IMPACT ASSESSMENT METHOD OF FREIGHT TRANSPORT MEASURES ON PRODUCTION AND LOGISTICS

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Abstract: *The objective of this study is to develop a method to investigate and assess the impacts of FTM measures on production and logistics. The proposed method is composed of two main stages. The first stage serves as a pre-selection of measures with a focus on defining and classifying the measures based on qualitative or partly-quantitative methods. The second stage investigates the core effects of selected measures using quantitative methods to carry out detailed analysis. The case study of the Vietnamese rice production and logistics is introduced and will be the application case for the method developed.*

Keywords: *Freight transport management, impact assessment*

I. INTRODUCTION

There are strong interactions among the three sectors of production, logistics and traffic, especially in the context of global supply chains. Decisions made in one sector often have impacts on the others. It is a fact that there are lots of methods that could be utilized to measure the impacts of freight transport management (FTM) measures. However, the research in multi-stage assessment method is considerably scarce as compared to the number of single methods. The objective of this study is to develop a method to investigate and assess the impacts of FTM measures on production, logistics and traffic. In this study, firstly, a review of existing assessment methods is discussed to provide a theoretical foundation for this study as a whole. The discussion of pros and cons of these methods is brought into focus. Subsequently, a multi-stage impact assessment method for FTM measures is developed by which the core effects of the measures can be effectively estimated and captured. The rice sector in Vietnam is chosen as an application case for the developed framework.

II. LITERATURE REVIEW ON IMPACT ASSESSEMENT METHODS FOR FTM MEASURES

From the literature review, many attempts have been made to develop methods for carrying out effective impact assessment on transport policies or measures. These methods can be classified by their purpose, their objects, or their scope. Building on the work of Fonauf, L (2015), assessment methods for FTM measures, in this study, are categorised by data generated in the research process. Specifically, they are divided into three groups: qualitative; partly-quantitative, and quantitative methods.

Within the context of freight transport, qualitative approaches have shown the most advantage in their ability to assess complex issues through relatively simple structures.

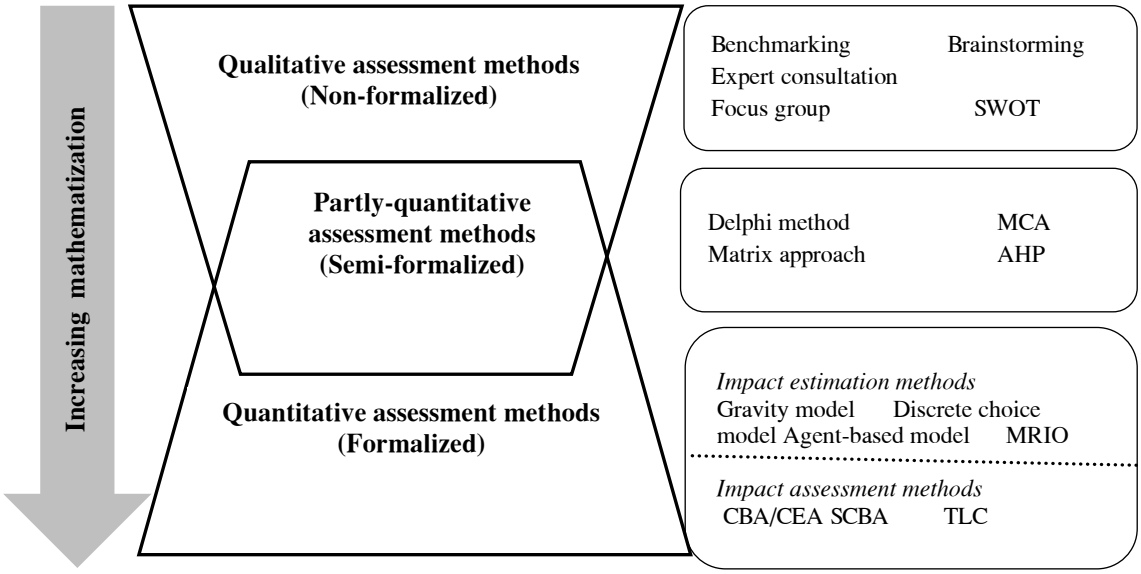


Figure 1. *Categorisation of impact assessment methods for FTM measures*

Explanations

SWOT	Strengths-Weakness-Opportunities-Threats	**CEA**	Cost-Effectiveness Analysis
AHP	Analytical Hierarchy Process	**SCBA**	Social Cost-Benefit Analysis
MCA	Multi-Criteria Analysis	**TLC**	Total Logistics Cost
CBA	Cost-Benefit Analysis	**MRIO**	Multi-Regional Input-Output

Source: Adapted from Fornauf, L (2015)

In particular, most qualitative methods such as brainstorming, expert survey or focus group discussion accommodate extensive involvement of stakeholders in the impact assessment process, which enables a quick highlighting of problems and consideration of a wide range of potential impacts. However, the key disadvantages of qualitative methods lies in the challenges associated with explaining the core effect of measure. In addition to this, most indicators used in the qualitative impact assessment processes are formed at an aggregate level, thus limiting the quality of assessment. Qualitative methods are further prone to higher degrees of subjectively and therefore potentially bias in research results.

Partly-quantitative methods, Delphi method, MCA or AHP as for examples, involve both qualitative and quantitative data analysis. This means that these methods incorporate a combination of subjective judgments and quantitative estimations in the assessment process. Therefore, their first advantage is the potential ability to provide sound reasoning for an impact assessment. Secondly, most of these methods allow for screening of the impacts under considerations with reference to of socio-economic, environmental, safety, and mobility implications in order to provide useful overall comparisons between proposed FTM measures.

However, the Delphi, MCA and AHP methods are often more subjective in nature and do not provide sufficient insights into the causality.

A review of the application of quantitative assessment methods has shown that they can actually be performed on different aspects of policy under assessment. Specifically, CBA, CEA, and SCBA deal with the detailed quantitative level of costs and benefits possibly caused by freight transport activities. These methods are especially useful in assessing impacts in terms of economic efficiency, hence can provide transparent results that are easily communicated. The TLC, discrete choice and agent-based models are seen as disaggregate approaches that focus on detailed analysis of stakeholder behaviors. The big advantage of such methods is the ability to model fundamental reactions of stakeholders to policy intervention, which ultimately enables explanation of the causality of impacts. The TLC model focuses on detailed population of commodity flows and allows taking into account mode and route choice for each commodity flow in the impact assessment process. Also, TLC has the ability to explain the most important drivers within a sector and their interdependencies which determines the behaviour of stakeholders. The discrete choice model can be applied to estimate and explain freight modal section based on shipper characteristics. However, while the discrete choice model is a powerful tool in analysing of discrete alternatives for passenger transport, its application is challenging in the freight transport sector due to the heterogeneity of stakeholders and diversity of alternatives present. Finally, three disaggregate approaches mentioned above demand high volumes of data and large amounts of processing work in order to model all entities at a micro-level. Unlike disaggregate approaches; gravity model and MRIO are especially useful in large-scale impact assessments at s international, national or regional levels. However, they operate based on the assumption of deterministic stakeholder relationship, and this presents a difficulty in explaining policy impact causality.

III. METHODOLOGY

The study is based on a large body of literature relating to impact assessment methods for FTM measures and an effort has been made to compare and assess those different approaches. The analysis shows the gaps in existing assessment methods and their practical application. As a consequence, the study develops a multi-stage assessment method by which the core effects of FTM measures can be captured and estimated. The multi-stage impact assessment method for FTM measures, as in this study, is divided into two stages. The first stage covers the working items of pre-selection of measures. In the second stage, a detailed quantitative assessment is carried out to estimate the core effects of the measures, considering the economic benefit as well as their social and environmental impacts.

The case study of the Vietnamese rice industry is briefly introduced. Surveys and observations are employed to investigate current practices in the chosen example sector (rice production and logistics). In particular, the study conducted practical data collection/survey/discussion with the key units (public and private) involved in production, transportation, processing, storage, consumption and export in the Mekong Delta. To gather

survey data, meetings between logistics experts and company managers in key positions were carried out. There were nice largest food companies from VINAFOOD 2, ten big IWT and road companies, and two regional port companies participating in the interview process. The main content of the questionnaire focused on areas including rice procurement, rice distribution, transport modes, transport routes, distance from suppliers to customer; typical frequency, delivery mode or lead time, and logistics cost.

IV. RESULTS

4.1. Developing a multi-stage impact assessment method for FTM measure

A literature review on impact assessment methods enables this study to propose a comprehensive impact assessment method for FTM measures as presented in fig.2. As presented in fig.2, a multi-stage impact assessment method has been developed which systematically integrates various FTM measures and evaluates them at different levels of detail**.**

The first assessment stage involves two main objectives: defining problems and a list of potential FTM measures to deal with those problems; and weighting and ranking these measures. In fact, ***it is of critical importance to determine and sufficiently understand the problems to be solved and list of potential measures***. The most common qualitative techniques for problem definition at this stage are brainstorming, focus groups, and expert consultation. These methods enable highlighting of problems associated with freight transport and potential FTM measures to deal with these problems. After defining the problems and understanding their reasons, latent effects and amplitude, as well as proposing a list of potential FTM measures, it is necessary to ***check the interdependency of proposed measures***. The rational for that is there are existing interdependencies between measures in freight transport, production and logistics. For effectiveness assessment criterion, the relationship between measures is evaluated as independent, complementary and substitutability relationship. After checking the interdependency of measures, a method is established ***to weight and rank the importance level of these measures***. A review and analysis of the pros and cons of the assessment methods has revealed that the Delphi, MCA, and AHP methods are powerful tools for fulfilling this objective. There are two hierarchical groups of criteria are employed to weight and rank FTM measures, namely ***Effectiveness*** representing the expected impacts and ***Applicability*** representing the main barriers in implementation of the measures. Within this context multiple goals related to FTM measures, the technique commonly adopted to assign weighting and ranking is via expert survey.

The second assessment stage focuses on detailed quantitative analysis of pre-selected measures based on a comprehensive sector analysis. Because of the multi-dimensional nature of FTM measure impacts, interdisciplinary consideration of production, logistics and freight transport system is necessary to identify the main factor driving changes in stakeholder behaviour following policy intervention. Policy application scenarios can then be defined and detailed quantitative impact analysis can take place. A review and discussion on the pros and cons of different assessment methods has shown that the application of disaggregate models is highly

necessary to capture and estimate the core effects of an intervention. Consequently, this study proposes methods for possible use in detailed analysis of the impacts of FTM measures including the TLC model, agent-based model, and discrete choice model. These models focus on analysis at a detailed behavioral level and differentiate disaggregate population of commodity flows.

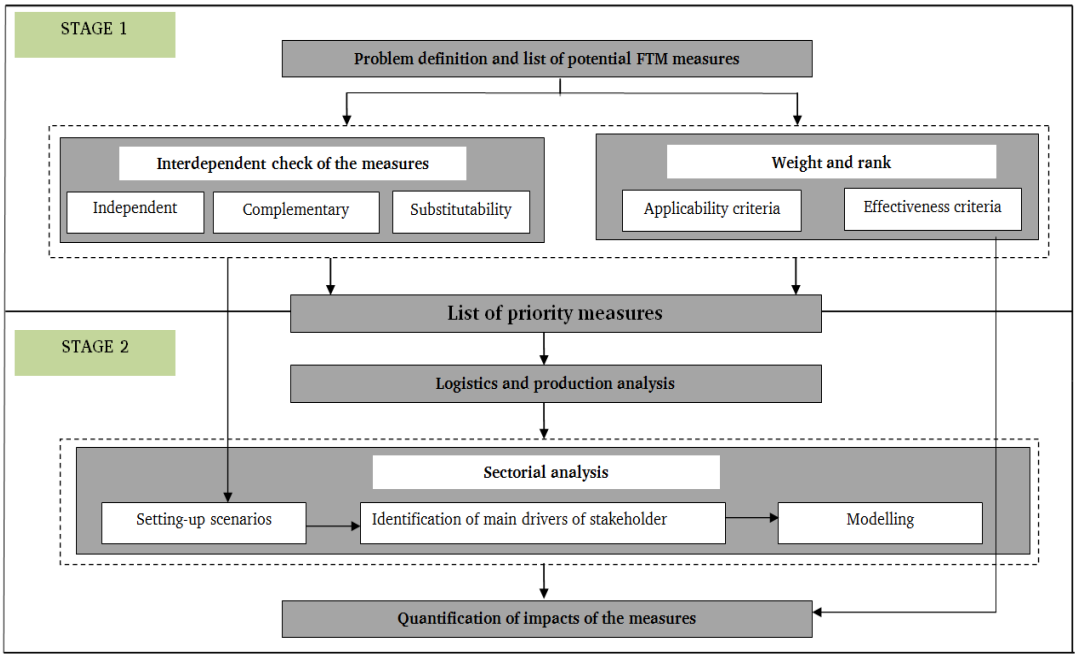


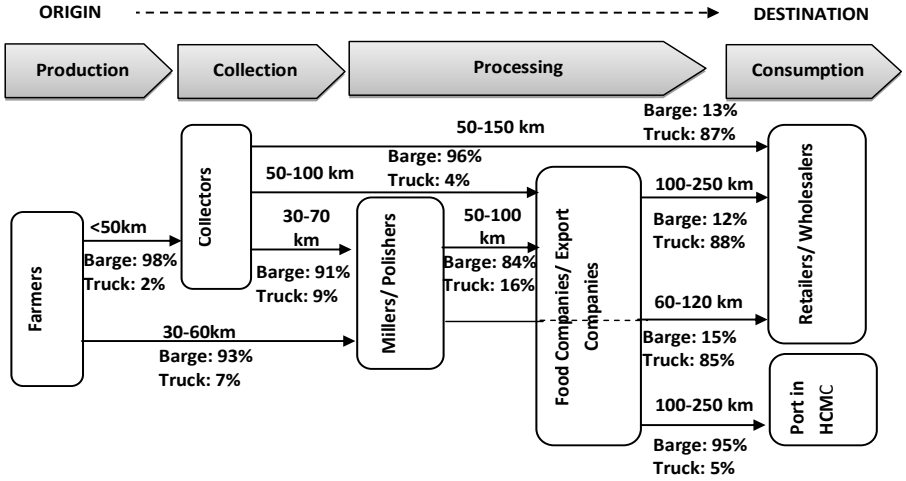
Figure 2. *Proposal of a multi-stage impact assessment method for FTM measures*

In particular, it allows for detailed knowledge of structure (of network or sector), stakeholders involved and their potential behavioral changes by which the core effects of proposed measures can be estimated and explained their causalities explained. Finally, as a result, traffic, safety, economic and environmental benefits can be quantified at both company level and transport network level.

This study plans to take the Vietnamese rice industry as an example sector for application. Following the review of the assessment methods for FTM measures, MCA is recommended for the first assessment stage of FTM measures in the rice industry since they take into account several stakeholders' interests and a wide range of impacts. Significantly, the application of this method can cause less cost than other ones since this study gets strong cooperation from VINAFOOD 2 and Vietnam Food Association in introducing stakeholders joining the expert interview survey. In the second assessment stage, TLC model could be very useful for the detail impact analysis of the measures in the rice industry. This is because TLC model has a strong ability in quantifying the impacts of FTM measures and explaining their causes. In addition, TLC is also one of the most crucial factors for transport mode choice which has been widely seen in the literature. Meanwhile, modal selection has for long seen as the most traditional decision from shippers' perspective in the rice industry. This decision is not only simply influenced by transport cost but also by other cost elements facing the particular shipper such as rice handling and inventory cost. Apart from that, available data is also a strong argument to choose TLC model as key method for the detailed analysis of the impacts of FTM measures in the rice industry.

4.2. Application in the Vietnamese rice industry

The rice industry in Vietnam is distributed across six basis economic zones - the Red River Delta, the Midland and Northern Mountains, the North Central and Central Coast, the Central Highlands, the Southeast and the Mekong Delta. The Mekong Delta indicated as the most important region for rice production, contributing over 50% of the total rice volume in Vietnam and 90% of the country's rice exports. Therefore, the study will focus deeply on the analyzing the rice production and logistics in the Mekong Delta of Vietnam.



Source: Own illustration based on data from Loc (2011)

***Figure 3**. Rice supply chain in Vietnam*

There are two kinds of rice supply chain domestic and export rice supply chain. Fig. 3 shows the relationship among key stakeholders in the rice supply chain. It becomes apparent that IWT (95%) is very popular in transporting rice to export ports whereas road (88%) is primarily used to distribute rice for domestic market. Currently, the share of IWT and road transportation in the rice industry is 90% and 10% respectively (MOT, 2014). However, road transport forecasts to increase fairly rapidly when the road infrastructure network in the Mekong Delta is significantly upgraded in the period 2020-2030. To solve the increasing problems of freight transport problems in the Mekong Delta, various traffic management measures need to be considered and applied. Table 1 presents a compilation of management measures that have already been applied and considered to be potential measures.

***Table 1**. Compilation of FTM measures in the context of the rice industry*

List of FTM measures in the rice industry		Level of application
M1	Regional rice logistics center in Chau Thanh A (Hau Giang province)	Potential
M2	Major markets for rice/paddy in Can Tho, Long An, and Tien Giang provinces	Potential
M3	Prohibition of trucks entering HCMC from 6:00 am to 12:00 pm	Already
M4	The establishment of centralized areas for e paddy production	Already
M5	Co-operation between collectors and millers and export companies	Already
M6	Improvement of NH 1A from the Mekong Delta to HCMC	Potential
M7	Restricting overloaded trucks on the highway from the Mekong Delta to HCMC	Already

Source: Own compilation from JICA (2010) and MOT (2014)

For efficiency reason, it is not appropriate to do impact assessment of all measures. Therefore the study did an expert interview survey to weight and rank the importance level of these measures. Particularly, the results of the weighting and ranking step have revealed that a high rating was given to the following FTM measures: ***the establishment of a regional rice logistics centre (M1) and NH 1A improvement (M6)***. Building on this, three scenarios can be set-up for impact assessment. ***The first scenario*** is if only a new regional rice logistics centre is established. It should be noted that this logistics centre is reserved only for rice products as the directive on promoting the rice industry of the government. ***The second scenario*** is the improvement of NH1A. ***The third scenario*** is the combination of the two measures above.

The study developed TLC model for detailed impact assessment of these different policy scenarios. We assume that supply chain managers try to minimize their total logistics cost while maintaining a certain level of service as required by their customers. Therefore, decisions on utilising supply path will be based on total logistics cost (TLC). In particular, given a volume of a commodity flow and distance from key rice generation sources to HCMC, the choice of transport mode or route will be associated with optimizing total logistics costs of individual commodity flows under the supply path i. The total logistics cost function of individual commodity flow is determined on a simple approach as follows:

$$TLC_{cf}^{i} = TC + HC + WC + Pack$$

In which:

TLC_{cf}^{i}	Total logistics cost of a commodity flow under supply path i	*WC*	Warehousing cost
TC	Transport cost	*Pack*	Packaging cost
HC	Handling cost		

It is assumed that all parameters are affected in the same way. The difference in value between the parameter values of the base scenario results in the change of total logistics cost as the determining factors that drive modal choice. The change in modal choice is expected to generate not only traffic and transport effects (e.g. fewer trucks on the road) but also environmental (e.g. fewer emission) and economic (e.g. TLC saving) benefits. Table 3 below provides final implications for traffic, safety, economic efficiency and environmental issues resulting from different scenarios in the Vietnamese rice industry.

Table 3. *Summary of the impacts of different scenarios*

Aspects of impact	Unit	Base scenario	Scenario 1	Scenario 2	Scenario 3
Rice freight transport					
Number of ton-km by road	million ton-km	126.84	98.44	131.75	97.74
Number of ton-km by IWT	million ton-km	3,012.94	2,811.34	2,999.96	2,635.05
Economic efficiency					
Total logistics cost per year	million US$	**153.08**	**129.49**	**129.23**	**114.05**
- Transport cost	million US$	*100.61*	*90.59*	*79.42*	*76.86*
- Warehousing cost	million US$	*33.46*	*20.91*	*31.56*	*19.96*
- Handling cost	million US$	*19.01*	*17.99*	*18.25*	*17.22*
Shipping inventory cost for road transport	million US$	**0.31**	**0.19**	**0.17**	**0.14**
Safety					
Cost of damaged rice shipments in transport	million US$	**17.57**	**16.28**	**17.52**	**15.29**
Accident cost caused by rice freight transport	million US$	**6.34**	**4.92**	**6.59**	**4.89**
Environment					
Total emission cost per year (**CO_2**, SO_x,NO_x)	million US$	**12.39**	**8.32**	**12.24**	**7.53**
Total cost of different scenarios	million US$	**189.69**	**159.21**	**165.76**	**141.90**
Change compared to Base scenario	**%**		**-16.1%**	**-12.6%**	**-25.2%**

According to the assessment results, Scenario 1 focusing on the establishment of the rice logistics centre in Hau Giang province, can affect a modal shift toward more IWT usage. There could be a reduction in some intermediate stages of inbound transport, which could potentially lead to a decrease in collecting trips from production sites to the consolidated centre. A reduction in the number of stops in the rice supply chain is expected to generate high level of economic efficiency through reducing inbound transport cost, warehousing and handling cost as well as TLC as a whole. A modal shift away from truck under the intervention of Scenario 1 could also generate impacts to the broader economy. More specifically, ton-kilometres shifts from road to barge would lead to a reduction in CO2 emissions and the improvement of traffic safety for both transport users and rice commodity.

Under Scenario 2, the improvement of NH 1A is expected to increase average speeds and reduce freight transport time from the Mekong Delta to HCMC. While some transport cost savings would be obtained via fuel efficiency, the larger impacts under the intervention of Scenario 2 is expected to originate from much higher savings of shipping inventory cost compared with the base scenario. That is because; NH 1A improvement would really help to facilitate inter-regional trade by reducing significantly transport time from the Mekong Delta to HCMC. In addition to positive impacts, the implementation of Scenario 2 is also expected to counter some impediments in term of traffic safety and environment because of a small modal shift from road transport to IWT. However, as for rice commodities, IWT is confirmed as an economically robust transport mode in the Mekong Delta, leaving limited room for shifting to road. Finally, traffic, safety and environmental impacts resulting from Scenario 2 could also be gained, albeit yielding slightly

lower levels than Scenario 1.

Scenario 3 is the combination of the two measures mentioned above. The improvement of NH 1A is projected to enable lower transport cost and transport time from the Mekong Delta to HCMC. The impacts associated with establishment of the rice logistics centre, as suggested by the above analysis, can provide inbound transport cost, warehousing and handling cost reduction. Building on these effects, the concurrent implementation of the two measures in scenario 3 is believed to strongly influence the economic efficiency in a positive way through significantly reducing TLC, benefiting all stakeholders involved in the rice industry. Additionally, the modal shift impact of the establishment of a rice logistics centre appears to be larger than that expected from improvement of NH 1A, resulting in a slight increase in IWT transport in the rice industry. Therefore, the intervention of Scenario 3 could generate positive impacts on traffic, environment and safety in the rice industry. Finally, Scenario 3 is confirmed to have the biggest impact in terms of improvements to rice freight transport, economic efficiency, traffic safety and environment for the rice industry.

V. CONCLUSIONS

The proposed multi-stage impact assessment method for FTM measures in this study indicated that it is possible to define and classify the FTM measures and their potential impacts. Significantly, this method can help to capture and estimate the core effects of these measures. The proposed impact assessment method also facilitates involvement of a broad range of stakeholders in different stages of the assessment process, increasing the validity of conclusion. The limitation to this method is the need for the extensive data and the large amount of processing work required in the assessment process.

The assessment results from the example sector could be of interests to transport decision-makers and logistics researcher as the different scenarios above demonstrate. Significantly, this assessment model is based on a deep knowledge of the sector, which enables clear explanation of anticipated impacts and their causality.

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