CONTAINERISED EXPORTS FROM JAVA: THE IMPACT OF POLICIES TO REDUCE GHG EMISSIONS

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INTRODUCTION

Indonesian containerised exports are primarily shipped from three ports in Java, namely Jakarta Port (Tanjung Priok), Semarang Port (Tanjung Emas) and Surabaya Port (Tanjung Perak). These ports account for almost 70% of total container throughput in Indonesia, with Jakarta Port being the biggest of the three. Issues relating to containerised exports from Java relate not only to the port, but also to the inland transport system for the movement of container from the origin region to the chosen port. Inland mode choice for transporting the container from the shippers' plant or warehouse should not be separated from the port choice itself. Most shippers and freight forwarders in Java choose truck as their preferred mode for delivery of containerised exports from the origin region to the three ports above.

This situation leads to various environmental impacts including greenhouse emission (GHG) effects (emission of gases such as CH_4, CO_2 and N_2O), acidification, toxic effects on ecosystems, toxic effects on humans, land use, noise and resource consumption (IFEU, 2011). One of the most important impacts, GHG emission, significantly contributes to global warming, almost a quarter of the worldwide CO_2 emissions coming from the transport sector (IEA, 2009). Between 1990 and 2008, CO_2 emissions in Indonesia increased from 140.54 million tonnes to 385.38 million tonnes – an average growth rate of 9.7% per year. Whilst the biggest CO_2 emitter in Indonesia was the manufacturing sector (which uses coal or peat as the main source of energy) with a volume of CO_2 emissions of 131.03 million tonnes and the second largest was the energy sector (with 108.10 million tonnes of CO_2), the transportation sector (75.91 million tonnes of CO_2) was the third largest contributor (IEA, 2010).

According to the Presidential Regulation of Indonesia (PP-RI, 2011) and the report from International Transport Forum (ITF & OECD/ITF, 2010), Indonesia has a commitment to reduce GHG emissions by 26% in 2025 relative to 2010. To reduce GHG emissions from road freight transport, a plan to increase the role of rail in freight transport has been launched by the Indonesian Government. The plan consists of re-opening 2 dry-ports that were closed due to low demand from the shippers, and developing a double-track rail network in Java to enhance passenger and freight transport capacity on the rail transport system.

In order to reduce GHG emissions from container freight transport on Java, shifting of container movement by truck to movement by rail is an appropriate choice due to the lower GHG emissions per ton-km of rail transport compared to road transport (Kruse, Protopapas, Olson, & Bierling, 2009; IFEU, 2011). To encourage shippers and freight forwarding companies to use rail transport, the government of Indonesia needs to implement appropriate policies that will accord with the preferences of shippers and freight forwarders with respect to inland mode choice. Hence the success of the plan for shifting containerised freight from road to rail will depend partly on the behaviour of the shippers and freight forwarder in choosing inland mode and port. This paper investigates how shippers or freight forwarders choose inland modes and ports to move their goods from origin regions to the chosen port of departure. Using a model of inland mode and port choice, this research examines the potential impacts of various policies that can be implemented to reduce GHG emissions during the inland transportation leg used for containerised export movements.

The main contribution of this research lies in its analysis of the shippers' and freight forwarders' attitudes related to GHG emissions, and the potential impacts of policies that may be implemented to reduce GHG emissions. The novelty of this research is in its development of a joint model of inland mode and port choice from the shippers' or freight forwarders' perspective using Stated Preference (SP) data collected for this purpose.

STATED PREFERENCE SURVEY

Due to a lack of data about inland mode and port choice in Java, we decided to conduct a stated preference (SP) survey to collect preference data from exporters and freight forwarders relating to inland mode and port choices. The SP survey method was adopted for this research because it is able to provide data on hypothetical situations and on choices for alternative options (such as new ports) which do not exist at the time of study.

Alternatives

Alongside the 3 existing main container ports in Java, this research also considered 1 proposed port (Cilamaya Port). Hence there are 8 possible alternative combinations of port and inland mode, as follows:

1) Alternative A1: Tanjung Priok Port (Jakarta) – Truck (JKT-ROAD)
2) Alternative A2: Tanjung Priok Port (Jakarta) – Train (JKT-RAIL)
3) Alternative B1: Tanjung Emas Port (Semarang) – Truck (SMG-ROAD)
4) Alternative B2: Tanjung Emas Port (Semarang) – Train (SMG-RAIL)
5) Alternative C1: Tanjung Perak Port (Surabaya) – Truck (SBY-ROAD)
6) Alternative C2: Tanjung Perak Port (Surabaya) – Train (SBY-RAIL)
7) Alternative D1: Cilamaya Port (Cilamaya) – Truck (CMY-ROAD)
8) Alternative D2: Cilamaya Port (Cilamaya) – Train (CMY-RAIL)

Attributes of inland mode and port

To determine the attributes of inland mode and port choice, an investigation of relevant literature was carried out. This suggested that the prominent factors influencing decision making on inland mode and port choice are;

1) *Mode Cost* (Garcia-Menendez et al. 2004; Beuthe & Bouffioux 2008; Ravibabu 2013; De Jong & Ben-Akiva 2007; Windisch et al. 2010; Abdelwahab 1998),
2) *Mode Time* (Garcia-Menendez et al. 2004; Beuthe & Bouffioux 2008; Ravibabu 2013)
3) *Mode Reliability* (Shinghal & Fowkes, 2002; Beuthe & Bouffioux, 2008; Norojono & Young, 2003) and
4) *Mode Frequency* (Shinghal & Fowkes, 2002; Garcia-Menendez et al., 2004; Feo-Valero et al., 2011).
5) *Port Cost* (Tongzon, 2009; Nir et al., 2003)
6) *Frequency of ship calls* (Tongzon, 2009; Nir et al., 2003)

This research uses 5 of the 6 key factors above and also considers GHG emission (Magala & Sammons, 2008) instead of inland mode frequency in order to investigate the preferences of exporters and forwarders with respect to the global warming issue. Table 1 displays the attributes, their units, definitions, and the expected direction of impact.

Table 1: Factors, attributes, units, definitions and the expected signs for this research

Factor	Attributes	Unit	Definition	Expected Sign
Port	Cost	Thousand IDR/TEU[1]	The port cost is represented by the cost of handling of 1 TEU Full Container Load (FCL)	-
	Ship Calls	Ship calls / week	Ship calls is the number of international container ship calls per week from each port, including indirect calls (i.e. with need for transshipment)	+
Inland Mode	Cost	Thousand IDR/TEU-Trip	Inland mode cost to transport 1 TEU container from the origin to the port (including haulage by truck from the shipper location to the consolidation station for alternatives using rail mode).	-
	Time	Hours/trip	The transport time between the mode departure from the origin and arrival at the port, including waiting time if any.	-
	Reliability	Percentage (%)	Percentage of on-time delivery	+
	GHG emissions	(Kg CO_2e / TEU-Trip)	Emissions from the alternative inland modes for a trip from the origin region to port	-

Respondents and data collection

The potential participants are the decision makers in exporter or freight forwarder companies who select inland mode and port. The survey was carried out in two steps: Pilot Survey and Main Survey. The candidate respondents for the survey were selected from two main sources: (1) The database of exporters in Java was obtained from the Directory of 8000 Indonesian Exporters book[2], (2) the database of freight forwarder companies was derived from the Directory of Indonesian Logistics and Guide book[3].

Respondents were recruited from 16 cities in Java: Jakarta, Bandung, Bekasi, Tangerang, Cirebon, Bogor, Karawang, Semarang, Surakarta, Yogyakarta, Jepara, Surabaya, Malang, Gresik, Sidoarjo and Pasuruan. Respondents were asked to state their preferred choice between the 8 hypothetical situations regarding inland mode and port choice. The respondents were also requested to state their current choice of inland mode and port and characteristics of their exports, in order to provide data that could be used in Revealed Preference (RP) analysis, most particularly to be used in the simulation process.

During the survey (conducted between July 2013 and April 2014), attempts were made to contact 4593 companies via fax, mail and email. Of these, 3340 companies (73%) were successfully contacted. A relatively low response rate of around 7% was obtained. Some 225 companies responded to the pilot and main survey, of which 180 respondents completed the questionnaire adequately. The online survey tool reveals that the average time to answer the questionnaire was 27 minutes with a standard deviation of 21 minutes. Data cleansing led to the exclusion of 17 respondents whose answers suggested data inaccuracies or who had completed the survey in less 10 minutes. As a result, data from 163 respondents was deemed eligible for use in the next steps of the research.

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[1] 1 GBP ≅ 20,000 IDR

[2] The Directory of 8000 Indonesian Exporters published by The Indonesian Statistics and Indonesian Exim Bank in 2011.

[3] Indonesian Logistics Directory and Guide book was published by the Indonesian Logistics Association (ALI) and PPM Management School

MODEL ESTIMATION AND SIMULATION

Model estimation

The data obtained from the pilot and main surveys has been used to estimate Multinomial Logit (MNL), Mixed Multinomial Logit (MXMNL), Nested Logit (NL) and Mixed Nested Logit (MXNL) models (Ben-Akiva & Lerman, 1985; Train, 2009) for the choice between the 8 port/inland mode alternatives presented in the SP. Bierlaire's *Optimisation Toolbox for General Extreme Value Model Estimation* (BIOGEME) version 2.2 (free software for estimation of various discrete choice models) was used for estimating the parameters of the model (Bierlaire, 2009). Based on the value of final likelihood, likelihood ratio test, ρ^2, adjusted ρ^2, the sign, and the significance of the estimated parameters, the MXNL model has been selected as the best model.

Table 2: Estimation result for Mixed Nested Logit Model using SP Data

Utility Parameters	Value	Std err	t-test	Robust Std err	Robust t-test
Alternative Specific Constant A1 (Jakarta - Road)	0	Fixed			
Alternative Specific Constant A2 (Jakarta - Rail)	-1.3	0.249	-5.21***	0.243	-5.33***
Alternative Specific Constant B1 (Semarang - Road)	0.694	0.343	2.03**	0.325	2.14**
Alternative Specific Constant B2 (Semarang - Rail)	-1.990	0.447	-4.46***	0.443	-4.5***
Alternative Specific Constant C1 (Surabaya - Road)	0.010	0.364	0.03	0.33	0.03
Alternative Specific Constant C2 (Surabaya - Rail)	-0.846	0.348	-2.43**	0.319	-2.65***
Alternative Specific Constant D1 (Cilamaya - Road)	-0.786	0.236	-3.33***	0.242	-3.25***
Alternative Specific Constant D2 (Cilamaya - Rail)	-1.740	0.429	-4.05***	0.452	-3.85***
Mode Cost for number Per shipment more than 2 TEUs	-0.410	0.070	-5.86***	0.068	-6.02***
Mode Cost for number Per shipment up to 2 TEUs	-0.312	0.064	-4.91***	0.064	-4.9***
Mode Cost Std Deviation for number Per shipment up to 2 TEUs	-0.329	0.093	-3.53***	0.103	-3.19***
Mode GHG Emissions for Volume export more than 10 TEUs/month	-1.080	0.203	-5.34***	0.217	-5.01***
Mode GHG Emissions for Volume export up to 10 TEUs/month	-0.757	0.194	-3.91***	0.2	-3.79***
Mode Reliability for Exporter	1.990	0.385	5.18***	0.377	5.28***
Mode Reliability for Forwarder	4.170	1.04	4.01***	1.02	4.09***
Mode Time for product with HSCode=44 or HSCoce=94	-1.08	0.265	-4.08***	0.278	-3.9***
Mode Time for product with others HSCode	-1.06	0.216	-4.93***	0.224	-4.74***
Port Cost for shipment frequency more than 5 times per month	-0.879	0.193	-4.55***	0.186	-4.73***
Port Cost for shipment frequency up to 5 times per month	-0.411	0.156	-2.62**	0.15	-2.73**
Port Ships calls for Exporter	0.684	0.293	2.34**	0.29	2.36**
Port Ships calls for Forwarder	1.54	0.547	2.82***	0.555	2.78**
Nested Model Parameter					
Cilamaya Port	0.622	0.159	3.9***	0.168	3.71***
Jakarta Port	0.751	0.149	5.05***	0.155	4.84***
Surabaya Port	1	Fixed			
Semarang Port	0.519	0.0722	7.19***	0.0733	7.08***
Number of estimated parameter	23				
Number of Observations	1287				
Null log-likelihood	-1784.161				
Final log-likelihood	-1352.993				
Likelihood ratio test	862.335				
ρ^2	0.242				
Adjusted ρ^2	0.229				

Note: * Significant at the 10% level, ** Significant at the 5% level, *** Significant at the 1% level

Policy scenarios for simulation

Five policy scenarios have been simulated using the MXNL model to examine the impact of each policy on GHG reduction for the inland transportation leg of containerised exports from Java. These policies are:

1) Route and time restrictions for Truck/Road, on an assumption that truck/road cost will increase by 5% and truck/road time will increase by 10%.
2) Reduced fuel subsidies will increase fuel price by 50%, leading to an increase in truck/road cost of 25%.
3) Double-track rail network between Jakarta and Surabaya will reduce the rail transport time by 20%.
4) The expansion of Jakarta Port (Tanjung Priok) will increase its capacity from 6 million TEU/year to 9 million TEU/year. It is assumed that this expansion will increase ship calls at Tanjung Priok port by 30%.
5) Provision of subsidy to rail freight transport to reduce the rail tariff by 20%.

Table 3: Simulation results for all policy scenarios using RP data

Port-Mode Alternative	Without Policy	With Policy Scenario 1		With Policy Scenario 2		With Policy Scenario 3		With Policy Scenario 4		With Policy Scenario 5	
	Share	Share	%	Share	%	Share	%	Share	%	Share	%
JKT-ROAD	54.30%	53.04%	-2.33%	52.95%	-2.50%	54.16%	-0.26%	56.36%	3.78%	54.13%	-0.31%
JKT-RAIL	2.07%	2.29%	10.73%	2.37%	14.37%	2.36%	14.06%	2.22%	7.16%	2.46%	18.67%
SMG-ROAD	4.00%	4.71%	17.94%	5.08%	27.17%	3.94%	-1.45%	3.83%	-4.08%	3.85%	-3.70%
SMG-RAIL	0.15%	0.19%	29.56%	0.24%	62.17%	0.16%	5.31%	0.14%	-4.18%	0.18%	19.38%
SBY-ROAD	24.92%	25.14%	0.87%	24.77%	-0.64%	24.73%	-0.79%	24.42%	-2.02%	24.58%	-1.39%
SBY-RAIL	0.95%	1.13%	18.54%	1.29%	35.83%	1.05%	10.60%	0.93%	-2.16%	1.20%	26.11%
CMY-ROAD	13.10%	12.94%	-1.25%	12.72%	-2.89%	13.04%	-0.46%	11.64%	-11.1%	13.01%	-0.68%
CMY-RAIL	0.50%	0.55%	10.73%	0.58%	15.11%	0.56%	11.27%	0.45%	-9.67%	0.59%	17.55%
Port Alternative											
JKT	56.37%	55.33%	-1.85%	55.32%	-1.88%	56.52%	0.26%	58.58%	3.91%	56.59%	0.39%
SMG	4.15%	4.91%	18.36%	5.33%	28.44%	4.10%	-1.21%	3.98%	-4.08%	4.03%	-2.86%
SBY	25.88%	26.27%	1.52%	26.06%	0.71%	25.78%	-0.37%	25.35%	-2.02%	25.78%	-0.38%
CMY	13.60%	13.49%	-0.81%	13.30%	-2.23%	13.60%	-0.03%	12.09%	-11.1%	13.60%	-0.01%
Mode Alternative											
ROAD	96.33%	95.83%	-0.52%	95.52%	-0.84%	95.87%	-0.47%	96.25%	-0.08%	95.57%	-0.78%
RAIL	3.67%	4.17%	13.52%	4.48%	21.99%	4.13%	12.43%	3.75%	1.99%	4.43%	20.47%

Table 4: Estimated GHG Emission reductions for each policy scenario

Policy Scenario	CO2e Emissions (Kg)		CO2e reduction (Kg)	% reduction
	Without policy	With policy		
1	4,367,599	4,171,587	-196,012	-4.49%
2	4,367,599	4,140,269	-227,330	-5.20%
3	4,367,599	4,354,984	-12,615	-0.29%
4	4,367,599	4,421,808	54,209	1.24%
5	4,367,599	4,348,987	-18,612	-0.43%

DISCUSSION

Factors affecting port and inland mode choices

As can be observed from Table 2, all of the utility parameter coefficients are significant or highly significant and have the expected signs.

Inland mode cost is highly significant and has a negative effect on the utility of the inland mode and port alternative. This result strengthens evidence presented by previous researchers. Whilst the direction of this effect does not depend on size of shipment (number of TEU per shipment), the value of the inland mode cost coefficients reveal the effect to be smaller for smaller shipment sizes (2 TEUs per shipment or less).

The inland mode time variable is also highly significant and shows a negative coefficient as expected. This research also estimated separately the inland mode time for the products with HS code number 44 and 94 (wood products) and for other products, but no significant difference between these 2 groups was found.

The GHG emissions factor has a negative sign and coefficient values are significantly different for bigger volumes of exports (more than 10 TEUs per month) and smaller volumes of exports (less than 10 TEUs per month). Larger volumes of exports are more sensitive to the change of GHG emissions than are smaller volumes of exports. This suggests that bigger companies tend to pay more attention to GHG emissions than the smaller companies.

For companies that make more frequent shipments, port cost is found to be a more important consideration than for companies making less frequent shipments, suggesting that port cost is one of the key factors for exporters or freight forwarders when they are selecting their preferred port.

The reliability of inland mode and the frequency of ship calls are factors that have positive signs, as expected. They are found to be more important for freight forwarders than for exporters when choosing between alternative port/inland mode combinations.

Policy impacts

Table 3 presents key results from simulation, whereas the outcomes of each policy in terms of reduction in GHG emissions are shown in Table 4. From Table 3, it can be seen that policy 2 and policy 5 lead to the most significant increments in the rail mode share. However, policy 5 does not significantly contribute to GHG reduction (only -0.43%). This may be because most of the switch from road to rail occurs for shorter distance inland transport legs for which the reduction in GHG emissions is comparatively small.

Policy 1 has a considerable influence in reducing the use of the road mode to the Jakarta port, however much of this traffic still chooses to use road transport but diverts to another port (Semarang Port), rather than making the switch to rail.

Compared to the impacts of policies 2 and 5, reducing the inland transit time on the rail mode (through the provision of double track from Jakarta to Surabaya), does not have an important impact on GHG emissions (with a reduction of just 0.29%), even though there is a significant increase of 12.43% in the use of the rail mode.

According to the MXNL analysis set out above, the expansion of capacity at the Tanjung Priok port (Policy 4), and an associated increase the frequency of ship calls, will increase the probability of exporters or forwarders choosing Tanjung Priok as their preferred port. However, this policy does not reduce GHG emissions; in fact emissions will increase slightly as some forwarders or exporters switch to Jakarta Port from Semarang Port, Surabaya Port or Cilamaya Port.

CONCLUSIONS

This paper has presented simulated results of the impact of a range of policies aimed at the reduction in GHG emissions related to containerised exports from Java, using the Mixed Nested Logit Model (MXNL). Through this approach, we can summarise that increases in inland mode cost, inland mode time, inland mode GHG emissions and port cost all have significant negative effects on choice utility. On the other hand, inland mode reliability and frequency of ship calls at ports have positive influence on the decision maker when selecting between inland mode and port alternatives.

To determine the impact of various potential policies relating to port and inland mode choice, simulations of policy implementations have been performed. Five policies have been examined in such simulations: (1) time and route controls for trucks, (2) reduction of fuel subsidies for road transport, (3) establishing double-track on the Jakarta to Surabaya rail (north) route, (4) the expansion of Jakarta Port (Tanjung Priok), and (5) providing incentives for the use of rail freight.

The simulation results show that the two policies of reducing fuel subsidies for road transport and giving incentives to reduce rail freight rates would provide the most significant encouragement to modal shift from road transport to rail transport. However, the analysis suggests that the largest reduction in GHG emissions can be obtained through policies of reducing fuel subsidies for road transport and placing restrictions on the times and routes permitted for road transport operations.

Currently, further research is being conducted on model estimation using joint source data, by combining SP and RP data. In addition, further simulations are being conducted to examine the combined effects of applying two or more of the policy options simultaneously, to identify which policy combinations are most effective in reducing GHG emissions.

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