contribute to an increase in ecological footprint during the study period.

In the context of these findings, there are three effects that play a role in supporting the Jevons Paradox, namely the scale, composition, and technique effects. First, the results of the study show that there is a scale effect, where the improvement of logistics performance, as a result of better efficiency techniques, leads to an increase in the scale of economic activity and transportation. This is reflected in the increase in EF which signifies greater resource consumption in line with the increase in trade volume and freight transportation. This scale effect highlights how higher logistics efficiency indirectly increases the scale of natural resource use, contrary to the initial assumption that efficiency will reduce resource consumption. Second, although the findings do not explicitly explain changes in the composition of economic activities or resources used, the implications of improved EF and logistics performance may indicate a shift in the composition of resource consumption—from more efficient to more resource-intensive. This may happen if sectors of the economy that experience growth due to improved logistics performance tend to use more resources or have a greater environmental impact. Third, these findings also suggest that improvements in technique or efficiency, i.e. through increased LPI values, have a direct impact on EF improvement. This indicates that although there is an increase in the efficiency of logistics techniques, instead of reducing the environmental impact, the efficiency actually increases resource consumption and environmental impact. The effect of this technique suggests that increased technical efficiency in logistics does not automatically contribute to a decrease in environmental burden.

These findings are in line with several previous studies. Aydin et al (2023) highlight the important role of energy intensity levels in this relationship, with lowering energy intensity

considered a factor that favors logistics performance and environmental factors. Subramaniam (2021) added the dimension that countries that do not adopt green practices in their logistics performance can have a negative impact on air pollution, climate change, and global warming. In addition, Liu et al (2018) found a significant relationship between logistics performance and environmental degradation in Asian countries, emphasizing the importance of environmental sustainability and green supply chain management in the region. In this context, there needs to be more attention to the implementation of green practices in logistics performance to maintain a balance between economic growth and environmental sustainability. Concrete measures such as improving energy efficiency and sustainable supply chain management can be solutions to reduce negative impacts on the environment.

In addition, the estimated output of the fixed effect data panel analysis showed that the control variables used, excluding FDI, had a significant influence on EF. First, the positive coefficient on GDP (0.333) confirms that the increase in GDP correlates with the increase in EF, indicating the contribution of economic growth to environmental damage. This finding is reinforced by the results of quantile regression which shows that GDP has a positive effect on EF in all quantiles with a significance level of 99%. These findings are in line with the analytical outputs of Feng & Wu (2011) and Alola et al (2019), which illustrate that increases in GDP per capita can increase EF, although at some point the increase slows down or even decreases. Therefore, increasing economic growth must be balanced with policies that support the use of renewable and sustainable energy to maintain a balance between economic welfare and environmental sustainability.

Second, the positive coefficient in the TRD (0.106) shows that the increase in export-import activity correlates with the increase in EF in APEC member countries during the period 2010 to 2022. These findings are consistent with previous research showing that Trade Openness can damage the environment through increased pollution, carbon dioxide emissions, and the use of natural resources. For example, a study on Pakistan found that trade liberalization led to increased environmental pollution (Khan et al., 2022). Increased Trade Openness can also increase energy consumption and carbon dioxide emissions, which can indirectly damage the environment (Elfaki et al., 2021).

In addition, the estimated output of the fixed effect data panel analysis showed that the pandemic dummy variable had an effect on EF, with a negative coefficient at D_PNDM (-0.043). This indicates that the occurrence of the Covid-19 outbreak correlates with the decline in EF in APEC member countries during the period 2010 to 2022. The impact of the pandemic, such as reduced fuel oil combustion, resource consumption, waste disposal, transportation, and industrial activities, can be identified as a factor causing the improvement in environmental quality during the Covid-19 pandemic era (Facciolà et al., 2021)

On the other hand, the estimated output of the fixed effect data panel analysis showed that the FDI variable had no effect on EF. Although the descriptive analysis shows an increase in FDI globally, the study confirms that such investment flows do not automatically affect the level of environmental sustainability. This indicates that investors are often not interested in investing in projects that have long-term environmental benefits, perhaps due to a lack of short-term financial benefits (Pagell & Shevchenko, 2014). Although no studies have directly addressed the insignificance of FDI to EF, some previous studies, such as those conducted by Ayamba et al. (2020), have found that FDI does not have a significant impact on environmental

quality in the long term.

CONCLUSION

This study employed a panel data regression model to examine the relationship between the Logistics Performance Index (LPI) and the ecological footprint (EF), as well as the effects of Foreign Direct Investment (FDI), trade openness (TRD), and Gross Domestic Product (GDP) in Asia-Pacific Economic Cooperation (APEC) member countries during 2010–2022. The findings reveal that LPI, TRD, and GDP have positive and significant effects on the ecological footprint, indicating that improvements in logistics efficiency, economic growth, and international trade may intensify environmental pressure, consistent with the Jevons Paradox, where greater efficiency can lead to increased resource consumption. In contrast, the COVID-19 pandemic variable negatively affected the ecological footprint, reflecting reduced economic activity and consumption during the pandemic period. These results highlight the complex relationship between logistics efficiency, economic development, trade, and environmental sustainability in the APEC region. Accordingly, the study recommends integrating environmental policies into logistics systems through green technology adoption, transportation efficiency improvements, renewable energy incentives, and environmentally oriented trade policies. Future research is suggested to conduct more detailed temporal and sectoral analyses, apply alternative approaches such as panel VAR or VECM models, and further investigate the roles of FDI, environmental regulations, and socio-cultural factors in shaping sustainable development outcomes.

REFERENCE

Alola, A. A., Bekun, F. V., & Sarkodie, S. A. (2019). Dynamic impact of trade policy, economic growth, fertility rate, renewable and non-renewable energy consumption on ecological footprint in Europe. *Science of the Total Environment*. https://doi.org/10.1016/j.scitotenv.2019.05.139

Ayamba, E. C., Haibo, C., Abdul-Rahaman, A. R., Serwaa, O. E., & Osei-Agyemang, A. (2020). The impact of foreign direct investment on sustainable development in China. *Environmental Science and Pollution Research, 27*(20), 25625–25637. https://doi.org/10.1007/s11356-020-08837-7

Aydin, C., Aydin, H., & Altinok, H. (2023). Does the level of energy intensity matter in the effect of logistic performance on the environmental pollution of OBOR countries? Evidence from PSTR analysis. *Journal of Environmental Planning and Management, 66*(7), 1494–1512. https://doi.org/10.1080/09640568.2022.2030685

Baloch, M. A., Zhang, J., Iqbal, K., & Iqbal, Z. (2019). The effect of financial development on ecological footprint in BRI countries: Evidence from panel data estimation. *Environmental Science and Pollution Research, 26*, 6199–6208. https://doi.org/10.1007/s11356-018-3992-9

Çelebi, Ü. (2021). The impact of logistics performance index upon gross domestic product: Mediating roles of foreign direct investment and patents. *Journal of Global Strategic Management*.

Demena, B., & Afesorgbor, S. K. (2019). *The effect of FDI on environmental emissions: Evidence from a meta-analysis* (ISS Working Paper Series/General Series No. 650). ISS Working Paper Series.

Elfaki, K. E., Handoyo, R. D., & Ibrahim, K. H. (2021). The impact of industrialization, trade openness, financial development, and energy consumption on economic growth in Indonesia. *Economies, 9*(4), 174. https://doi.org/10.3390/economies9040174

Facciolà, A., Laganà, P., & Caruso, G. (2021). The COVID-19 pandemic and its implications on the environment. *Environmental Research, 201*. https://doi.org/10.1016/j.envres.2021.111648

Halaszovich, T. F., & Kinra, A. (2020). The impact of distance, national transportation systems and logistics performance on FDI and international trade patterns: Results from Asian global value chains. *Transport Policy, 98*, 35–47. https://doi.org/10.1016/j.tranpol.2020.07.005

Jayathilaka, R., Jayawardhana, C., Embogama, N., Jayasooriya, S., Karunarathna, N., Gamage, T., & Kuruppu, N. (2022). Gross domestic product and logistics performance index drive the world trade: A study based on all continents. *PLOS ONE, 17*(3), e0264474. https://doi.org/10.1371/journal.pone.0264474

Khan, A., Safdar, S., & Nadeem, H. (2022). Decomposing the effect of trade on environment: A case study of Pakistan. *Environmental Science and Pollution Research, 30*, 3817–3834. https://doi.org/10.1007/s11356-022-22740-7

Khan, S. A. R., Zhang, Y., Anees, M., Golpîra, H., Lahmar, A., & Qianli, D. (2018). Green supply chain management, economic growth and environment: A GMM based evidence. *Journal of Cleaner Production, 185*, 588–599. https://doi.org/10.1016/j.jclepro.2018.02.226

Khan, S. A. R., Zhang, Y., Golpîra, H., & Dong, Q. (2018). The impact of green supply chain practices in business performance: Evidence from Pakistani FMCG firms. *Journal of Advanced Manufacturing Systems, 17*(2), 267–275. https://doi.org/10.1142/S0219686718500103

Krstić, M., Tadić, S., Miglietta, P. P., & Porrini, D. (2025). Enhancing biodiversity and environmental sustainability in intermodal transport: A GIS-based multi-criteria

evaluation framework. *Sustainability, 17*(4), 1391. https://doi.org/10.3390/su17041391
Lemmetty, L. (2024). *Increasing biodiversity in logistics sites: Approaches and economic benefits of enhancing biodiversity on-site*.
Liu, J., Yuan, C., Hafeez, M., & Yuan, Q. (2018). The relationship between environment and logistics performance: Evidence from Asian countries. *Journal of Cleaner Production*. https://doi.org/10.1016/j.jclepro.2018.08.310
Subramaniam, Y. (2021). Logistic and environmental quality. *Present Environment & Sustainable Development, 15*(1), 35–48. https://doi.org/10.15551/pesd2021151003
Tian, G., Hua, X., Li, D., & Tian, J. (2025). How energy intensity and global energy dynamics shape renewable energy transition in APEC economies. *Geoscience Frontiers*, 102134. https://doi.org/10.1016/j.gsf.2025.102134
Zaidi, S. A. H., Zafar, M. W., Shahbaz, M., & Hou, F. (2019). Dynamic linkages between globalization, financial development and carbon emissions: Evidence from Asia Pacific Economic Cooperation countries. *Journal of Cleaner Production, 228*, 533–543. https://doi.org/10.1016/j.jclepro.2019.04.210
Zhang, J., & Khan, I. (2024). Energy use, energy access, and oil price fluctuations as new determinants of environmental quality in APEC countries. *Gondwana Research, 132*, 309–322. https://doi.org/10.1016/j.gr.2024.03.012