A Stochastic Logistics Model for Indonesia's National Freight Transport Model

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Abstract

This paper presents research towards the development and implementation of a stochastic approach for estimating the transport chain and shipment size choices for domestic shipments in Indonesia. This stochastic model aims to improve the logistics choices within Indonesia's national freight transport model (INTRAMOD), which at the moment handles such choices deterministically. The logistics model in INTRAMOD describes five different transport chain alternatives involving four main modes: truck, train, vessel and plane. The key data required to model the stochastic logistics decisions should refer to the main actors in freight transport shipment size and transport chain choice, defined here as manufacturers or shippers. A revealed preference (RP) and stated preference (SP) survey has been conducted to collect the data required, though this paper will focus solely on the SP survey for the transport chain choice by the shipper. There are three aspects considered here as factors in choosing the transport chain: transport cost, transport time, and reliability. For the SP survey, a maximum of four choice alternatives, generated using an efficient experimental design in NGene, has been presented to respondents. Using the SP data obtained in a pilot survey, the transport choice model is estimated using a multinomial logit (MNL) model. Relatively high values of time (VoT) have been found compared to the previous studies, perhaps due to the small sample being gathered. Nevertheless, these values obtained from the pilot survey will still be utilized to correct the prior values for the main survey, in line with the general objective of the pilot survey to validate the survey properties before the conducting the main survey and also because such high values may not carry forward to the main survey results. It is considered that the pilot data set has provided the best data portraying the current Indonesian situation and will be included in the analysis for the estimation of the main model.

Keywords: freight transport, stochastics approach, logistics model, INTRAMOD

1. Introduction

Enhancing model reliability is a critical part of national freight transport model development, and model outputs must be well grounded to forecast and predict the behavior of actors (e.g., shipper and carriers). One noted direction of freight model development involves encompassing logistics activities in the form of a logistics module in the freight modelling framework (De Jong et al., 2013). A logistics model is the simplified representation of the relation between freight transport actors' choices in logistics activities and the factors behind their decisions. Some noted directions on the logistics model examine the inventory choices and the transport choices on a multimodal transport network (Davydenko, 2015; Halim, 2016; Huber, 2017).

Abate et al. (2016) argue that freight transport models which incorporate logistics decisions commonly rely on optimization theory in which firms aim at solely minimizing the annual total logistics cost. Such logistics models could be found in the version of the national freight model for Norway and Sweden which was developed in first decade of the 21st century (De Jong, G. et al., 2007; Ben-Akiva and De Jong, 2008). Developed within the aggregate-disaggregate-aggregate (ADA) model framework, the Norwegian and Swedish national freight models estimate the shipment size and transport chain choices of firms following the Economic Order Quantity (EOQ) concept by trading-off the inventory costs, order costs, and transport costs to achieve the minimum annual logistics cost. A similar approach is also considered in the development of Indonesia's National Freight Transport Model (INTRAMOD).

Within the INTRAMOD, three modules are constructed: (1) Aggregate zone-to-zone demand model (i.e., to model the zonal trade flow distribution, from production (P) zone to consumption (C) zone, PC flows), (2) Disaggregate logistics model, and (3) Aggregate network assignment model. In the second step, a first subtask is performed to disaggregate the zone-to-zone flows into hypothetical firm-to-firm flows, as a prerequisite to model individual firms' choice of transport chain. Afterwards, aggregation to origin-destination (OD) flows will take place prior to performing network assignment. All modules, apart from the main logistics model, are beyond the scope of this paper. The current logistics model in INTRAMOD is developed using a deterministic approach (i.e., follows the EOQ theory). Despite lacking an empirical basis by merely assuming that firms will choose the transport chain and shipment size that has a minimum cost, such a deterministic model is easy to calculate and the required data is available. In contrast to that, a stochastic model (e.g. a logit discrete choice model) is usually rooted in observed behavioral data which may better reflect the actual process of logistics choice decision making (Abate et al., 2018), yet exhaustive data collection is required. Consequently, this paper aims at improving the prediction of the current INTRAMOD logistics model by taking into account the firms' behavior regarding their transport chain choice to allow richer and more realistic policy analysis.

Recently various studies have been conducted to move away from a deterministic model to a stochastic model (Abate et al., 2014; Abate et al., 2016; Abate et al., 2018; de Jong, G. et al., 2014). The stochastic approach employs the random utility discrete choice model to provide a probability that a specific combination of the transport chain and shipment size is chosen by a shipper. The stochastic approach aims to overcome a problem that is inherent to the deterministic model. The deterministic model, as the implication of the all or nothing assumption, may suffer from an overshooting or 'sticky' choice problem (Abate et al., 2014). Overshooting occurs if the logistics cost function is rather flat, so that slight changes in the logistics cost will result in entirely different choices. Meanwhile, 'sticky' choice happens when an alternative is distinctly cheaper than the other alternatives. Thus, improvement of another alternative will not have an effect on this alternative mode share unless this alternative becomes the cheapest alternative, which then leads to an abruptly different model result.

The remaining part of this paper is structured as follows. Section 2 presents a review of existing studies of transport actors' choices on transport chain and shipment size. Section 3 describes the stated choice experiment in an effort to gain data on firms' transport chain choice. Pilot survey results and how these results are utilized to update the main stated preference survey are discussed in Section 4. Finally, section 5 provides conclusions and suggestion for future work.

2. Transport Chain and Shipment Size Choices

A transport chain is the sequence of modes employed in the process of shipping goods from the point of production P to the consumption location C (PC flows), during which goods could pass through logistics hubs such as warehouses, distribution centres, and transport terminals (De Jong et al., 2013; Huber et al., 2015; Huber, 2017). Huber (2017) argues that many freight movements involve more than a dedicated mode. The reason is that it is sometimes impossible to transport freight directly from production to consumption location. Moreover, direct shipping is often inefficient. These considerations have motivated researchers to put more emphasis on the big issue of transport chain choice and explore its potential in order to enhance the performance of freight transport models (Abate et al., 2018; Jensen et al., 2019).

De Tremerie (2018), 2018; Tuğdemir Kök and Deveci (2019) and Huber (2017) provide comprehensive literature reviews on the issue of transport chain (i.e., transport mode) choices. These authors argue that the transport chain is a complicated matter. Thus, it is crucial to identify multiple relevant factors concerning the determination of transport chain choices. In general, there are three primary considerations: First, consideration of the actors and their complex interaction. Many actors could be involved in the organisation of the transport chain with their different roles. This creates complex relationships, and there could be interdependencies between them. Second, considerations relating to the shipment characteristics, such as shipment size, shipment weight and value, shipment frequencies and delivery time, etc. Finally, characteristics of the transport system (e.g., transportation network and transport terminals).

Huber (2017) provides a review of logistics models in existing national freight transport models, finding relatively few national freight transport models accommodating logistics. Only 14 freight models among 126 freight transport models available globally that were reviewed involved multimodal transport changes, with practically all of those 14 being established in developed countries. Tuğdemir Kök and Deveci (2019) systematically review freight transport choice models employing stated preference (SP) technique. A more extensive review on a similar theme can be found in De Tremerie (2018), which considers many aspects such as mode type being predicted, the most used explanatory variables, actors being studied most, and the approaches (models) being applied most. Both De Tremerie (2018) and Tuğdemir Kök and Deveci (2019) conclude that transport cost, transport time, reliability, and frequency are the most frequently used and powerful variables in explaining the transport mode choice. Accordingly, variables and method applied in this paper are selected based on these reviews.

3. Setup of The Stated Choice Experiment

Joint RP/SP Survey

RP surveys are designed to obtain the actual choice behaviour from the respondents, while SP surveys provide respondents with various scenarios and register their choices under distinct circumstances (Lavasani et al., 2017). SP could be used to test consumer responses to new alternatives that have not yet been implemented. Another advantage of the SP survey is reducing the collinearity between attributes. However, the key issues with SP are the dependence of the results on the experimental design (i.e. poor design may lead to a misleading or less reliable model) and the fact that "in real life what people say they will do is often not the same as what they actually do" (Train, 2009). RP studies, on the other hand, would not have these problems since they deal with the real choices of the participants in existing conditions. A major problem of RP in the context of freight transport chain choice lies in the difficulties in gathering data, often resulting in a very limited number of observations.

Another problem is limited information on how shippers determine their choice. Using RP data, the researcher has insufficient knowledge on the trade-off behaviour of the shipper due to limited information on the unchosen alternatives and on the availabilities of the alternatives considered by shipper. In the case of SP, the possible alternatives of transport chain choices along with their attributes are presented by the researcher to the shippers. Furthermore, RP data can suffer from the problem of heavy correlation between attributes, whereas in SP the researcher can control for this correlation.

Even though RP data provide a foundation on reality, its drawbacks might cause difficulties in estimating a significant coefficient with the right sign for an attribute when the available alternatives have only a very limited variation in this attribute. As an example, loss and damage is an important factor for all stakeholders (i.e., shippers/consumers), and by knowing this all the available transport providers will also devote considerable attention to this factor and the result could be no or almost no variation in damage in the available alternatives. Therefore, despite the importance of this factor in shipping freight, damage to the goods is rarely found as one of the main attributes in an RP study. As another example, transport cost is an essential factor in determining mode choice for shipper. Consequently, many carriers using same mode (e.g. truck) will offer more or less the same cost to the shipper and this lack of variation due to market equilibrium could make the estimated coefficient of a cost variable insignificant. In an extreme case, the researchers may conclude that the cost variable is not important due to this insignificance.

Accordingly, joining SP and RP data will be beneficial as each dataset can complement each other. The SP data offers variation in attributes, while "the revealed-preference data ground the predicted shares in reality" (Train, 2009). Within this research, the RP data will be used to estimate the transport chain and shipment size choices. Meanwhile the SP data will be used to estimate the transport chain choice which will be the focus of this paper. In a later stage the joint data will be utilized to estimate a joint RP/SP model of transport chain and shipment size choice.

Efficient Survey Design

An experimental design is a process to produce a set combination of attributes and levels to be presented to the respondent. The experimental design's process and considerations in this study are customized using a so-called “efficient experimental design”. The efficient design aims at producing more reliable parameter estimation with an equal or lower sample size (Rose and Bliemer, 2009). Aiming at minimizing the expected asymptotic variance-covariance (AVC) matrix given prior knowledge about possible parameter values, an efficient experimental design has been generated using the NGENE software. Priors used for pilot survey are derived from Nugroho (2015) for the attribute parameters, and Kim (2014) and Valeri (2013) for the mode alternative specific constant (ASC).

The alternatives for the SP scenarios are the available transport chain options between production (P) and consumption (C) zones (alternatives are different for every PC pair). The zone represents a group of regions (i.e., categorized as city or "kabupaten" i.e. Indonesian administrative area). There are 509 regions in Indonesia; however, to make the calculations manageable, these regions are aggregated into 91 Transport Analysis Zones (TaZ). Therefore, around 8281 PC pairs will be generated. Each PC pair has at most five possible transport chains: Truck (alternative 1), truck-train-truck (alternative 2), truck-vessel-truck (alternative 3), truck-plane-truck (alternative 4), and truck-train-vessel-truck (alternative 5). These alternatives reflect single mode used (one leg), two modes used (three legs), three modes used (four legs). Among these possible alternatives, the SP scenario will only show a maximum of four alternatives to each respondent. The four cheapest alternatives and the base value of attributes (time and cost) for each alternative are determined using a multimodal chain builder, which will be explained in the next section. Meanwhile, the attributes employed are transport cost, transport time, and reliability.

The Multinomial logit (MNL) model, being widely used for such estimation, was then applied as a starting point for running the NGene software to obtain the efficient experimental design. Such MNL models have error terms which are distributed independently and identically across alternatives and respondents, following the type I extreme value Gumbel distribution leads to the logit formula (Train, 2009). Employing the utility function with single parameter for all attributes and specific prior for each alternative, the utility of each alternative can be expressed by Equation (1) below:

Category (i) is a choice using a specific transport chain type (i.e., alternative).

$$U_{mni} = ASC_i + \beta_1 T1_{mni} + \beta_2 T2_{mni} + \beta_3 T3_{mni} + \varepsilon_i \qquad \text{Eq. (1)}$$

Where:

U_{mni} = Utility of choosing a discrete transport chain alternative *i* by shipper q (this index is not shown to reduce complexity) for shipment from m (origin) zone to n (destination) zone
ASC_i = Alternative specific constant
β_1 = Parameter of transport cost
$T1_{mni}$ = Transport cost of a discrete transport chain alternative *i* for shipment from m to n
β_2 = Parameter of transport time
$T2_{mni}$ = Transport time of a discrete transport chain alternative *i* for shipment from m to n
β_3 = Parameter of reliability
$T3_{mni}$ = Reliability of a discrete transport chain alternative *i* for shipment from m to n
ε_i = Error term

The values of the transport cost and transport time attributes presented to the respondents are varied around base values which depend on the location of the goods' origin and destination. As no available data supported these fundamental attributes, a tool to calculate 'base value'' data on transport cost and transport time between all zones for each type of transport chain alternative was developed, called 'the transport chain builder' (TC builder). The detailed explanation of the TC builder is provided in the next section. The last attribute is the reliability which is defined as the percentage value of 'how often the shipment is delivered on time'. For example, if a shipper makes 5 shipments within a month, in a case where a shipment is delayed once a month (not considering the length of the delay), the reliability is 80%.

The attribute levels and the expected signs of the attributes for the pilot survey are as follows: The attribute of transport cost is differentiated into four levels -30%, -15%, +10%, and +20% of the initial ('base') value. The transport time also has four levels around base value : -15%, -7%, +15%, and +30%. Lastly for the reliability attributes; the levels are 70%, 75%, 90%, and 95%. Such choice of attribute levels is based on previous studies and the range of situation that may be experienced by the respondents.

There are three parts in the online survey, the first part is an inquiry about the respondent's comapny details. In the second part, there are 3 sections related to the shipment: 1. type of commodity, 2. detail of the current choices of shipment transport chain and shipment size, and 3. The SP scenarios. The third part is a question related to the effect of pandemic on their shipment choices. The number of SP scenarios displayed to the respondent differs depending on the number of transport chain alternatives available for the shipment,. If the number of alternatives is ≥ 3, then 8 SP scenarios will be displayed, otherwise 12 SP scenarios will be presented. Figure 1 exhibits the example of how an SP scenario appears in the web survey.

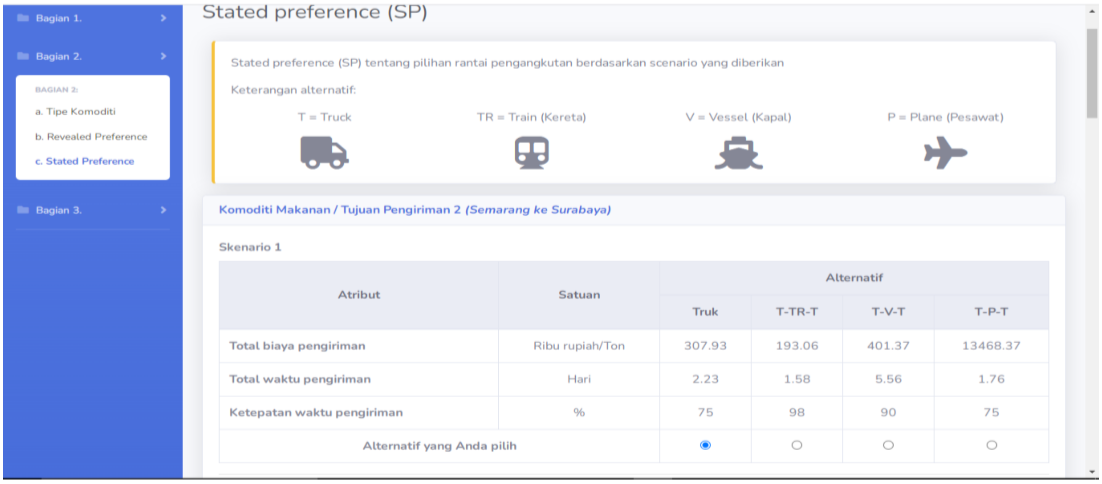

Figure 1. The SP scenario part of the online survey

Determination of Base Values

This section presents the general architecture of the transport chain (TC) builder, a program to estimate the transport cost and transport time of each transport chain alternative for every zone relation. This program was used for setting the base levels in the SP, and is needed because no available data for transport cost and transport time for every zone pair exists. As previously stated, there 91 TaZ in Indonesia called TC zones. The TC zones are categorized into three types; zones which have a strategic port (Zone A), zones which have other transport terminals except ports (i.e., airport or train station) (Zone B), and zones with no transport terminals (Zone C).

A multimodal transport network in Indonesia was developed, that covers the road, rail, sea, and air transport network, and became the main building block for the TC builder. This network was used in this study to determine all possible transport chain alternatives and their attributes: transport cost and transport time. As previously discussed, there are three types of zones considering the availability of the transport terminals (port, airport, train station), further in the network model transport terminals will be considered as nodes along with the TC zone and road junctions. Meanwhile, the links represents the national road, railways, sea routes, and flight routes.

The road transport network in the TC builder is limited to only the national roads, as this type of roads can accommodate a truck with maximum load >10T. Only one toll road is included in the model, Jakarta Outer Ring Road (JORR), as in Indonesia truck drivers usually prefer the arterial road over the toll road in order to save money. Still within the road network, other roads with a charge are the ferry link between Sumatera Island and Java Island; and the ferry link between Java Island and Bali Island. These links represent ferry transport, which has a crucial role in improving road transport accessibility between Java and its adjacent islands. Those ferry lines are Bakauheni – Merak (i.e., connecting Sumatera and Java) and Ketapang – Gilimanuk (i.e., connecting Java – Bali). Meanwhile, for the rail network, railways in Indonesia are only available on Java and Sumatera islands and are managed solely by the Indonesia Railway Company (PT KAI). In total, there are 21 train stations connected by 4.816 kilometers of rail track of which 3.464 km are on Java Island and 1.352 km (of non-continuous railway network) in the North, West, and South of Sumatera Island.

There are 33 ports examined in this chain builder; these cover various ports in the new sea routes network developed by Ministry of Transport (MoT) and 24 strategic ports suggested in the blueprint of the national logistics system. Liner shipping companies in Indonesia have the privilege of determining their routes, yet these routes should be registered to the MoT to obtain approval. Private operators mostly establish liner service in connecting well-developed regions, while the state-owned shipping company mostly serves the connections between less developed regions or between remote regions and the developed regions (Halim, 2016).

The TC builder includes around 246 links featured in 193 sea routes which connect the 33 ports. In terms of the distance calculation for the links; the nautical mileage and air mileage are obtained from the following websites: https://www.airmilescalculator.com/, https://sea-distances.org/, and http://ports.com/sea-route, while rail distance is based on the data from train operator (i.e., PT KAI). Lastly, the driving distance was determined using ArcGIS software, except for the distance between the ferry ports. This data was obtained from the ferry port authority.

Based on the road development plan in the directorate general of highways strategic plan 2015 – 2019, the road transport travel time was around 2.7 hours/100 km (i.e., average speed around 37 km/hour) in 2014. For this current study, three-axle trucks with a capacity of 15T are the only mode considered for road transport in this chain builder. Meanwhile for rail transport, level of service of rail transport in terms of train speed in Java and Sumatera is also different according to Nugroho (2015), with Java having better conditions than Sumatera. The average train speeds are 36.24 km/hour and 27.13 km/hour for Java and Sumatera railways respectively.

In the TC builder, we use sea vessels is the 3000 – 6000 DWT range, these being the second-highest volume in terms of number of vessels operated. This is considered to be the only vessel type in the network. The sailing speed is assumed to be 18.52 km/hr (10 knots). Meanwhile, for air freight transport, as only a few dedicated cargo planes are used in Indonesia, most air freight air transport is transported in a plane shared with passenger transport (Susanto, 2005). According to the airline historical operating data, Garuda Indonesia, air freight transport using such a shared plane is expected to have a freight capacity around 3 Tons (i.e., 25% of payload) in a single trip. Connections between minor economic regions in Indonesia tend to be serviced by small plane (Yuliana et al., 2019), but due to data limitations, we assume the shared plane is the only type of mode servicing interregional freight trips in Indonesia. The speed of the plane is assumed to be 635 km/hr (343 knots).

The mode characteristics explained above affect the unit cost applied for that particular mode of transport which also will have an impact on the five possible alternatives that could be generated by the TC builder. Level of service of the links in the TC builder follows the mode unit costs presented above. The transport cost function used here is derived from a cost function applied in Frazila et al. (2018) for truck, rail, and vessel. The transport cost is calculated by considering the cycle time, daily operation cost and payload capacity. The cycle time is a function of round-trip travel time, waiting time, loading and unloading time. The daily operation cost is then derived from the mode purchasing cost, the depreciation cost, the routine cost for operating the mode and the maintenance cost. The base value for each mode is presented in Table 1. Meanwhile, the air freight unit cost is assumed to be 1.02 USD/ton. This value is obtained through trial and error within the TC builder calculation to balance with a World Bank (2009) assumption in which the air freight has a price about 12 - 16 times that of the sea freight price.

Table 1. Transport cost function of the mode

Mode	**Cost function (USD/ton)**
Truck (capacity 15 T)	0.058 d
Rail mode (20 wagon @ 20 T)	0.047 d
Vessel (self-propelled barge 6000 T)	0.031 d
Plane (Boeing 737 – 300, capacity 3 T)	1.02 d

Based on the results from the TC builder, there are 18 types of possible alternative combinations connecting the TC zone pair as provided in Table 2. Further, the experimental design was generated only for 14 types among them (i.e., an SP scenario is only applied for the situations which have 2 or more options since this is required for an SP choice experiment).

Table 2. Possible alternatives result of TC builder

No	Type of possible alternatives	Count	SP Scenario
1	Zero	119	Not applied
2	Alternative 1	64	Not applied
3	Alternative 3	218	Not applied
4	Alternative 4	1190	Not applied
5	Alternative 1,2	58	Applied
6	Alternative 1,3	38	Applied
7	Alternative 1,4	45	Applied
8	Alternative 3,4	2384	Applied
9	Alternative 3,5	112	Applied
10	Alternative 1,2,3	14	Applied
11	Alternative 1,2,4	96	Applied
12	Alternative 1,3,4	301	Applied
13	Alternative 1,3,5	2	Applied
14	Alternative 1,4,5	5	Applied
15	Alternative 3,4,5	2352	Applied
16	Alternative 1,2,3,4	644	Applied
17	Alternative 1,3,4,5	25	Applied
18	Alternative 1,2,3,5	614	Applied
Total		8281	

4. Results

The logistics model in this study is developed at the disaggregate level so it can describe the behaviour of individual shippers on their choice of the transport chain and shipment size. The respondents of the survey are firms with domestic trade in Indonesia which are listed in a manufacturing industry directory published in Indonesia's in 2019.

The SP experiment is carried out in two phases: a pilot survey that was conducted in August to October 2021, and the main survey that currently is in progress. Consequently, the results from the pilot survey will be the empirical basis of this paper. The pilot survey aims to validate the attributes, levels and design of the experiment as well as to confirm the questionnaire and survey procedures. After this, the estimated parameters resulting from the pilot survey were adopted as the new priors to produce the 'efficient design' for the main survey. The survey collected the current choices of transport chain and shipment size of the shipper as the RP data, followed by data of solely transport chain choice through the SP scenarios. The SP pilot data will be the main data for this paper.

In the recruitment of respondent candidates for the pilot survey, 400 companies were contacted via email and an additional 196 companies were invited through letter, in which fifty among them were also invited through a phone call. This approach succeeded in gaining 21 respondents which adequately provided 212 SP choice observations. As with many other SP survey related to the transport choice, this survey has low response rate of about 3.5%. The distribution of the respondents according to the 5 big islands in Indonesia are as follows:

Java with 12 respondents (57%), Kalimantan with 5 respondents (24%), Sulawesi with 2 respondents (9%), and Sumatera and Maluku-Nusa Tenggara with 1 respondent each (5%).

The transport chain choice model for the pilot survey was then estimated using the Multinomial Logit (MNL) considering three utility functions, the first model as expressed in Eq. (1), while the other two are as follows:

$U_{mni} = ASC_i + \beta_{1i}T1_{mni} + \beta_{2i}T2_{mni} + \beta_{3i}T3_{mni} + \varepsilon_i$ Eq. (2)

$U_{mni} = ASC_i + \beta_1 T1_{mni} + \beta_{2i}T2_{mni} + \beta_{3i}T3_{mni} + \varepsilon_i$ Eq. (3)

Table 3. Results of the pilot survey

Attributes	Coefficient		
	Utility function 1	Utility function 2	Utility function 3
asc_alt1	0	0	0
asc_alt2	-0.185	4.319	3.718
asc_alt3	0.218	3.291	2.133
asc_alt4	-1.571*	-11.334*	-5.140
asc_alt5	-0.462	-2.730	-4.995
b_1	-9.07E-05		-1.32E-04*
b_2	-0.353*		
b_3	0.030*		
b_11		-0.003*	-
b_21		-0.482	-0.639*
b_31		0.065*	0.049*
b_12		-0.005*	-
b_22		-0.042	-0.765*
b_32		0.006	0.006
b_13		-0.003*	-
b_23		-0.494*	-0.412*
b_33		0.028	0.019
b_14		-0.000164*	-
b_24		1.706*	0.731
b_34		0.107*	0.059
b_15		-0.003*	-
b_25		0.343	-0.100
b_35		0.021	0.065*
Statistics			
LL(start)	-238.497	-238.497	-238.497
LL(0)	-238.497	-238.497	-238.497
LL(final)	-191.439	-161.417	-161.417
Rho-square (0)	0.1973	0.323	0.323
Adj.Rho-square (0)	0.168	0.244	0.244
AIC	396.880	360.830	360.830
BIC	420.370	424.610	424.610

*Significance at the level of 5%

The complete parameters estimation results are provided in Table 3 above. First, the utility function was assumed to have only one parameter for each variable, cost, time, and reliability, for all types of alternatives. The second utility function considers different parameters for each type of alternative for all attributes, the transport cost, transport time, and reliability. The third utility function is assumed to have only one parameter for cost, but different time and reliability parameters are estimated for each type of alternative. According to the model performance, value of final log-likelihood, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values, as well as the signs of the estimated parameters, the first utility function was the one chosen to settle the prior value for the main survey experimental design.

In terms of the value of final log-likelihood, the higher the value the better the model fit. Function 2 and function 3 both are having the same value, whilst function 1 has the lowest value among the three. On the other hand, the opposite effect applied for the AIC and BIC values, in which the selected model should have the lowest value. Both function 2 and function 3 beat function 1 for the AIC, but function 1 is preferable considering the BIC value. In terms of the statistical value of these models, we could claim that function 2 and function 3 are similar. However, considering the signs of parameters, function 3 has slightly better performance with only one parameter having unexpected sign (for the time parameter for alternative 4). Meanwhile, in function 2, the time parameters for alternative 4 and alternative 5 both have opposite signs from the theory. The problem with unexpected signs does not occur in function 1. Accordingly, function 1 is selected with all the three attributes in this specification have expected signs, with attributes for transport time and cost having negative signs while reliability has a positive sign. For the significance, two of three attributes, travel time and reliability, are significant at the level of 5%. The sign for the alternative specific constant meets the expectation in which truck mode only (alt1) is the most preferable alternative (when everything else is kept constant). For alt3 (vessel), even though its ASC has a positive value which indicates the most preferred transport chain, the coefficient is insignificant. In terms of the value of time (VoT) which is calculated as β_2/β_1, this yields 162215 IDR per tonne/hour. Hence the VoT from the pilot survey is equivalent to 11.5 USD per tonne/hour. This is very high compared to the average result for Indonesia’s VoT in a meta-analysis study by Tao and Zhu (2020) of 1.6 USD per tonne/h, and also when compared to Binsuwadan et al. (2021) (0.9 USD per tonne/h). This result seems high and could be affected by the small sample gathered. However, as the purpose of the pilot survey is to validate the survey properties before conducting the main survey then this result may not be replicated in the final results. Moreover, the pilot data set that has been obtained will also be included in the analysis for the estimation of the main model.

Considering that the results from the pilot survey portray the current situation in Indonesia, and to make the best used of data being gathered, the following updates have been applied to the main survey SP scenario. First, the priors that had previously been derived from Nugroho (2015) for the attribute parameters, and from Valeri (2013 and Kim (2014) for the mode alternative specific constant (ASC) have been changed into the pilot survey results, as shown in Table 4. Second, the attribute levels used in the pilot survey are being retained for the main survey, except for the levels for the cost attributes. For the transport cost attribute, the levels are being changed into -40%, -20%, +15%, +20% respectively for levels 1 to 4. This is to accommodate trading between alternatives which have a big gap in terms of cost such as choices between road and air transport.

Table 4. Coefficient values applied for pilot survey and main survey SP efficient design

Attributes	Pilot survey priors	Main survey priors
asc_alt1	0	0
asc_alt2	-0.001083	-0.185
asc_alt3	-0.000385	0.218
asc_alt4	-0.00403	-1.571
asc_alt5	-0.0006053	-0.462
b_cost	-0.000693	-0.0000907
b_time	-0.195	-0.353
b_rel	0.000504	0.030

5. Conclusion

This paper has presented research towards the development of a stochastic logistics model for Indonesia's national freight transport model (i.e., INTRAMOD). It describes in detail how the SP scenarios were designed, how the pilot survey was carried out and how its results are being used to inform a larger data collection exercise currently under way.

Like many other surveys on freight transport chain choice, the pilot survey has a low response rate, which is one reason why the main survey is not yet complete. The SP scenario was developed using the so-called efficient experiment design, employing priors estimated from previous studies. Parameter estimation was conducted using three specifications of MNL model: (1) single parameter for each attribute for all types of alternatives, (2) different parameters for each attribute for each alternative, (3) single parameter for the transport cost attribute for all type of alternatives, but different parameters for transport time and reliability for each type of alternatives. On the basis of the statistical attributes of the model and the expected signs of variables, the result of the first specification was chosen as the prior value for the main survey experimental design. Despite having high Values of Time (VoTs) compared to previous studies, perhaps due to the small sample being gathered, the results from the pilot survey will still be utilized to correct the prior values for the main survey, as explained in Section 4 above.

Further research will be conducted to estimate the transport chain choice of firms in Indonesia using the completed data set as gathered in both the pilot and main surveys. Other model specifications such Nested logit model will perhaps be estimated, in addition to the MNL model. Finally, a full stochastic logistics model for INTRAMOD covering both the RP and SP data to estimate the transport chain and shipment size will be developed.

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