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A Comprehensive Sector Analysis for Detailed Impact Assessment of Freight Transport Management Measures*

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Abstract

The concept of freight transport management is perceived as an aspect of traffic management that has a significant influence on freight transport. There are lots of methods that could be utilised to measure the impacts of freight transport management. This study presents a comprehensive sector analysis for a detailed impact assessment of freight transport management. Such a method allows detailed understanding of sector knowledge of structure, stakeholders involved and stakeholder decision-making behaviours, which are key underlying factors requiring consideration in the analysis of core effects. The Vietnamese rice industry will serve as an example for using the sector analysis to assess the core effects of freight transport management initiatives. Following this detailed analysis, traffic, economic, safety and environmental benefits can be estimated at the rice sector level and transport network level.

Keywords: sector analysis; freight transport, Vietnamese rice industry

1. Introduction

The concept of freight transport management (FTM) is perceived as an aspect of traffic management that has a significant influence on freight transport. The assessment method utilised for estimating the impacts of FTM should be based on the type of measures being reviewed, and on the sector under consideration. The objective of this study is to present a comprehensive sector analysis as a method to investigate and assess the impacts of FTM measures on production, logistics and traffic. Such a method allows detailed understanding of sector knowledge of structure, stakeholders involved and stakeholder decision-making behaviours, which are key underlying factors requiring consideration in the analysis of core effects.

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Specifically, the proposed method is composed of two main steps of assessment. The first step involves to list, then weight and rank FTM measures via qualitative methods. The second step focuses on specific measures identified in the first step and core anticipated effects are assessed using methods that employ detailed quantitative analysis.

The rice industry in Vietnam was selected to be a case study for this application since data is available to test various kinds of impacts caused by FTM measures. Additionally, the rice industry in Vietnam has experienced freight transport problems that have led to many issues related production and logistics. Traffic volume due to rice transport is increasing quickly and contributes up to 21% of the total freight traffic volume on some key transport corridors (MOT, 2014), for example from the Mekong Delta to Ho Chi Minh City (HCMC). Vietnam is also currently the second largest rice exporter in the world. The rice industry involves various stakeholders such as farmers, collectors, millers, polishers, food companies, wholesalers, retailers and so forth, and knowledge of the decision-making behaviour of those stakeholders is needed to predict their reactions to FTM measures.

2. Methodology and data collection

The research flow of the study is presented in Figure 1. As presented in Fig.1, a comprehensive sector analysis method has been developed which systematically integrates various FTM measures and evaluates them at different levels of detail. Specifically, it starts with a brief introduction of the Vietnamese rice industry. Numerous techniques are useful for problem definition at this stage. As in this study, 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 nine largest food companies from Vietnam Southern Food Corporation (VINAFOOD II), ten big Inland Waterway Transport (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.

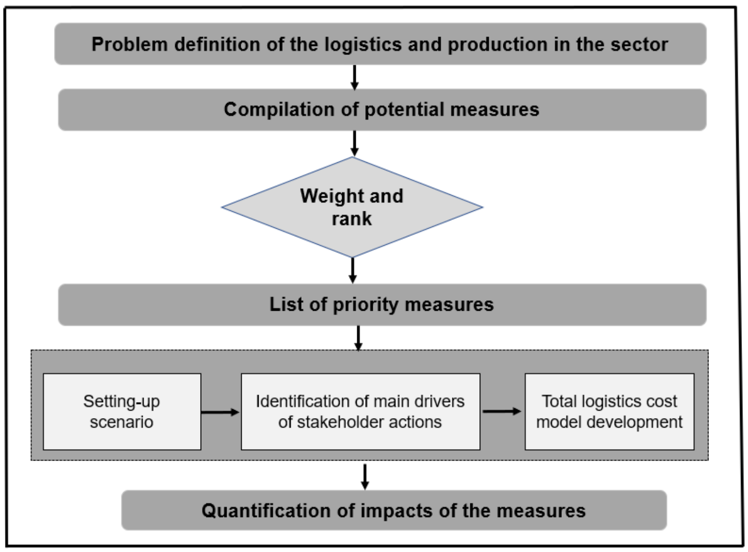

Fig. 1 The research flow of the study

After defining the problems and understanding their reasons, latent effects and amplitude, the study compiles potential

FTM measures to deal with those problems; and weighting and ranking these measures. A review and analysis of the pros and cons of the assessment methods has revealed that the Multi-Criteria Assessment (MCA) method is a powerful tool for fulfilling this objective. This method allows for screening of the impacts under considerations to determine socio-economic, environmental, safety, and mobility implications, which ultimately allows for an overall comparison between FTM measures. In addition to this, the involvement of multiple stakeholders in the assessment process demonstrates the effectiveness of this method in terms of generalization of inclusions. More specifically, in order to weight and rank the importance level of these measures, the study conducted an expert survey. Three groups of experts were selected to complete questionnaires. The first group included ten experts coming from freight transport companies and LSPs in the rice industry. Though their works, this group are experience first-hand the conditions of the rice transport and logistics. The second group consisted of five big shippers who are food companies in the rice industry. The last group was comprised of five traffic management experts who have been working for more than five years as transport decision-makers for transport authorities in HCMC and in the Mekong Delta. These people also have a wide range of experiences in introducing traffic management system in major cities in Vietnam. The questionnaire was designed to get experts' opinions about the effectiveness and applicability of the FTM measures in the context of the Vietnamese rice industry. At the end of this step, list of priority FTM measures in the rice industry is presented and will be the focus of a detailed quantitative impact assessment in the next step.

The next step is detailed quantitative analysis of pre-selected measures**.** Because of the multi-dimensional nature of FTM measure impacts, interdisciplinary consideration of rice 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 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 method for possible use in detailed analysis of the impacts of FTM measures in the rice industry is Total Logistics Cost (TLC) model. 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. This model starts with analyzing the generation of sources of rice in the Mekong Delta and the generation of establishments in HCMC. Then, analysis of the allocation of rice commodity flows from the Mekong Delta to HCMC is carried out, taking into consideration mode and route choices for each rice commodity flow. Accordingly, the TLC of different transport mode choices will be estimated. Expected modal shift under the intervention of the scenarios will be based on an optimization of TLC for the individual rice commodity flows.

3. Impact assessment of FTM measures in the rice industry

The following text will present the main research results in the application of a comprehensive sector analysis for the impact assessment of FTM measures in the rice industry. First, an overview of the rice industry in the Mekong Delta is presented, which briefly describes the rice supply chain including its transport modes and transport routes. Then, a list of measures potentially to deal with the problem in the rice industry, will be compiled. The MCA method is employed for weighting and ranking the importance level of these measures. Building on these results, different scenarios are identified for detailed quantitative assessment. TLC is employed as the core of this analysis, differentiating a disaggregate population of rice commodity flows and locations of distribution centres in HCMC. Consequently, traffic, safety, economic and environmental benefits can be estimated at the rice sector level and the transport network level.

3.1. Overview of the rice industry in Vietnam

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.

The Mekong Delta is located in the lower reaches of the Mekong River, which includes thirteen provinces and cities with nearly four million acres of land used for agricultural purposes, 700 km of coast line, 400 km of border and hundreds of islands. 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. Currently, up to 70% of the rice volume produced in the Mekong Delta is for export, with the remaining 30% consumed domestically (GSO, 2016).

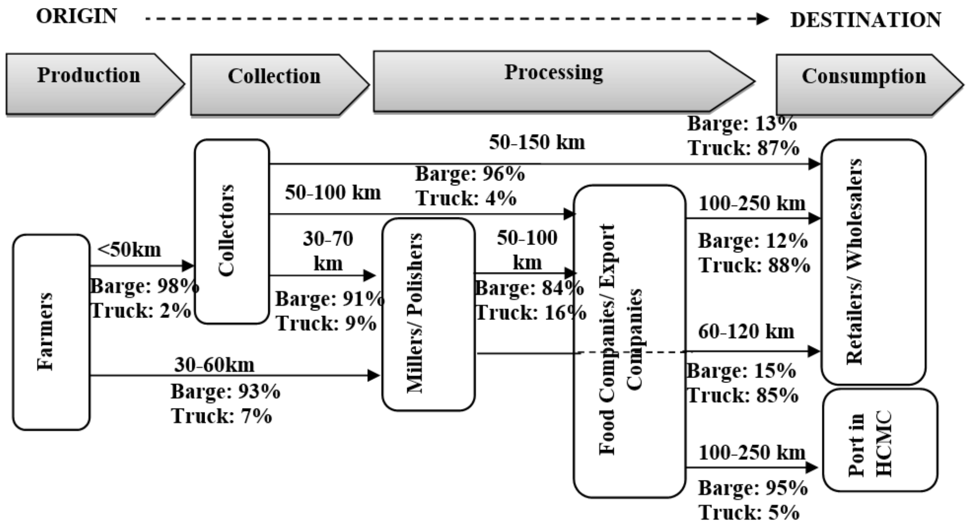

Fig. 2 The rice supply chain in the Mekong Delta of Vietnam
Source: Own illustration based on data from Loc (2011) and field survey in the Mekong Delta (2015)

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.

So far, the rice freight transport in the Mekong Delta have been facing some challenging issues related to the increase in road freight transport, high transport and logistics cost and overloading in long-distance freight transport. Transport cost makes up the largest proportion in total logistics cost figures, nearly 60% and 43% for the domestic and export rice supply chains, respectively. Lead-time is another important part of logistics in the rice industry. Lead-time, in this context, is the clock time spent in the supply chain to convert paddy into rice and to place it into the hands of the distributor (export ports or the wholesale system in HCMC). Actually, there is no big difference between transporting rice from the Mekong Delta to HCMC by road and by IWT. Interestingly, most time is spent on warehousing by food companies or export companies in the Mekong Delta. This can be partly explained by the food storage habits in the Mekong Delta in particular and in Vietnam in general. As rice export orders annually are not stable, export/food companies often keep a portion of their stock in reserve to cope with the volatility of the market.

It is likely that increased heavy dependence on road transport in the rice industry will lead to an increase in GHG emissions as road freight transport generally generates much higher CO2 emissions than IWT. Furthermore, an increase in the density of road transport carries the potential danger of an increase in traffic accidents. In the rice industry, it seems that minimising transport cost is prioritised over reduced time-response. At present, rice is mostly exported via ports in HCMC, located about 200 km from the Mekong Delta. Only a small quantity is exported via ports in the region such as Can Tho and My Thoi ports, the shallowness of the Hau River, and consequently the "last mile" of the rice supply chain is increased, leading to increased transport costs. The average loading factor for road freight from the Mekong Delta to HCMC is 1.7. The trucking industry in Vietnam is highly competitive placing downward pressure on transport costs. Freight companies in the rice industry tend to reduce transport costs to remain competitive by overloading vehicles. Monitoring and management systems for long distance freight are also weak making the issue more severe. Consequently, infrastructure network deteriorates quickly.

To solve the increasing problems of freight transport problems in the Mekong Delta, various traffic management measures need to be considered and applied. Table 2 presents a compilation of FTM measures in the rice industry.

Table 2. Compilation of FTDM measures in the context of the rice industry.

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

Source: Own compilation from JICA (2012)

It should be noted that this list is incomplete since many others measures which already be applied in the world could be utilised for the Vietnamese rice industry. For this study, the selection of measures is based on identified problems and established objectives in the Vietnamese rice industry. Therefore, in this case, there are seven measures considered because of their highly potential implementation to deal with those problems in the near future. The other freight transport management measures, for example the measures on harvesting time, incentive for off-peak hours, low-emission zones or technology-based route planning management, are seen as the next-best measures in the long-term.

3.2. Weighting and ranking of FTM measures

<u>Set-up criteria for the assessment</u>

There are two groups of criteria used for the first assessment and ranking the FTM measures in the rice industry. They are Effectiveness and Applicability (or Barrier) criteria. Effectiveness represents the expected impacts and applicability represents the main barriers in implementation of these measures in the rice industry. Stemming from the challenging issues of rice freight transport, the assessment criterion of Effectiveness was measured by estimating the expected impacts of FTM measures toward four objectives of the rice industry. These objectives are the improvement of rice freight transport, improvement of economic efficiency, improvement of traffic safety, and environmental protection. Under each objective, there is a set of criteria stated in measurable term and geared toward achieving that objective.

Similarly, the criterion of Applicability is measured indirectly by estimating the barriers to implementation of FTM measures in the rice industry. The major barriers are financing for the measures and public acceptance. Financing for the implementation of an intervention represent the affordability to the state or local provinces of implementing measure in practice. It covers two main components of cost: investment cost and operational and maintenance cost. The applicability of measures also depends on whether authorities get the support from the public or not. There are two main groups of public concerned: transport users and non-transport users. The transport users can be clearly defined as people who are directly involved in rice transport activities such as collectors, carriers or LSPs. Non-transport users are other people who do not use any mode of transport but who are indirectly influenced by implementing FTM measures (e.g. farmers, transport authorities…).

Weighting the assessment criteria

The weight of effectiveness and the applicability criteria group were obtained by conducting an expert survey. The main objective of this survey in the context of this study was to gain insights from experts on the relative importance of the assessment criteria. The questionnaire was designed to get experts' opinions about the weight of assessment criteria for the FTM measures in the context of the Vietnamese rice industry. An extract of the questionnaire is presented in Fig.3.

PART 2: EXPECTED EFFECTIVENESS

Q2.1: To achieve the sustainable development of the rice industry in the Mekong Delta, how should the goals of FTM be ranked? (*From the most important (1) to the least important (4), the same rank can be given for different criteria)*

Goals	Rank
Improve freight transport (FT)	Give here your rate
Improve economic efficiency (ECO)	Give here your rate
Ensure traffic safety (SF)	Give here your rate
Protect environment (EN)	Give here your rate

Q2.2. TO IMPROVE FREIGHT TRANSPORT in the context of rice industry in Mekong Delta, which criteria used to measure this goal are important than the others? (*Give your rank from the most important (1) to the least important (4). The same rank can be given for both)*

Criteria	Rank
Reduction in the number of ton-km (TON.KM)	Give here your rate
Change in modal split (SPLIT)	Give here your rate
Change in temporal traffic (TEMPORAL)	Give here your rate

Please formulate the criteria-matrix according to the ranks that are given in Q 2.2 and conduct a simple pairwise comparison between the impacts by the following rule:

Give "1" if two criteria are equally important.
Give "3" if the basic criterion is slightly more important than the other
Give "5" if the basic criterion is significantly more important than the other
Give "7" if the basic criterion is extremely more important than the other

Criteria-matrix					
Rank		**1**	**2**	**3**	**4**
Rank	Title (abrv.)	title	title	title	title
Rank 1:	title			Give here your rate	Give here your rate
Rank 2:	title				Give here your rate
Rank 3:	title				

Figure 3. Questionnaire sample

It should be noted that one expert might display bias towards criteria relevant to his area of expertise or economic interests; therefore, subjectivity is a risk in the weighting process. To minimize subjectivity and fronting individual interests, experts were provided with a short presentation about this study and the questionnaire by email before direct interview. They were also assured that all their personal assessments would be kept confidential and only published with written permission. Interviews were carried out at the different workplaces of the experts involved. On the interview day, at the beginning of the process, objectives of the study were again explained, as was the interview process. A direct discussion of over an hour then took place between the author and the experts based on questionnaire designed for the interview.

After collecting different assessments of the experts on the importance levels of criteria, results were documented in form of assigned percentages using Excel software. The comparison matrix is based on a standard seven-point scale. The resulting relative weights of importance were then fixed for further analysis. Table 3 presents the scale for pairwise comparison.

Table 3. Scale for pairwise comparison.

Numerical scale	Definition	Explanation
1	Equal Importance	Two criteria contribute equally to the effectiveness
2	Moderate importance	Moderate importance of one criterion over another
3	Significant importance	Significant importance of one criterion over another
4	Extreme importance	Extreme importance of one criterion over another

The pairwise comparison matrix of each expert was analysed individually to determine the relative weights of the importance by percentage. The final weighting of importance of each for each assessment criteria was estimated by using geometric means as an indicator of the central tendency across individual weighting of all selected experts. Results of the analyses therefore represent and aggregate expert opinion on the importance level of assessment criteria. Results are presented in detail in Table 4.

Table 4. Relative weight of assessment criteria for FTM measures in the rice industry.

Assessment criteria group	Assessment criteria	Factor weights (1)	Assessment sub- criteria	Sub-criteria weights (2)	Final weight of criteria (1) x (2)
Effectiveness (100%)	Improvement of freight transport	0.38	Reduction in the number of ton-km	0.27	0.10
			Change in modal split	0.52	0.20
			Change in temporal traffic	0.21	0.08
	Improvement of economic efficiency	0.36	Reduction in transport time	0.25	0.09
			Reduction in logistics cost	0.45	0.16
			Improved reliability	0.16	0.06
			Improved flexibility	0.15	0.05
	Improvement of traffic safety	0.14	Reduction in accident frequency	0.58	0.08
			Reduction in accident severity	0.42	0.06
	Enhancement of environmental protection	0.12	Reduction in air pollution	0.49	0.06
			Reduction in noise pollution	0.51	0.06
Applicability (100%)	Financing for the measures	0.71	Investment cost	0.74	0.53
			Operation and maintenance cost	0.26	0.18
	Public acceptance	0.29	Transport users (carriers. LSPs)	0.43	0.12
			Non users (residents...)	0.57	0.16

Notes: 20 experts in total were involved in the expert interview process. Experts are from freight transport companies, food companies, and transport management authorities

Rating the FTM measures

After describing the assessment criteria, the study will scale qualitatively the effectiveness and applicability score for each measure. As mentioned above, effectiveness of measure is assessed by the impacts on the rice transport towards four dimensions including improvement of freight transport, improvement of economic efficiency, improvement of traffic safety, and enhanced environmental protection. Applicability of measures is evaluated by estimating the difficulty level in getting the basic requirements involving costs and the support of stakeholders. Levels of effectiveness and applicability are rated as high, medium, and low corresponding points from 3 to 1. Thus, a measure that has the highest level of effectiveness in meeting the given assessment criteria is rated as 3. Similarly, a measure that has the highest level of applicability is also rated as 3. The final qualitative scaling of three potential measures in terms of the effectiveness and applicability is presented in Table 5.

Table 5. Qualitative scaling of potential FTM measures in the rice industry.

Criteria	**Sub-criteria**	**M1-VN**	**M2-VN**	**M3-VN**	**M4-VN**	**M5-VN**	**M6-VN**	**M7-VN**
Effectiveness								
Improvement of freight transport	Reduction in the number of ton-km	2	2	1	1	2	3	1
	Change in modal split	3	1	2	2	1	3	2
	Change in temporal traffic	1	1	2	1	1	1	2
Improvement of economic efficiency	Reduction in transport time	2	1	1	1	1	3	1
	Reduction in logistics cost	3	1	1	2	2	2	1
	Improved reliability	2	1	1	1	1	3	1
	Improved flexibility	1	1	1	1	1	2	1

Improvement of traffic safety	Reduction in accident frequency	2	2	2	1	1	1	2
	Reduction in accident severity	2	1	2	1	1	1	2
Enhancement of environmental protection	Reduction in air pollution	3	1	1	1	1	1	1
	Reduction in noise pollution	2	1	1	2	1	1	1
Applicability								
Financing for the measures	Investment cost	2	2	2	1	1	1	1
	Operation and maintenance cost	2	2	1	1	1	3	1
Public acceptance	Transport users (carriers. LSPs)	3	1	1	2	2	3	1
	Non users (shippers, receivers, residents...)	2	1	1	2	1	2	2

<u>Final evaluation of FTM measures</u>

Qualitative assessment model has been developed to calculate the final effectiveness and difficulty score of each measure. The formulas consist of three elements: (i) the relative weight of assessment criteria (C_m or C_x), (ii) the relative weight of assessment sub-criteria ($C_{s,mn}$ or $C_{s,xy}$), (iii) author's rating of the measure (e_{mn}^{ij} and a_{xy}^{ij}). A measure would be more effective and more easily applied if the effectiveness and applicability scores are higher and vice versa.

$$E_{ij} = \sum_{m=1}^{4}\left(C_m * \left[\sum_{n=1}^{p} C_{S,mn} * e_{mn}^{ij}\right]\right)$$

In which

E_{ij}: Total effectiveness score of FTM measure i under modal category j
C_m: Weight of criteria m (m=1 to 4)
$C_{S,mn}$: Weight of sub-criteria n under criteria m
e_{mn}^{ij} : Effectiveness point of measure *i* on category j, on criteria m and sub-criteria n

$$A_{ij} = \sum_{x=1}^{2}\left(C_x * \left[\sum_{y=1}^{q} C_{S,xy} * a_{xy}^{ij}\right]\right)$$

In which

A_{ij}: Total applicability score of FTM measure i under modal category j
C_x: Weight of criteria x (x=1 to 2)
$C_{S,xy}$: Weight of sub-criteria y under criteria x
a_{xy}^{ij} : Applicability point of measure i on category j, on criteria x and sub-criteria y

The calculation of effectiveness and difficulty scores of the measures provided the formation of priority classes of FTM measure. Table 6 gives the detailed results of the qualitative assessment of FTM measures in the rice industry.

Table 6. Final assessment of pre-selected measures.

	Measures	Effectiveness score (**E_{ij}**)	Applicability score (**A_{ij}**)	Ranking
M1-VN	A regional rice logistics centre in Hau Giang province	2.3	2.1	**The first priority**
M2-VN	Major markets for rice in Can Tho, Long An, Tien Giang provinces	1.6	1.7	The third priority
M3-VN	Prohibition of trucks entering HCMC from 6:00 am to 12:00 pm	1.4	1.5	The fourth priority

M4-VN	The establishment of centralized areas for paddy production	1.5	1.3	The fourth priority
M5-VN	Co-operation between collectors and millers and export companies in An Giang province	1.3	1.1	The fourth priority
M6 -VN	Improvement of NH1A from the Mekong Delta to HCMC	2.1	1.7	**The second priority**
M7 -VN	Restricting overloaded trucks on the highway from the Mekong Delta to HCMC	1.7	1.5	The third priority

According to the assessment results, an establishment of a regional rice logistics centre in Hau Giang province (M1-VN) is recommended as the first priority measure because of its high level of effectiveness and low level of difficulty in implementation. Next, improvement of NH 1A (M6-VN) is ranked in the second priority group since it involves a quite high level of effectiveness and ease to application. The establishment of major markets for rice/paddy (M2-VN) and restricting overloaded trucks on the highway (M7-VN) is assigned as the third priority measure since they involve in a moderate level of effectiveness and applicability. The other measures including M3-VN, M4-VN, M5-VN are assigned as last priority measure due to low level of effectiveness and high level of difficulty involved in implementation. M1-VN and M6-VN will be a focus of a detailed quantitative impact assessment in the next section.

3.3. TLC model development in the rice industry

The development of the TLC model involves the following assumptions. Firstly, rice demand in HCMC is met in full provided by suppliers from the Mekong Delta. Secondly, a key rice supplier in the Mekong Delta serves at least four customers in HCMC. A customer, though, involved several rice commodity flows attached to different rice supply paths from the Mekong Delta. However, since the rice demand of a customer is believed to be much smaller than the capacity of a key rice supplier in the Mekong Delta, it is assumed that these commodity flows are allocated to one supplier. These assumptions are reasonable; that is because, as stated above, HCMC is responsible for about 75% of 6the total rice volume of the Mekong Delta. In addition to this, the statement from the field survey by the author (2015) implies that the number of customers for rice produced in the Mekong Delta is concentrated densely in HCMC, ranging from 4 to 6 customers per supplier.

A Pareto distribution of quantities per supplier is utilised to generate the commodity flows in the rice industry. The cumulated Pareto distribution function is defined by the following formula:

$$F(x) = 1 - \left(\frac{x_m}{x}\right)^{\alpha}, x \geq x_m$$

Where, x_m is a positive minimum possible value of x, called a "scale parameter" and α is a positive parameter, called a "shape parameter". For this study, the number of customers per supplier depends on the annual rice handling volume of supplier. Suppliers in the Mekong Delta with high volume would have more customers in HCMC. For each relation of a supplier and one customer a commodity flow is generated. The number of commodity flows is determined proportionally to the number of customers. For each supplier the volume of a commodity flow is determined based on Pareto distribution and the differences in the annual rice handling volumes of suppliers. Shape parameter α indicates these differences. In particular, there are three different shape parameters assuming in this model: α = 1 for suppliers with annual rice handling volumes from 25,000 to 75,000 tons; α = 2 for suppliers with annual rice handling volumes from 75,000 to 180,000 tons; and α = 3 for suppliers with annual rice handling volumes more than 180,000 tons.

In this study, there are 351 commodity flows generated from 74 key rice sources in the Mekong Delta. In fact, rice commodity flows can pass through different supply paths, which incorporate the usage of different stakeholder warehouses, transport modes, reloading points and transport links. There are currently five rice supply paths from the Mekong Delta to HCMC presented schematically in Figure 3.

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		

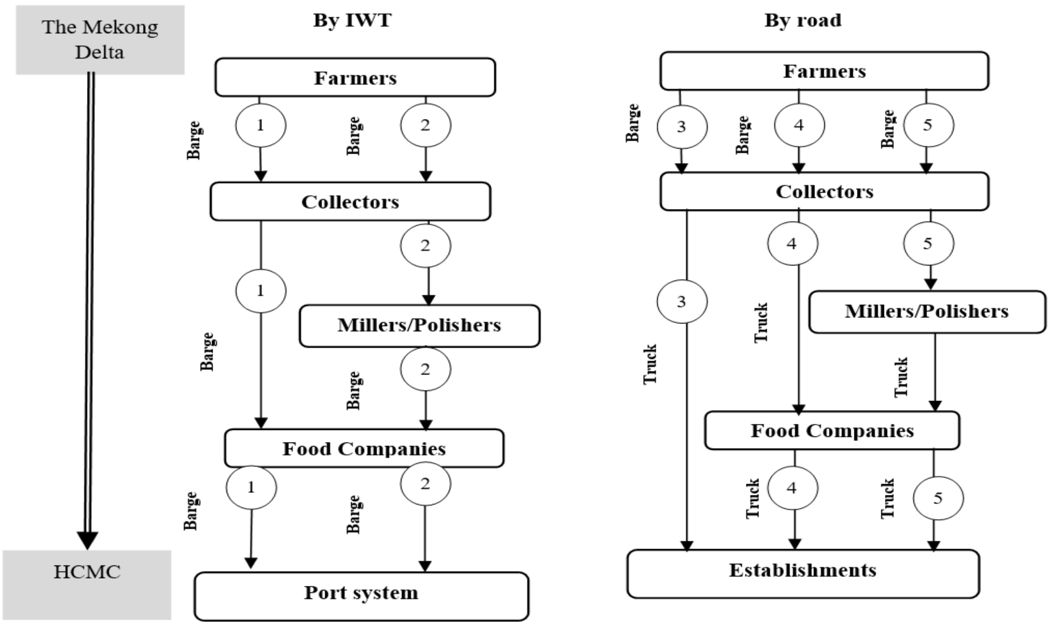

Fig.3. Current supply paths in the rice industry (Base scenario).

The cost components are described in different levels of details depending on its influence on TLC. Specifically, **total transport cost of a commodity flow** (TC_{cf}) is composed of inbound transport and outbound transport costs.

$$Total\ TC_{cf} = TC_{inbound} + TC_{outbound}$$

For this study, the total outbound transport from the Mekong Delta to HCMC has to be modelled in more detail, since this influences significantly total transport costs for the whole supply chain. the outbound transport cost is determined on a simple approach including *transport cost rate per ton* **(**$TC_{per\ ton}$**)** *and the volume of a commodity flow* (Q_{cf}). Usually, transport cost rate per ton is used in the descriptive analysis of influencing factors on transport cost. This rate can be expressed as a function of fuel cost, crew cost, depreciation cost, repair and maintenance cost, and capital opportunity cost.

The transport cost rate per ton in the rice industry is estimated based on information from JICA (2012) coupled with interviews with rice LSPs and carriers as introduced above. Also, small vessel (less than 700 tons) and/or large truck (15 tons) are confirmed as typical transport modes for rice shipment in the Mekong Delta. Currently, a one-way trade of full truckload to HCMC with an empty truck moving back to the Mekong Delta is common. Vehicle overload has also been better control since load factor controls were implemented on the highway from the Mekong Delta to HCMC. Average load factor is therefore assumed to reduce from 1.7 to 1.3 (MOT, 2014). Based on assumed characteristics of transport modes in the rice industry, the next section will discuss each cost component of these representative modes in detail.

Total handling cost (HC) is comprised of the throughout costs driven by the handling cost rate h_c and total quantity of load unit (in tons). The detailed estimation of total handling cost is defined as follows:

$$HC = h_c * Q_{cf}$$

For this study, the handling rates are different depending of the stage in the rice supply chain. For example, the unit handling cost of collectors is generally lower than that of food companies, since collectors often use small and low-quality handling facilities. Therefore, the handling rate of the supply chain will be estimated by the sum of unit handling costs corresponding to each stakeholder.

The warehousing cost (WS) is proportional to warehousing cost per storing position (wc_{pp}) and is driven by the total commodity volume in stock, while capital costs are driven by the weighted average cost of capital (w_{acc}), the value of a commodity (v_{pc}) and total volume in stock (Q_{cf}^{stock}). The detailed estimation of total warehousing cost is as follows:

$$WC = wc_{pp} * Q_{cf}^{stock} + w_{acc} * Q_{cf}^{stock} * v_{pc}$$

For the rice industry, a food company warehouses can be used to bundle rice flows from different collectors. Cross docking is assumed at collector level, meaning that no storage cost on collector level has to be considered. The data on warehousing cost per storing position is collected from empirical surveys covering a large number of food companies and milling companies in the rice industry, and the effectiveness of one or more level of warehouse structure is discussed based on the optimization of TLC. The warehousing cost per storing position at food companies and millers/polishers are different depending on warehouse technology. Under miler/polisher's management, there are often warehouses responsible for basic functions such as assembling, drying that do need less investment in warehouse technology.

The total packaging cost of a commodity is calculated by multiplying the demand expressed as number of tons (Q_{cf}) with the packaging cost rate PC. This cost has a slightly difference between scenarios as confirmed by the expert survey in Section 4. Therefore, the effects of packaging cost are not so high to the change of TLC.

To sum up, the TLC modelled in this study consists of transport cost, warehousing cost, handling cost and packaging cost. The estimation of these cost components are used as input of the TLC model. The changes in TLC are assumed a main factor that determines the modal choice of shippers. The reflected indicator of the TLC model is therefore oriented to TLC per ton-km via different transport modes ($TLC^{i}_{per\ ton-km}$).

$$TLC^{i}_{per\ ton-km} = \frac{TLC^{i}_{cf}}{Distance * Q_{cf}}$$

As for the estimation of TLC per ton-km of individual commodity flow, rather than using average distance and volume, different distances, different volumes and different mode choices from key rice sources in the Mekong Delta to the establishment in HCMC are taken into consideration. GIS can delineate the distance of each origin destination pair. The quantity of one commodity flow is based on the analysis of generation of key rice sources and establishments as mentioned at the beginning of this section.

3.4. Model calibration and sensitive analysis

The model calibration and validation are carried out based on the available data. More importantly, the results of TLC model calibration will be used to analyse the impacts of FTDM measures resulting in shifts between road and IWT in the rice industry. In the first step, it is necessary to make clear which parameters are assumed as fix and which are utilised for calibration.

The first assessment of FTM measures in the rice industry inferred the high importance level of the establishments of a regional rice logistics centre and improvement of NH 1A. Outbound transport cost by road and IWT from the Mekong Delta to HCMC actually can significantly affect TLC. In addition, the establishment of a regional rice warehouse is expected to reduce some immediate stages of the rice supply chain. As a result, warehouse cost and handling cost could be also affected. Therefore, for this study, outbound transport cost; warehouse cost and handling cost per ton will be variable parameters used for the model calibration. An overview of these parameters is presented in Table 7.

Table 7. Overview of variable parameters in the model.

	Model parameters
Outbound transport cost	Fuel cost (USD/ton)
	Crew cost and overhead cost (USD/ton)
	Depreciation cost (USD/ton)
	Repair and maintenance cost (USD/ton)
	Capital opportunity cost (USD/ton)
Warehousing cost	Warehousing cost per ton (USD/ton)
Handling cost	Handling cost per ton (USD/ton)

As mentioned, the changes in TLC are assumed a main driver for modal choices of shippers, the indicators of the overall model are therefore oriented to TLC per ton-km and freight modal share in the rice industry. The base scenario results from the model calibration.

The calibration process of the outbound transport cost from the Mekong Delta to HCMC and warehousing cost and handling cost rate in the rice industry are carried out based on five biggest road freight, three main IWT companies and 5 key food companies in the region. All of chosen companies have their own fleet and more than five experiences in the rice freight transport. The results of calibration process will form the base scenario for further analysis

Sensitivity analysis serves to demonstrate model behaviour to changes of parameters. For the parameters, changes from -50% to +50% to values in the base scenario are assumed. For each parameter change, other parameters are assumed stable. The results of sensitive analysis is presented in details in Table 8.

Table 8. Sensitivity analysis of variable model parameters.

Model parameters		**Indicator**	**Change of indicators for a change of model parameters by**									
			-50%	-40%	-30%	-20%	-10%	+ 10%	+ 20%	+ 30%	+ 40%	+ 50%
Outbound transport cost	Fuel cost	Road modal share	9.64%	8.24%	6.24%	4.24%	1.14%	-0.56%	-1.76%	-1.76%	-1.96%	-1.96%
		IWT modal share	1.16%	0.86%	0.56%	0.56%	0.56%	-0.54%	-0.54%	-0.84%	-0.84%	-2.84%
	Crew cost and overhead cost	Road modal share	3.14%	2.24%	0.84%	0.54%	0.54%	0.04%	-0.56%	-0.56%	-0.86%	-1.16%
		IWT modal share	1.76%	0.56%	0.56%	0.56%	-0.04%	-0.54%	-0.54%	-1.14%	-2.54%	-3.44%
	Depreciation cost	Road modal share	0.54%	0.54%	0.54%	0.54%	0.04%	0.04%	0.04%	0.04%	-0.56%	-0.56%
		IWT modal share	1.76%	1.76%	0.86%	0.56%	0.26%	-0.54%	-0.54%	-0.54%	-0.54%	-0.54%
	Repair and maintenance cost	Road modal share	0.54%	0.54%	0.54%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	-0.26%
		IWT modal share	0.56%	0.56%	0.56%	0.56%	0.56%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%
	Capital cost	Road modal share	0.54%	0.54%	0.54%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	-0.26%
		IWT modal share	0.26%	0.26%	0.56%	0.56%	0.56%	-0.04%	-0.04%	-0.04%	-0.54%	-0.54%
Warehousing cost	Warehouse cost per ton	Road modal share	-0.57%	-0.57%	-0.10%	-0.06%	-0.01%	-0.02%	0.01%	0.03%	0.56%	0.56%
		IWT modal share	0.57%	0.57%	0.10%	0.06%	0.01%	0.02%	-0.01%	-0.03%	-0.57%	-0.57%
Handling cost	Handling cost per ton	Road modal share	-0.57%	-0.57%	-0.57%	-0.05%	-0.01%	-0.01%	-0.01%	0.57%	0.58%	0.56%
		IWT modal share	0.57%	0.57%	0.57%	0.05%	0.01%	0.01%	0.01%	-0.57%	-0.58%	-0.56%

Explanation: Grey columns indicates that the change of proportions can be feasible

It shows the changes of indicator of modal share in the rice industry by the changes of variable model parameters. In general, this indicator is affected in all cases but at different rates. Fuel cost parameter is the most sensitive factor caused to the changes of the model indicators. If it fuel cost is lowered, road modal share increase and vice versa. Fuel cost has a smaller effect for the case of IWT transport. The reason is fuel cost makes up smaller proportion than that of road transport cost. In addition, the Mekong Delta processes many advantages of waterways in transporting bulk cargo at lower costs. However, it should be noted that the change of fuel cost may be plausible from -30% to 30% to values in the base scenario. That is because; the government has so far controlled the price of fuel in Vietnam. Crew cost and overhead cost also directly affect the model indicator. Since the companies mostly regulate driver's wages, the variation in the rate of crew cost and overhead cost can be more flexible. The model also reacts to the changes of depreciation, repair and maintenance and capital costs. However, the road modal shares do only change very little. At present, the average vehicle speed is about 40km/h and the expected speed under the policy intervention in this study is 70km/h. Thus, the model parameters on depreciation repair and maintenance cost could only be changed to a certain degree compared to the base scenario. For the change of warehouse and handling cost to the base scenario, rice commodity flows would get two effects of overlap: warehouse and handling cost reduction due to the decrease of immediate stages of the rice supply chain, and the increase of warehouse and handling cost rate because of using modern technology and facility in the regional warehouse. Finally, a small effect in the change of modal shares in the rice industry can be seen for the changes of warehouse cost and handling cost rate.

3.5. Detailed analysis of the impacts

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 9 below provides final implications for traffic, safety, economic efficiency and environmental issues resulting from different scenarios in the Vietnamese rice industry.

Table 9. Summary of the impacts of different scenarios.

Aspects of impact	Unit	Base scenario	Scenario 1	Scenario 2	Scenario 3
Rice freight transport	million ton-km	126.84	98.44	131.75	97.74
Number of ton-km by road	million ton-km	3,012.94	2,811.34	2,999.96	2,635.05
Number of ton-km by IWT					
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*
- Handing 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 costs by rice freight transport	million US$	**6.34**	**4.92**	**6.59**	**4.89**
Environment					
Total emission cost per year (**CO_2**, SOx,NOx)	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%**

Within the first scenario, a rice logistics centre is established in Chau Thanh district of Hau Giang province. Under this scenario, the role of middlemen (e.g. collectors or millers) can be significantly reduced since farmers can go directly (by IWT or road) to the rice logistics centre to sell paddy or rice. The functions of milling and polishing are integrated in the rice logistics centre, which also can reduce some intermediate stages in the rice supply chain. A reduction in the number of stops would help to reduce significantly total warehouse and handling cost of the rice supply chain. On the other hand, the service quality of new central warehouse is expected to improve; the handling cost and warehouse cost rate is then believed to be slightly increased. Since proposed centre will be convenient for IWT accessibility, and an extensive network of rivers, lakes and canals has long supported IWT throughout the Mekong Delta region, it is anticipated that TLC would significantly decrease, with a focus on reduction in inbound transport cost. Outbound transport cost is assumed unchangeable since the transport distance from the logistics centre to HCMC does not change between scenarios. 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 mainly from less stops in inbound logistics resulting in the reduction of inbound transport cost, warehousing and handling cost which is directly affected by the establishment of the regional rice logistics centre.

In summary, rice industry supply paths, in the first scenario, are towards more IWT usage. This would lead to a decrease in total number of ton-km for road. In addition, this intervention would result in savings more than US$23.6

million in TLC and nearly US$2.71 million in economic cost of safety for people and rice cargo as well as about US$4.07 million of emission reduction cost in the rice industry. Finally, the implementation of Scenario 1 would lead to total cost savings, about 16.1% compared to Base scenario.

Scenario 2 is defined by the implementation of the project on upgrading NH 1A from the Mekong Delta to HCMC. This highway has been congested many years. Adding more traffic on this highway would further increase road congestion. The improvement of NH 1A is expected to reduce traffic pressure, and save freight transport time from the Mekong Delta to HCMC. It is clear that higher speed will result in more fuel efficiency and lower fuel cost. Assuming that all parameters are affected in the same way, the difference in value between the fuel cost of the base scenario and Scenario 2 will be directly affected by the improvement of NH1A. In particular, fuel consumption and fuel cost savings would obtain via fuel efficiency gains, which finally lead to emission reduction

To sum up, the majority of benefits associated with the intervention of Scenario 2 stems from lower transport cost, as higher speed enables lower fuel cost. Therefore, Scenario 2 can improve the economic efficiency for the rice industry through significantly reducing TLC as a whole. Additionally, CO2 volumes and local pollutant emissions are projected to be reduced under Scenario 2. Only projected economic benefits of safety improvement could be limited due to unexpected modal shift. However, the Mekong Delta is generously endowed with extensive networks of rivers and canals, rice products in this region are substantially captured by the waterways already, thereby leaving limited opportunities for shifting to road. Finally, the implementation of Scenario 2 is expected to result in total cost savings, about 12.6%, compared to Base scenario.

In the Scenario 3, the combination of the two measures - the establishment of a regional rice logistics centre and the improvement of NH 1A - is expected to yields a synergy of benefits. Under this scenario, improved efficiency in rice cargo flows will be facilitated through the reduction of immediate stages in the rice supply chain and the improvement of the road transport system. Within Scenario 3, the modal shift impact of establishing a rice logistics centre appears to be larger than the impacts of improvements to NH 1A. More specifically, there is a small increase in IWT (about 0.6%) in the rice industry. This can be partly explained by acknowledging that the planned rice logistics centre in the Mekong Delta intends to be situated on a convenient location for road and IWT transport. In particular, such a rice logistics centre would not only support the existing intensive use of IWT network in the region, but also support the development of the use of multi-modal transport. For this meaning, rice would be collected by trucks and then consolidated deliveries from the rice logistics centre to HCMC by barge. Additionally, many activities related to rice logistics, distribution transport and other value-added would be integrated in this centre. Therefore, the concurrent implementation of the two measures in scenario 3 is believed to bring highest level of effectiveness at the lowest cost for the rice industry.

4. Conclusions

The impact assessment for FTM measures remains a field with a need for comprehensive evaluation methods in order to understand the core effects of measures applied in the industry. The main contribution of this study is the presentation of a comprehensive sector analysis through which the core effects of FTM measures can be identified and impact estimated. More specifically, this method can help to identify relevant interventions and estimate the core effects of these measures. Additionally, the proposed method has been applied to a specific sector, taking the rice industry in Vietnam as an example. Quantitative estimation of impacts has been carried out in the second step of assessment at both governmental and company levels. This research is therefore expected to be of value for the government and local transport authorities in providing suitable methods for assessing decisions in freight transport management. As presented, the comprehensive sector analysis for FTM measures in this study is developed primarily from a comprehensive literature review and then applied in a case study of the Vietnamese rice industry. It is developed with the aim of being generalized across multiple contexts and it should, therefore possible to apply this assessment approach to different sectors.

Although the study has achieved its goal, there were some inevitable limitations. Specifically, the detailed quantitative impact assessment implemented in the second step can only be carried out with extensive data, which may hinder the application of the proposed methods in other sectors. If future research intends to extend the application of the method, it is suggested that prior to beginning a research project, the availability of data associated with the target sector is reviewed or assumptions identified that could simplify the analysis required by the model.

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