Sustinere
Journal of Environment and Sustainability
Volume 2 Issue 1 (2018) 11 – 23

Print ISSN: 2549-1245 Online ISSN: 2549-1253
Website: https://sustinerejes.com E-mail: sustinere.jes@iain-surakarta.ac.id

RESEARCH PAPER

The relationship between the freight transportation, economic growth and environmental degradation experienced by ninety countries

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Article history:
Received 12 January 2018 | Accepted 12 April 2018 | Available online 05 May 2018

Abstract. This paper investigates the relationship between freight transport, economic growth and environmental degradation (CO_2 emissions) experienced by ninety countries over the period 1980-2014. The estimation is divided into the global panel, high-income countries, upper-middle income countries, lower-middle income countries, and lower-income countries. This paper employed simultaneous equation Model and was estimated by Three-Stage Least Squares (3SLS). The results discovered the existence of bi-directional causality relationship between economic growth and freight transport in the high-income countries and lower-income countries. The result also indicated the bi-directional causality relationship between the transportation and CO_2 emissions in the panel upper-middle-income countries. Lastly, the finding indicated the bi-directional causality between economic growth and CO_2 emissions in lower-middle income countries.

Keywords: economic growth; energy; environmental degradation; 3SLS

1. Introduction

Economic growth is the main indicator of the economic development. Therefore, economic growth becomes an interesting topic in domestic and international level. Many research studies about economic development, particularly on the influences of demography, investment, human capital, export, technology, and inflation. In recent years the relationship between environmental and economic growth also becomes popular. It includes the effect of transport activity and the degradation of the environment on economic growth which is caused by energy used by transportation activity rising rapidly and bringing positive impact on the emission and economic growth. Some investigations

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DOI 10.22515/sustinere.jes.v2i1.28

on the relationship between transport activity and economic growth have been conducted by researchers (Chi & Baek, 2013; Hakim & Merkert, 2016; Marazzo et al., 2010; Moschovou, 2017), while others also studied about environmental degradation and economic growth (Kivyiro & Arminen, 2014; Omri, 2013; Omri et al., 2014).

The quality of the environment has already had strong influences on the climate change. Therefore, reducing the energy consumption and limiting the pollutant emissions is a great attention. Energy consumption is main decisive factors influencing the quality of the environmental. While the high level of energy consumption tends to lead more output, unfortunately, it will generate more emissions and pollution. The result found by Azlina et al. (2012) shows that the energy consumption has the significant positive impact on the economic growth and CO_2 emissions increase in Malaysia both on the short-term and long-term. Of course, the high level of the pollutant will have a negative impact on health which consequently threatens the human well-being.

Transport activity has the main role in economic development in all countries. Transport activities are only influenced by economic activities, but also cultural, political, social, and other forms human interaction (Loo & Banister, 2016). Therefore, the high rate of transport activities tends to increase economic growth. Besides increasing the economic growth, transport activity also produces some externalities and one of them is CO_2 emissions. Chandran and Tang (2013) suggested that the energy consumption in transport energy significantly leads to the CO_2 emissions.

Many kinds of literatures investigate the relationship between economic growth and environmental degradation. In this case, environmental degradation is indicated by the high level of CO_2 emissions. Generally, economic growth has a significant negative impact on environmental degradation. The result found by Kivyiro and Arminen (2014), Omri et al. (2014) show that there is a unidirectional causal relationship between the economic growth and CO_2 emissions. In contrast, the study conducted by Omri (2013) showed that there is a bi-directional causal relationship between economic growth and CO_2 emissions in all of MENA countries.

In the research field, environmental degradation is associated with economic growth. According to Saidi and Hammami (2017), two main causes of environmental degradation are economic development and energy demand. However, , the separated studies about energy consumption and economic growth may not explain environmental degradation (Saidi & Hammami, 2017). Therefore, to analyse the environmental degradation, it needs to consider other variables that are correlated with carbon emissions which one of them is freight transport.

This study aims to explain causal linkages between transport activities, economic growth and environmental degradation in ninety countries or global panel period 1980-2014, which are analysed based on three different income groups, namely: high income, upper middle income, lower middle income, and low-income countries. This paper is structured as follows: Section 2 reviews the literature about transport activity, economic growth, and environmental degradation; Section 3 describes data and methodology; Section 4 discusses the results; and section 5 concludes the paper.

2. Literature review

Kivyiro & Arminen (2014) have investigated about causality relationship between CO_2 emissions, energy consumption, economic growth and FDI in sub-Saharan (9 countries) by employing time series and Granger causality. They found that the all variables have unidirectional causality relationship, but did not find bi-directional causality. Generally, the all variables have causality relationship to CO_2 emissions. Omri et al. (2014) have studied a relationship between CO_2 emissions, FDI, and economic growth used panel data for 54 countries over period 1990-2011. They found the existence of unidirectional positive causality from economic growth to CO_2 emissions in Middle Eastern, North African and Sub Saharan. Also, Wang, et al. (2011) have analyzed the CO_2 emissions, energy consumption and economic growth in China, by using panel data. They found that in its long term, energy consumption and economic growth cause CO_2 emissions. Abdouli & Hammami (2016) investigated the causal relationship between the environmental, FDI and the economic growth by using panel data of 15 MENA countries. They found the existence of unidirectional causality running from FDI and CO_2 emissions to the economic growth, and unidirectional causality running from economic growth to CO_2 emissions. The results indicate that economic growth reduces the environmental quality.

In contrast, Saboori and Sulaiman (2013) analysed the co-integration and causal relationship between economic growth, CO_2 emissions, and energy consumption in Southeast Asian (Indonesia, Malaysia, Thailand, Singapore, and Philippines) for the period of 1971-2009, using ARDL and VECM. They found the existence of bi-directional Granger causality between economic growth and CO_2 emissions in Indonesia, Singapore, and Thailand in the short-term. Omri (2013) investigated the nexus between CO_2 emissions, energy consumption and economic growth with panel data of 14 MENA countries in 1990-2011. The result shows that there is an evidence of the bi-directional causal relationship between the economic growth and CO_2 emissions.

The transportation has held the main role in economic activity and globalization process. Many studies show that transport and economics have a strong relationship. Marazzo et al. (2010) studied about air transport demand and economic growth in Brazil. They found that the GDP and air transport demand are co-integrated, and indicates a strong positive reaction to air demand transport due to a positive change in GDP. However, a shock in air demand transport made the slower react of GDP. Hakim and Merkert (2016) investigated the causal relationship between air transport and economic growth in South Asia, using panel data of 1973-2014. The result shows the existence of long-term unidirectional Granger causality running from GDP to air transport both of passenger traffic and freight volumes. Hu, et al. (2015) investigated the relationship and Granger causality between the economic growth and domestic air passenger traffic. They found the evidence of a long-term equilibrium relationship between the economic growth and domestic air passenger traffic. Chi and Baek (2013) also found that the long-run air passenger and freight service tend to increase the economic growth.

Chandran and Tang (2013) studied about the impact of transport energy consumption, foreign direct investment and income on CO_2 emissions in Southeast Asian countries (Indonesia, Malaysia, Thailand, Singapore, and The Philippines). They found that

the economic growth and the transport energy consumption have a positive impact on CO_2 emissions. Banister and Stead (2002) also found that transportation has a significantly positive impact on CO_2 emissions (Saidi & Hammami, 2017).

3. Methods

The data in this paper were obtained from World Development Indicators (WDI) World Bank, over the period 1980-2014. We used panel data for 90 countries and then divided them into four groups namely global panel, high-income countries, middle-upper income countries, middle-lower income countries and low-income countries. The variables are presented in Table 1.

Tabel 1. Variable definitions

Variables	Description	Measurements	Source
Dependent/Independent			
GDP	GDP per capita	Gross domestic product per capita	WDI
CO_2	CO_2 emissions	metric tons per capita	WDI
FT	Freight transport	ton-kilometers	WDI
Control			
K	Capital stock	constant 2010 US$	WDI
FDI	Foreign direct investment	net inflows (BOP, current US$)	WDI
URB	Urbanization	% urban population of the total population	WDI
EC	Energy consumption	kg of oil equivalent per capita	WDI
TO	Trade openness	% of GDP	WDI
Pop	Total population	in thousands	WDI

This paper attempts to analyse the relationship between transport, economic growth, and environmental degradation (CO_2 emissions). The Model in this paper was duplicated Saidi and Hammami's (2017) model. They used data from 75 countries over the period 2000-2014 with the Generalized Method of Moment (GMM) approach. However, in this research we take 90 countries over the period 1980-2014 as the panel data and using Three-Stage Least Squares (3SLS) approach. According to Bakhsh et al. (2017) in simultaneous equation, 3SLS is more efficient than 2SLS, because 3SLS allows the correlation between unobserved disturbance across various equations, and it is more consistent. Another difference of the paper from Saidi and Hammami is it has estimated all Models to the four-panel group, as explained above. The empirical Models in our estimation are as follows:

$$lnGDP_{it} = \alpha + \beta_1 lnFT_{it} + \beta_2 lnCO_{it} + \beta_3 lnEC_{it} + \beta_4 lnK_{it} + \beta_5 lnTO_{it} + \mu_i + \nu_{it} \quad (1)$$

$$lnFT_{it} = \alpha + \beta_1 \ln GDP_{it} + \beta_2 lnCO_{it} + \beta_3 lnEC_{it} + \beta_4 lnK_{it} + \beta_5 lnFDI_t + \beta_5 lnUrb_t + \mu_i + \nu_{it} \quad (2)$$

$$lnCO_{it} = \alpha + \beta_1 lnDGP_{it} + \beta_2 lnFT_{it} + \beta_3 lnEC_{it} + \beta_4 lnTO_{it} + \beta_5 lnPop_{it} + \mu_i + \nu_{it} \quad (3)$$

The first Model explains the impact of freight transport and (environmental degradation) CO_2 emissions to economic growth. Freight transport and CO_2 emissions indicate the economic activity, thus they encourage the economic growth. The high rate of freight transports illustrates the high rate of goods distribution, thereby it increases the economic growth. The relationship between CO_2 emissions and economic growth is inverted in U-shaped environmental Kuznets Curve (EKC) hypothesis.

The second Model explains the impact of economic growth and CO_2 emissions to freight transport. The high productivity then will certainly increase the freight transport. The high level of CO_2 emissions is also caused by transport activity. It allows a policy for efficiency so that CO_2 emission resulting from transportation activities will decrease. Study about efficiency as the one which was done by Leonardi & Baumgartner (2004). Finally, the third Model explains the impact of economic growth and freight transport to CO_2 emissions. The economic growth and freight transport due the production activities of goods bring impact on CO_2 emissions.

We estimate the all Models to the global panel (all of the countries), higher income countries group, upper-middle-income countries group, lower-middle income countries group, and lower income countries group. The country's groups are divided by data according to World Development Indicator (World Bank) in CO_2 emissions data. The divisions are in four panels, and aim to capture specific characteristics of each group based on income level.

4. Result and Discussion

This paper used 3SLS to identify the linkages between freight transport, economic growth, and environmental degradation. We estimated all Models (Model 1, 2, and 3) to four panels group (global panel, high-income countries, upper-middle income countries, lower-middle income countries and lower income countries). The results are presented in Table 2-6, the global panel is in Table 2, the high-income countries are in Table 3, the upper-middle income is in Table 4, the lower-middle ones are in Table 5, and the lower income country is in Table 6.

Global Panel (Table 2)

In the global panel, where GDP is as the dependent variable, it is shown that the all variables have no significant effects on economic growth. In Model 2, economic growth has the significant negative impact on freight transport at 5% level. The 1% economic growth will reduce the freight transport by 0.27%. CO_2 emission has the significant positive impact on the freight transport at 1% level. The increase of CO_2 emissions by 1% will increase the freight transport by 1.3%. Freight transport is also affected by energy consumption, stock capital and urbanization.

In Model 3, we can see that CO_2 emissions are significantly positively affected by the economic growth at 1% level. This suggests that the high economic growth might contribute to CO_2 emissions. The coefficient shows that CO_2 emissions increases by 0,67% when there is a 1% increase in economic growth. These results are consistent with the finding by Zaman and Moemen (2017). We found that freight transport has a negative and significant relationship with CO_2 emissions at 10% level. This result contrasts with finding

by Saidi and Hammami (2017). This result indicates that there is no bi-directional causality relationship between CO_2 emissions and freight transport. In this Model, we also found that energy consumption has the positive and significant impact on CO_2 emissions. When energy consumption increases by 1%, then CO_2 emissions will increase by 0.76%. Variable trade openness and total population also have a positive and significant effect on CO_2 emissions. The results are consistent with finding by Zaman and Moemen (2017).

Tabel 2. The results related with the global panel

	Model 1	Model 2	Model 3
	GDP per capita	Freight transport	CO_2 emissions
GDP per capita		-0.268**	0.667***
		(0.107)	(0.188)
CO_2 emissions	2.045	1.295***	
	(1.590)	(0.473)	
Energy consumption	-2.556	-1.315***	0.756***
	(1.626)	(0.459)	(0.063)
Capital stock	7.359	1.002***	
	(5.969)	(0.032)	
Foreign direct investment		0.020	
		(0.023)	
Urbanization		-0.314*	
		(0.176)	
Freight transport	-6.862		-0.295*
	(5.486)		(0.151)
Trade openness	1.148		0.307***
	(1.331)		(0.081)
Total population			0.404**
			(0.177)
Constant	-123.322	-7.885*	-16.918***
	(120.596)	(4.249)	(3.808)
Observations	2,427	2,427	2,427

Standard errors in the parentheses

*** p<0.01, ** p<0.05, * p<0.1

High-income countries (Table 3)

The countries which are classified as the high-income countries by World Bank on WDI (2015) in this paper are Australia, Austria, Belgium, Brunei Darussalam, Canada, Chile, Cyprus, Czech Republic, Denmark, El Salvador, Estonia, Finland, France, Germany, Greece, Hong Kong, Hungary, Israel, Jordan, Korea Republic, Latvia, Lithuania, Morocco, Netherlands, Philippines, Senegal, Slovak Republic, Slovenia, Spain, Switzerland, UK, Uruguay and Venezuela.

Model 1 shows that CO_2 emissions have significant positive impact on economic growth at 1% level. It was found that 1% increase in CO_2 emissions raises the economic

growth for the high-income countries by 5.2%. The highest CO_2 emission shows that developed countries are identical with the number of its industry sectors. Freight transport has the significant negative impact on its economic growth on 5% level. It implies that the increase of freight transport by 1% reduces 0.75 economic growths.

Tabel 3. The result related to the high-income countries

	Model 1	Model 2	Model 3
	GDP per capita	Freight transport	CO_2 emissions
GDP per capita		-0.574*	-0.381***
		(0.315)	(0.108)
CO_2 emissions	5.199***	6.977***	
	(1.403)	(2.702)	
Energy consumption	-4.837***	-7.201***	1.219***
	(1.639)	(2.435)	(0.082)
Capital stock	1.160***	1.298***	
	(0.433)	(0.081)	
Foreign direct investment		0.184***	
		(0.071)	
Urbanization		-0.703	
		(1.266)	
Freight transport	-0.722**		0.247***
	(0.299)		(0.049)
Trade openness	0.270		-0.185***
	(0.193)		(0.059)
Total population			-0.379***
			(0.074)
Constant	12.709***	22.217	1.595
	(4.353)	(20.369)	(1.625)
Observations	920	920	920

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In Model 2, economic growth has the significant negative impact on freight transport at 1%, there is the bi-directional relationship between economic growth and freight transport. It was found that the 1% reduce in economic growth raised by the freight transport for the high-income countries by 0.57%. CO_2 emission also has significant positive impact on freight transport. This result is consistent with the finding in the global panel. When CO_2 emission increases 1%, then transport freight will increase by 6.98%.

In Model 3, interestingly we found that economic growth has the significant negative impact on CO_2 emissions at 1% level. This finding indicates that high-income countries are more capable to maintain the quality of the environment. The statistic shows that the increase in economic growth by 1% will reduce the CO_2 emission by 0.38%. Freight transport has the significant positive impact on CO_2 emission. It was found that 1% increase in freight transport raises CO_2 emission by 0.25% for high-income countries.

In high-income countries, the environmental degradation (CO_2 emissions) is strongly affected by the level of energy consumption and transport activities even though both

variables have the negative impact on economic growth. Therefore, the energy use in this countries group is inefficient, because the environmental quality and economic growth decline.

Upper-middle-income countries (Table 4)

The group of upper-middle-income countries in this paper consists of Argentina, Azerbaijan, Belarus, Botswana, Brazil, Bulgaria, China, Colombia, Costa Rica, Croatia, Dominican Republic, Ecuador, Gabon, Iran, Ireland, Italy, Japan, Mexico, Nepal, Pakistan, Panama, Portugal, Romania, Tajikistan, Togo, Tunisia, Turkey, and Uzbekistan.

Tabel 4. The results related to the upper middle countries

	Model 1	Model 2	Model 3
	GDP per capita	Freight transport	CO_2 emissions
GDP per capita		-0.112	0.996***
		(0.118)	(0.382)
CO_2 emissions	0.570	-4.073***	
	(1.990)	(0.937)	
Energy consumption	-1.894	3.835***	0.513*
	(1.789)	(1.072)	(0.286)
Capital stock	3.122*	1.243***	
	(1.804)	(0.054)	
Foreign direct investment		-0.015	
		(0.042)	
Urbanization		1.664***	
		(0.448)	
Freight transport	-3.123*		-0.825**
	(1.801)		(0.368)
Trade openness	-2.044*		-0.158
	(1.190)		(0.172)
Total population			0.950**
			(0.399)
Constant	-31.450	-54.057***	-23.061***
	(35.552)	(8.752)	(6.034)
Observations	748	748	748

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Model 1 shows that the economic growth is just affected by the freight transport, capital and trade openness. Freight transport has the significant negative impact at the level of 10%. This finding is consistent with the result of global and high-income countries. This implies that when freight transport increases by 1%, then economic growth will reduce by 3.1%. In Model 2, it can be seen that the CO_2 emission has the significant negative impact on freight transport at 1% level. The statistic shows that the increase in

CO_2 emission by 1% will reduce the freight transport by 0.1%. The freight transport is also affected by the energy consumption, capital and urbanization. All of them have the significant positive impact.

In Model 3, we can see that the economic growth has the significant positive impact on CO_2 emissions at 1% level. The statistic shows that the increase in economic growth by 1% will increase the CO_2 emission by 0.996%. The freight transport has the significant negative impact on CO_2 emissions. It was found that the 1% increase in freight transport raises CO_2 emission by 0.83% in high-income countries. This finding indicates the existence of the bi-directional causal relationship between CO_2 emission and the freight transport. CO_2 emission in upper-middle income countries is also affected by the energy consumption and the total population of a region.

Tabel 5. The results related to the lower middle countries

	Model 1	Model 2	Model 3
	GDP per capita	Freight transport	CO_2 emissions
GDP per capita		-4.997*	0.418***
		(2.746)	(0.092)
CO_2 emissions	1.639***	7.242*	
	(0.155)	(3.799)	
Energy consumption	-0.984***	-3.636*	0.682***
	(0.184)	(2.180)	(0.058)
Capital stock	0.076	0.701***	
	(0.090)	(0.222)	
Foreign direct investment		-0.078	
		(0.152)	
Urbanization		1.738*	
		(0.902)	
Freight transport	-0.129		0.136**
	(0.095)		(0.059)
Trade openness	-0.011		-0.023
	(0.077)		(0.056)
Total population			-0.098
			(0.062)
Constant	12.713***	44.258	-6.343***
	(2.387)	(33.669)	(1.528)
Observations	573	573	573

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Lower-middle-income countries (Table 5)

The lower-middle income countries discussed in this paper are Armenia, Bangladesh, Bolivia, Cambodia, Cameroon, Egypt, Guatemala, India, Indonesia, Kazakhstan, Kenya, Kyrgyz Republic, Mozambique, Nigeria, Peru, Singapore, South Africa, Thailand, Trinidad

and Tobago, USA, and Vietnam. In lower-middle income countries, CO_2 emission has the significant positive impact on economic at 1% level. The results show that economic growth increases by 1.64% when the CO_2 emission rises by 1%.

In Model 2, it can be seen that the economic growth has the significant negative impact on freight transport at 10% level. The result shows that 1% increase in economic growth reduces the freight transport in lower-middle income countries by 5%. CO_2 emission has the significant positive impact on freight transport. The statistic shows that 1% increase in CO_2 emission raises freight transport for lower-middle income countries by 7,2%.

In Model 3, we can identify that the CO_2 emission is significantly positively affected by the economic growth at 1% level. This indicates that an increase in economic growth tends to promote CO_2 emissions in lower-middle countries. The coefficient shows that CO_2 emission increases by 0,42% when there is a 1% increase in economic growth. These results are consistent with the finding in the global panel, upper-middle countries by Zaman and Moemen (2017). We found that the freight transport has a positive and significant relationship with the CO_2 emission at 5% level. This result indicates that in lower-middle income countries, there is a bi-directional causal relationship between economic growth and CO_2 emissions, as well as the CO_2 emission and freight transport.

Lower income countries (Table 6)

The group of lower income countries consists of Benin, Lebanon, Mauritius, Moldova, Norway, Russian Federation, Sudan and Tanzania. The freight transport has the significant positive impact on the economic growth at 1% level, which is consistent with Saidi and Hammami's (2017) research result. This finding implies that the increase of the freight transport by 1% will increase the economic growth by 0.77%. The energy consumption also has significant positive effect on the economic growth at 1%. Economic growth is also affected by the energy consumption, capital and trade openness.

In Model 2, it can be seen that the economic growth has the significant positive impact on the freight transport at 1% level. The 1% increase in economic growth will boost the freight transport by 0.95%. This finding indicates that the economic growth and freight transport have bi-directional causality relationship. Freight transport is also affected by the energy consumption, capital, and trade openness. In Model 3, we can see that the CO_2 emission in lower-income countries is affected by the economic growth (the negative significance is at the level of 5%. CO_2 emission will reduce by 0.38% when economic condition grows by 1%. Meanwhile, freight transport has a significant positive impact on CO_2 emission. The coefficient shows that CO_2 emission increases by 0.42% when freight transport increases by 1%.

Tabel 6. The results related to the lower income countries

	Model 1	Model 2	Model 3
	GDP per capita	Freight transport	CO_2 emissions
GDP per capita		0.948***	-0.380**
		(0.217)	(0.161)
CO_2 emissions	-0.516	-0.971	
	(0.375)	(0.666)	
Energy consumption	1.299**	-0.182	1.398***
	(0.509)	(0.880)	(0.156)
Capital stock	-0.359***	0.771***	
	(0.118)	(0.207)	
Foreign direct investment		-0.188**	
		(0.076)	
Urbanization		3.365***	
		(1.142)	
Freight transport	0.777***		0.366***
	(0.141)		(0.084)
Trade openness	0.928**		0.894***
	(0.407)		(0.130)
Total population			-0.182**
			(0.074)
Constant	0.775	-29.398***	-8.460***
	(4.519)	(7.114)	(1.572)
Observations	186	186	186

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

5. Conclusions

This paper aims to analyze the relationship between transport, economic growth, and environmental degradation (CO_2 emissions). The estimation is divided in to the global panel, high-income countries, upper-middle income countries, lower-middle income countries, and lower-income countries. The main results are bi-directional causality relationship between economic growth and freight transport in the high-income countries, and lower-income countries. The result also discovers the bi-directional causality relationship between transport and CO_2 emissions in the panel upper-middle-income countries. Lastly, the finding indicates the existence of the bi-directional causality between economic growth and CO_2 emissions in lower-middle income countries.

The existence of the bi-directional causality relationship between economic growth and freight transport in lower income countries indicates that the transport activities have the important role in economic activities. The transportation plays an important role in the distribution of goods. In contrast, the relationship between the economic growth and the freight transport in high-income countries shows a negative causality. The bi-

directional causality between the economic growth and the CO_2 emission in lower-middle income countries show that developments in this countries group do not pay attention to the environmental quality.

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