

Encouraging the Shift of Modes of Freight Transport from Road to Railways in Indonesia (Case Study: Java Island)

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| Submitted: December 18, 2023 | Revised: December 19, 2023 | Accepted: May 24, 2024 |

| Published: September 21, 2024 |

ABSTRACT

Freight transportation has a positive effect on the development, on the other hand, transportation also has negative impacts that need to be considered. Rail as a mode that has the potential to be a solution is still little used compared to trucks. This research aims to investigate the weighting factors and actors in Indonesia to encourage the shift of freight transport modes from trucks to railways, to know the constrain the utilization of railways as a mode of freight transportation and provide policy recommendations by benchmarking from other countries. The research was carried out using qualitative and quantitative methodologies. A qualitative approach was carried out through a literature review covering various countries and sources, and interviews with experts. The analytic hierarchy process is formulated for quantitative analysis and executed with Expert Choice software. Data was collected through a questionnaire, with a purposive sampling method. The results show that Time, Service Quality and Area Coverage are considered as the 3 main factors with the highest weight. Government and Logistics Service Providers are the most influential actors in promoting the shift of freight from trucks to trains. Recommendations for priority policies are policies related to factors and involving actors with the greatest weight, and overcoming the obstacles that exist in Indonesia in using trains as a mode of freight transportation by increasing modal transfer facilities to increase the efficiency of freight transportation via train, with support from the government in the form of incentives as has been done by the Britain Railway.

Key word: freight transport; environmental; policy; Analytic Hierarchy Process (AHP); Expert Choice Software.

INTRODUCTION

Freight transport assumes a pivotal role in the advancement and economic growth of a nation. Nasreen et al. (2018) conducted an analysis of the correlation between freight transport and economic growth across 63 countries characterized by varying income levels, and the findings led to the conclusion that freight transport exerts a positive influence on the global economy. However, major transportation activities impact in a variety of ways, including congestion, accidents, and exhaust emissions. The substantial contribution of diesel trucks to traffic-related emissions degrades air quality (Inkinen and Hämäläinen, 2020). The transportation sector constituted nearly 64% of final petroleum consumption in 2012 and responsibility for approximately 25% of worldwide carbon dioxide emissions stemming from fuel combustion and the potential escalation in CO₂ emissions attributed to international freight transport is estimated to undergo a 3.9-fold increase between 2010 and 2050 (Nasreen et al., 2018). One proposed approach for mitigating the detrimental consequences of emissions involves substituting road transportation with rail transportation. Implementing intermodal rail operations reduces emissions exceeding 77.4% (Pinto et al., 2018). Due to the impracticability of a rail freight transition, numerous nations' global green logistics initiatives are hampered. While the benefits of using trains for freight transportation are well known, their use is limited. This is evident in Indonesia, where up until 2019, Road transport still dominated goods transport., accounting for 91.25%, with alternative transport modes comprising 8.06%, including railways (Dwiatmoko, 2018). Several factors contribute to respondents' disinclination towards selecting railways include the station's dual handling procedure, a discrepancy between train

schedules and delivery times, and the contractual obligation to remit train fees (Sihombing et al., 2021).

In pursuing a country's development, it is paramount for freight transportation to accord precedence to sustainable modes of conveyance. This emphasis on sustainability aligns with the overarching objectives of national developmental pursuits, which foster prosperity and well-being for the region's inhabitants (Dwiatmoko, 2018). Nevertheless, road networks dominate the transportation of goods in Indonesia, which contributes to economic, social, and environmental problems. This research aims to investigate the weighting or prioritization of factors and actors in Indonesia to encourage the shift of freight transport modes from trucks to railways to provide appropriate policy recommendations in the study area by benchmarking from other countries.

RESEARCH METHODS

Research Steps

The research conducted four research stages: The research's main issue, shifting freight transportation modes, is identified in Phase 1. The problem is created to set research goals. Phase 2 collects qualitative data from academic journals, online articles, and books. Transportation logistics experts were interviewed to verify the literature review. Phase 3 defines AHP model hierarchy. The AHP model becomes online questionnaire questions after development. Participants completed questionnaires and AHP analyzed the data. Research data was analyzed using expert choice software for reliability. Phase 4 examined and drew conclusions from analysis results. The research process diagram is presented in Figure 1.

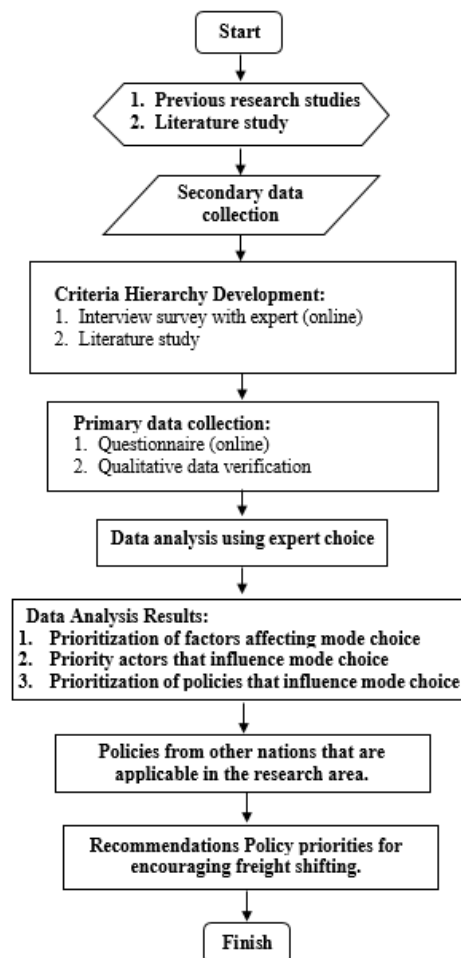


Figure 1. Research Flow Chart

Research population and sample

The sampling method used is the Purposive sampling technique, a non-probability sampling technique used in research with careful consideration when selecting certain samples to be included (Guarte and Barrios, 2006). To achieve the desired dataset, a minimum of 30 respondents is targeted. Respondents are selected to provide a comprehensive perspective from various viewpoints and expert sampling, thereby facilitating a deeper comprehension (Etikan, 2016). The interviewed respondents, targeted actors, were experts engaged in transportation logistics, as follows: Consumer, Logistics Actors, Logistics Service Provider, Logistics Supporters, Government

Interview

The interview aims to determine the criteria within the AHP hierarchy. These criteria derived from the viewpoints of diverse stakeholders regarding freight transportation activities, which were carried out with five distinct groups of logistics participants. Interviews were also conducted to validate the findings of the literature review, in relation to the condition of freight transportation in Indonesia as the study area. The interviews were conducted using the Zoom application. Open-ended interview techniques involving open-ended questions were employed. All participants were presented with an identical question.

Questionnaire

Data collection was carried out utilizing the JIS Online Survey (<https://www.onlinesurveys.ac.uk/>), which was designed and implemented to gather pairwise comparison data of a set of criteria formulated from participants representing predefined stakeholder groups. The questionnaire was divided into three sections, 1) Introductions contain the purpose and objectives of the survey, data security guarantees, Instructions for completing the consent form, and the respondent's declaration of willingness to participate, 2) The question section (Demographic data, pairwise comparison data, and Willingness to be contacted again), and 3) Closure and acknowledgement. The questionnaire was disseminated as a hyperlink and transmitted to participants through the WhatsApp messaging application and email.

Data Analysis

This study employs the Analytic Hierarchy Process (AHP) method for quantitative analysis technique. AHP is a method for logically summing up human perception while allowing for slightly inconsistent inputs. This model's primary input is the opinions of individuals considered experts. Using qualitative inputs (human perceptions converted to weighted numerical values), the AHP model is an all-encompassing framework for decision-making that takes qualitative and quantitative factors into account. Multi-objective and multi-criteria problems are another area in which the AHP model excels (Saaty, 1990).

RESULT AND DISCUSSION

Interview result

The respondents selected for the interviews encompassed representatives from each stakeholder entity engaged in freight transportation activities. Based on the outcomes of interviews corroborating the literature review concerning freight transportation, the ensuing points are ascertainable:

1. The selection of the freight transportation mode, particularly trucks, and trains, in Indonesia is influenced by the following factors:
 - a) Cost (Total Cost)
 - b) Time (Total Travel Time)
 - c) Frequency
 - d) Quality of Service
 - e) Capacity
 - f) Coverage area.

2. Every stakeholder involved in freight transportation activities is crucial in fostering the transition of freight movement from trucks to trains.

AHP Criteria Development

After a thorough literature review and interviews with transportation logistics experts, create a criteria hierarchy. Starting with the factors influencing transport mode choice, which are also factors facilitating freight movement and include stakeholders with the power to influence mode selection, and the top policies relevant to each alternative policy. The hierarchical configuration is shown in Figure 2.

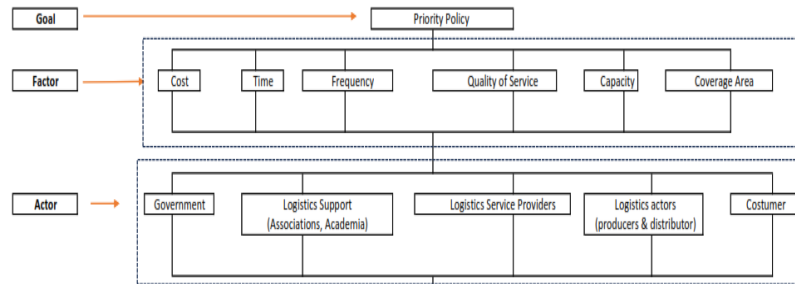


Figure 2. Structure of the research process hierarchy.

Questionnaire

A total of 37 survey responses were received, of which 34 were deemed valid, while 4 raised concerns regarding their validity. Data is considered potentially invalidated when all responses for each question are uniform, wherein respondents consistently select "equally important" during pairwise comparisons.

From the data obtained, the characteristics of the respondents are shown in Figure 3

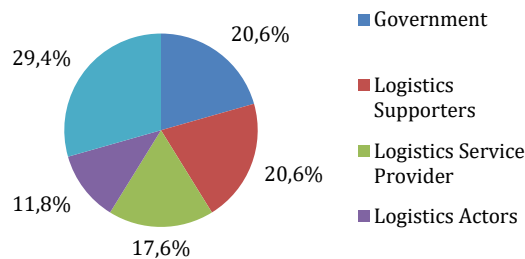


Figure 3. Composition of respondents based on role in logistics activities.

Figure 3 depicts the distribution of participants among the five stakeholder groups engaged in freight transport activities. It can be affirmed that all five groups are encompassed. Logistics Service Providers and logistics actors, resulting in proportions of merely 17.6% and 11.8%, respectively. The most substantial stakeholder group in freight transportation activities, specifically consumers, is the most prominently represented, comprising nearly 30%. Additionally, respondents affiliated with the Government and Logistics supporters selected an almost equal percentage of 20.6%.

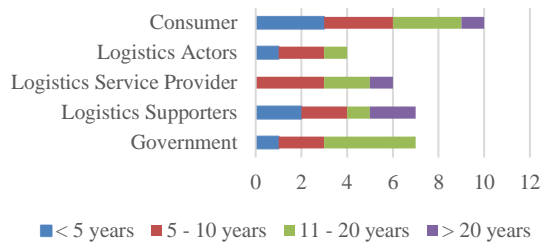


Figure 4. Length experience of respondents.

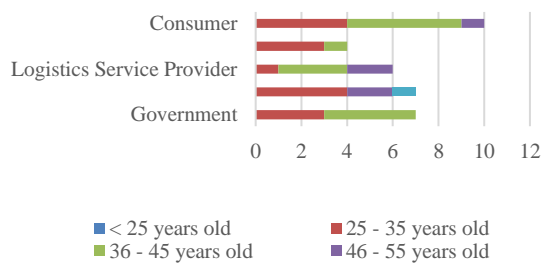


Figure 5. The age range of respondents.

Figure 4 and Figure 5 illustrate the comprehensive distribution of respondents' experience length and age range, it is apparent that each stakeholder group manifests the presence of experts, as indicated by experience durations falling within the 11-20 years and over 20 years brackets, notwithstanding the inclusion of respondents with less than 5 years of experience. This trend parallels the age distribution of respondents, which demonstrates uniformity across each age range while excluding those below 25 years old.

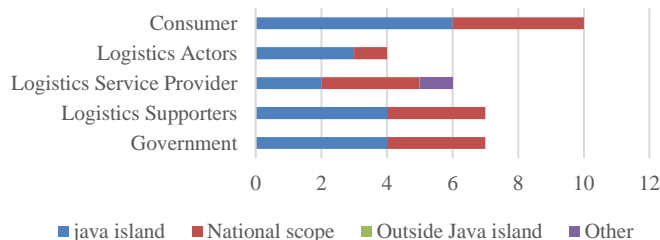


Figure 6. Coverage of Work area of respondents.

Figure 6 illustrates the extent of coverage of respondents' work areas. All participants fall within the study's designated region, namely the island of Java. This coverage encompasses a broader national context. Only a solitary respondent deviates from this pattern by indicating international coverage. Notably, no participants identified work areas lying beyond Java. Consequently, the viewpoints and expertise of these respondents are deemed pertinent for utilization in this study.

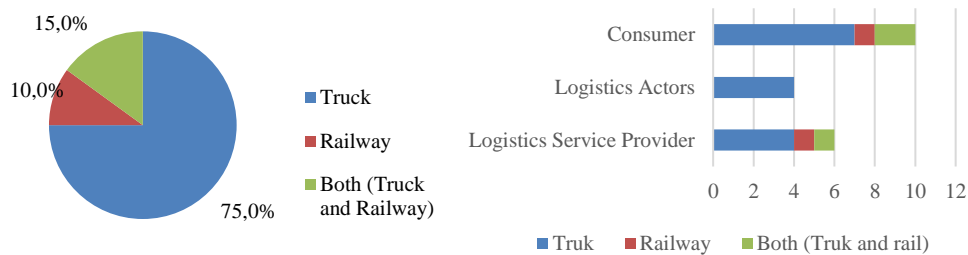


Figure 7. Respondent's mode choice.

With a specific focus on mode selection, the inquiry is exclusively directed to three key stakeholders: Logistics Service Providers, Logistics Actors, and Consumers, all of whom directly influence mode selection within freight transportation activities. Conversely, regulators and logistics supporters are exempt from this inquiry. As indicated by Figure 7, it becomes apparent that freight transportation activities are prominently governed by trucks, constituting a substantial 75%, while trains account for a mere 10%. While data presentation derived from purposive sampling is insufficient for population-wide generalizations, the diagram effectively portrays the utilization patterns of modes among stakeholders engaged in freight transportation activities. This observation is underscored by the absence of train usage among respondents from the logistics actor group.

The data acquired from respondents is subsequently processed employing the Expert Choice software. The procedural sequence for utilizing the Expert Choice application within this research encompasses the following stages 1) Criteria Identification, 2) Criteria Comparison Assessment, 3) Final Weight Calculation, and 4) Analysis of Results. Within Expert Choice, the coherence of pairwise comparisons made by each respondent is also computed. A permissible threshold for inconsistency is $CR < 0.1$ or 10%.

Discussion

Several factors impede the utilization of trains for freight transportation in Indonesia.

1. Due to limited infrastructure, not all areas have accessible stations, particularly in regions with the potential for generating commodity deliveries (industrial locations), thereby increasing the expenses associated with transportation to and from the station to the delivery destination. Similarly, not all stations possess loading and unloading facilities dedicated to freight. Consequently, no separate line is dedicated solely to freight transportation; instead, it shares tracks with passenger lines, impacting freight train operations' efficiency.
2. Trains are not economically viable for distances less than 500 km. Moreover, while the cost per kilometre of train transportation is lower over certain distances, the expenses associated with handling and unloading can contribute significantly to the overall cost.
3. While trains can transport large capacities, this feature can become a bottleneck when there is a minimum shipping requirement.
4. Truck violations

Analysis of the response

The subsequent elucidation outlines the analysis outcomes yielded by the Expert Choice application. Weighting analysis is conducted across all criteria and alternatives, encompassing each stakeholder group, and involving all respondents. This is based on the individual preferences of every individual. For instance, even if two people create the same hierarchy, their preferences may result in distinct decisions. Nonetheless, a group of individuals can work together to reach a consensus on the hierarchy's structure (design), evaluation, and synthesis (Vargas, 1990).

Weights on factor criteria

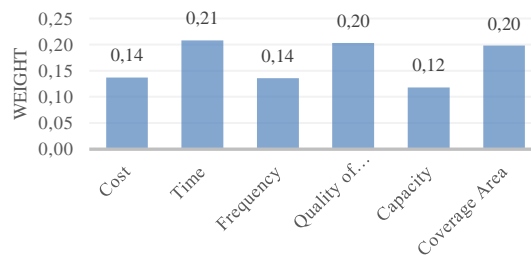


Figure 8. Weighting on factor criteria in all respondents

The results of weighting on the criteria for factors that influence mode selection are shown in Figure 8. The outcomes of the weighting analysis concerning the determinants of mode selection for all respondents underscore that the Time aspect holds the most significant influence, demonstrated by a weight value of 0.21. Moreover, the second factor with nearly the same value is Service Quality and Coverage Area, both possessing an identical weight value of 0.20, indicating a marginal disparity from the highest weighting values. Occupying the third position with an equivalent weighting value of 0.14, the pivotal determinants significantly influencing the choice of freight transportation modes in Indonesia encompass Cost and Frequency. This corroborates the viewpoint expressed by respondents within the Logistics Service Provider group during interviews and questionnaires. Presently, cost does not hold a central position within freight transportation activities, as freight transportation service users are willing to incur higher charges in exchange for improved delivery services.

Weight based on actor criteria.



Figure 9. Weighting on Actors criteria in all respondents

Furthermore, the weighting results on the factors that most influence the shift of freight transportation from trucks to trains are shown in Figure 9. Within the calculation of weights assigned by all respondents, the outcomes signify unanimous consensus across the entire cohort, with the Government and logistics service Providers sharing an equivalent weight value of 0.26. Following this, logistic actors emerge with a value of 0.22, while consumers wield a weighting value of 0.16. Notably, Logistic Supporters attain the smallest value, attributable to their role primarily as intermediaries facilitating communication between the government and other stakeholders, despite their involvement as stakeholders in freight transportation activities.

Consistency of pairwise comparison of participants

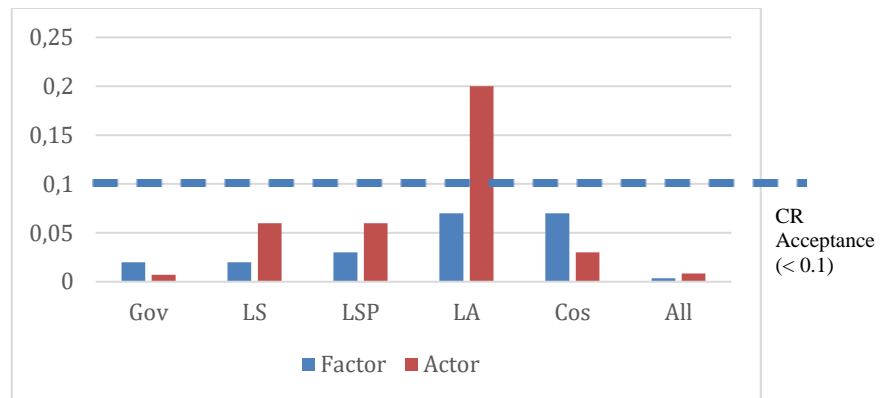


Figure 10. Consistency Ratio Value on Stakeholders

Figure 10 depicts the Consistency Ratios of all stakeholder groups for each pairwise comparison across all criteria. The consistency ratio is calculated for each criterion with more than 2 options. CR is not used in two-option pairwise comparisons (Saaty, 1990). Comparing infrastructure policy focus between building new and developing existing infrastructure is one example. If the CR is below 0.1, inconsistency is acceptable. The CR sometimes exceeds 0.1 in all calculations. Pairwise actor-operational regulation criteria CR values for the Logistic Actor Respondent group are above 0.1. In the AHP, this is common. Because people make inconsistent judgements, especially when assessing complex entities or concepts. AHP acknowledges the possibility of slight inconsistencies in judgment, recognizing that human evaluations may not invariably align (Teknomo Kardi, 2006).

Policy recommendations for government

This subsection will discuss the answer to research objective number 3, namely to find out transportation policies from other countries be potentially implemented. Several obstacles to using rail transport in Indonesia were identified during the interviews. Derived from these findings, several strategies can be proposed, including but not limited to:

1. Strengthening infrastructure in the rail mode

Aligned with the weightage results, which highlight that fostering the shift of freight transportation from trucks to trains should prioritize policies applicable to rail transport, a fundamental consideration emerges: the imperative for enhanced infrastructure within rail freight transport. Escalating investment in rail infrastructure constitutes a pivotal stride towards surmounting the impediments to transitioning freight transport from trucks to trains. It is incumbent upon the government to prioritize enhancing and expanding more extensive and efficient rail networks. Especially on modal shift facilities to achieve intramodality. The ideal freight transportation system requires a combination of transportation modes with warehousing and delivery systems, so that the efficiency of freight transportation will be achieved (Parikesit, 2016). In Indonesia, the transfer facilities are currently only at the end of the node points and large ports but there are no stations in the middle of the PANTURA route. With the existence of this facility, it can provide convenience and smooth flow of freight transportation and can shorten the time for shipping goods via rail mode.

2. Subsidy policies that support freight transport on rail modes

In contrast to most passenger services, rail freight operates without general government financial support (Woodburn, 2007b). Based on the interview findings, it is evident that Indonesia provides a subsidy for truck transportation, impacting truck shipping costs and consequently impeding trains' competitive standing. Conversely, train subsidies are exclusively allocated to passenger transportation. To surmount this challenge, implementing a policy that prioritizes freight transportation via trains becomes imperative. This policy would foster the transition of freight

transportation from trucks to trains. Conversely, an alternative approach involves reducing or eliminating fuel subsidies for truck transportation. This strategy is supported by the findings of the interviews, revealing that entrepreneurs do not oppose the reduction of fuel subsidies due to their potential to augment fuel availability within the market. The current scenario is characterized by increased fuel consumption and subsequent market scarcity due to the existing subsidy. Hence, it can be contemplated either through the phased reduction of fuel subsidies or the reallocation of these subsidies towards alternative modes of transportation. Nevertheless, the conducted weightage analysis outcomes reveal that considering the significance level, the policy warrants application in favour of the rail sector. Consequently, the government should implement subsidization policies for freight transportation via rail. Subsidies could be modeled on the UK government's Track Access Grants (TAGs), which have been in place since 1993, paid to rail freight operators for specific flows that provide broad environmental and social benefits (Woodburn, 2007a). In addition, the form of grants that can be used is Freight Facilities Grants (FFG). By implementing FFG, the government can provide grants in the form of facilities, especially the mode shift facilities discussed in point 1 in supporting mode shift.

3. Taxation

Concerning the tax levied on trains, although it burdens users of freight transportation via trains, the outcomes of expert interviews indicate that the policy should not entail tax removal. This is because taxes also yield positive repercussions for a country's development. Alternative policies could be directed towards the trucking sector to elevate shipping expenses. For instance, an external tax imposed on trucking could be considered. While this aspect carries limited weight in the research findings, it has succeeded in various countries. Despite its diminished influence on the analysis of respondent preferences in Indonesia, this policy could be considered optional and implemented progressively. Moreover, based on the weightage of the outcomes, it is apparent that rail-oriented policies are more likely to be pursued. Addressing the barriers and challenges inherent in promoting the transition of freight transportation from trucks to trains necessitates formulating a comprehensive and sustainable strategy. This entails bolstering infrastructure, formulating supportive policies, and enhancing coordination. By approaching these barriers comprehensively, the government and the industry can collaboratively facilitate a more sustainable and efficient shift in freight transportation modes. This endeavour holds significance for the future of Indonesia's logistics industry. In addition to encouraging the shift of freight transportation from truck to rail is the implementation of an externality tax, which has been done in European countries. Transportation taxes should consider the negative impacts. Taxes on transportation consist of two components. The first component is aimed at raising revenue. The second component corrects for external effects (Mayeres, 2003). Externalities are costs that must be borne or indirect benefits due to economic activity in terms of transportation externalities in the form of road damage, environmental pollution, accidents, and congestion (Dwiatmoko, 2018). By taxing the external effects of freight transportation, it is expected that there equal price competition between truck and rail freight transportation. The higher the tax imposed on trucks, the more likely it is that logistic actors switch to rail.

4. Law enforcement on truck violations

The significance of implementing dimensional and load limits in the transportation of goods via trains rather than trucks is inferred from expert interviews and questionnaire responses, despite the lack of direct research on the subject. Insights into this phenomenon indicate that truck-train freight transportation competition is characterized by a price disparity. Thus, trains are unable to compete economically with trucks. Existing research has demonstrated that trucks in the United States are subject to lower payment rates than other vehicle categories (Forkenbrock, 1999). Additionally, due to the practice of trucks carrying loads exceeding their rated capacity, Logistic Service Providers are positioned to provide services at reduced rates. This phenomenon also contributes to the prominence of truck vehicles as the primary mode of freight transportation in Indonesia. An approach to enhance price competition within freight transportation involves raising the cost of truck delivery through external taxation. However, considering its relatively minimal significance, this strategy bears the least weight in terms of efficacy. As a result, its appropriateness for implementation in the Indonesian context is questionable.

To overcome the challenges associated with railway freight transportation, a sustainable and all-encompassing approach is required. It is necessary to enhance infrastructure, supportive policies, and coordination. By addressing these obstacles, the government and industry can collaborate to shift goods transport modes in an efficient and sustainable manner. This undertaking is vital for the future of logistics in Indonesia.

To encourage shifting

This section will discuss the answer to research objective number 4, namely the priority policies for encouraging the shift of freight transportation from trucks to trains, which can be summarized as follows:

1. Technical aspect: Railway Infrastructure Development

The government must accord precedence to the enhancement of loading and unloading infrastructure capable of expediting the rail transportation of goods. This is particularly crucial due to the paramount influence of time in the choice of freight transportation modes. Additionally, attention should be directed towards augmenting various facilities contributing to service quality, constituting a secondary determinant in mode selection. Similarly, enhancing rail infrastructure, including expanding rail lines and broader coverage to facilitate an extended range of rail services and increased train frequency, can be instrumental. Sufficient infrastructure heightens the potential for transitioning from road transport to rail transport. As experience demonstrated within the European Union, the achievement of a modal shift from road to rail hinges on a synergistic integration of customer and market-oriented prerequisites, coupled with the requisite enhancements to the rail system (Islam et al., 2016).

Based on the results of the weighting calculation, it is known that Time, Quality service and Coverage area These factors are the 3 main factors with the highest weight. One example of policies and technology that can be applied is the "light comby" system technology that has been used in Europe, which is shown in Figure 11. With this technology, the loading and unloading process is easier, and it saves shipping time even though there are additional activities in the form of switching modes (Translation and Hutchinson, 2005.)

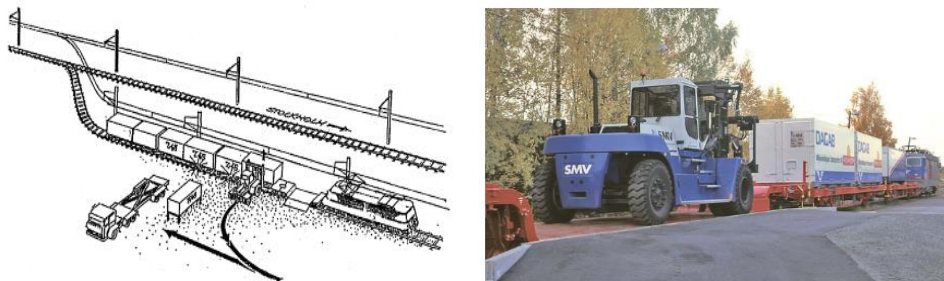


Figure 11. Light Comby system (Translation and Hutchinson,2005.)

2. Economic Aspect: Reduce shipping costs on rail freight.

The reduction of freight transportation costs via rail entails implementing policies that foster investment in rail infrastructure and operations, as elucidated in point 2 of the policy. Furthermore, subsidizing freight transportation can be pursued apart from mitigating shipping expenses in rail transportation. Based on the insights gathered from interviews with respondents, it becomes apparent that while subsidies have not yet been extended to freight transportation in Indonesia, new subsidies have been introduced for passenger transportation. Therefore, enacting a freight transportation subsidy policy becomes imperative, similar to China, Europe, and the US practices. While providing subsidies for freight transport carries the risk of market distortion by favouring rail transport over alternative modes, potentially leading to overcapacity within the rail sector, this challenge must be proactively addressed within the Indonesian context.

3. Legal Aspect: Law enforcement on truck violations

Improvements in the technical and economic aspects will indirectly encourage the movement of goods transported by rail trucks. However, law enforcement on trucking violations can realize fair price competition. Hence, trains are unable to compete with trucks in terms of pricing. Existing research has demonstrated that trucks in the United States are subject to lower payment rates than other vehicle categories (Forkenbrock, 1999). Additionally, due to the practice of trucks carrying loads exceeding their rated capacity, Logistic Service Providers are positioned to provide services at reduced rates. This phenomenon also contributes to the prominence of truck vehicles as the primary mode of freight transportation in Indonesia. An approach to enhance price competition within freight transportation involves raising the cost of truck delivery through external taxation. However, considering its relatively minimal significance, this strategy bears the least weight in terms of efficacy. As a result, its appropriateness for implementation in the Indonesian context is questionable.

CONCLUSION

Responding to the aim of finding out the weight of the level of importance of factors and actors that influence mode selection, the results of the Analytical Hierarchy Process (AHP) analysis show that the Time, Quality service and Coverage area factors are the factors considered to be the 3 main factors with the highest weight, with equal consideration of value (0.2), and on the actor side the Government and Logistics service providers are the actors with the largest weight in encouraging the movement of goods transport from trucks to trains, therefore, in developing policies, it is necessary to consider these issues. Furthermore, to respond to the objectives of transportation policies from other countries to be potentially implemented and recommendations, the results of the study found that from the UK experience, policies that can be implemented in Indonesia in each aspect, namely economic aspects, and technical aspects, including the provision of modal shift facilities in encouraging the effectiveness and efficiency of freight transportation (Time, Quality service and Coverage area) through railways, for example in the form of subsidies (involving the government and logistics service providers) and can emulate incentive patterns such as Freight Facilities Grants (FFG) that have been applied to British railways. For suggestions and recommendations, further investigation can attain greater depth by conducting a detailed Cost-Benefit Ratio (CBR) analysis. There is room for development by incorporating the viewpoints of groups not directly engaged in freight transport activities but impacted by their presence. Additional studies should be conducted on various other islands in Indonesia with distinct alternative mode and infrastructure conditions. Next research can be directed toward analyzing the preparedness of rail modes to meet the potential demand for shipping goods via rail.

ACKNOWLEDGEMENT

Authors would like to thank the Ministry of Transportation of the Republic of Indonesia and Gadjah Mada University as well as the university of Leeds for helping the completion of this research through a double degree scholarship program. The author is also grateful to all those who have also provided support and assistance in the preparation of this research.

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