INLAND CARGO FLOW MODELING UNDER SHIPMENT TIME VARIABILITY IN LANDLOCKED DEVELOPING COUNTRIES

（内陸開発途上国における
輸送時間変動を考慮した貨物流モデルの開発）

by

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Abstract

As several international organizations recognize, the shipment time variability on cross-border transport adversely contributes on extra cost of the shipment. Nowadays in this globalization world, maritime transport is likely to be one of the most important transport modes for trade activities due to its high economies of scale. Focusing on landlocked countries, no direct access to seaport is allowed due to geographical nature. In order to access to seaport from landlocked countries, one needs to pass across at least one border that is a first bottleneck in the route. Once arrived at seaport, it is appeared as a second bottleneck. As several literatures mentioned, seaport is to be sometimes more severe bottleneck in terms of the scale of shipment time variability. Therefore, border and seaport would be a source of additional cost for logistics companies, particularly for landlocked developing countries.

In an initial stage of this dissertation, the bottlenecks on freight transport in landlocked developing countries are confirmed through field survey in several landlocked countries, Central Asia and Lao PDR. As literature reviews identified, the bottlenecks of inland freight transport are also identified as shipment time variability at border and seaport in field survey. Subsequently, impact of shipment time variability on estimating expected shipment time for logistics decision maker in Lao PDR is examined in order to clarify whether shipment time variability could be an additional cost of the shipment. The result shows that more highly variable route requires more number of information source for estimating next shipment time. In general, it can be postulated that people requires more information sources as situation becomes unstable. If this hypothesis is true, it is highly expected that there is additional cost due to shipment time variability, which should be considered in the route and departure time choice problem.

Finally, inland cargo flow model considering cost of shipment time variability is developed so that the impact of increase in reliability of two bottlenecks is observed. This model basically consists of two sub-models, valuation of shipment time variability and schedule variability cost model. Using developed model, the scenario analysis was conducted. It shows that improving seaport reliability receives more impact on the cost reduction comparing to reliability increase at the border. For seaport choice, as reliability of the bottlenecks increases, decrease in cargo volume in Laem Chabang seaport and increase in Vietnamese seaport are observed.

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Abbreviation

3PL	Third Party Logistics
ADB	Asian Development Bank
AH	Asian Highway
ASEAN	Association of South-East Asian Nations
CACO	Central Asia Cooperation Organization
CAF	Central Asia Forum
CAREC	Central Asia Regional Economic Cooperation
CBTA	Cross-Border Transport Agreement
CIA	Central Intelligence Agency
CIF	Cost, Insurance and Freight
CIS	Commonwealth of Independent States
CBA	Cost Benefit Analysis
CLB	China Land Bridge
CPS	Champassak
DAN	Da Nang
ECO	Economic Cooperation Organization
EEC	Eurasian Economic Community
ERIA	Economic Research Institute for ASEAN and East Asia
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
FITA	Federation of International Trade Associations
FNEM	Freight Network Equilibrium Model
FEU	Forty-Foot Equivalent Unit
FOB	Free on Board
GSPEM	Generalized Spatial Price Equilibrium Model
GTAP	Global Trade Analysis Project
GMS	Greater Mekong Subregion
GDP	Gross Domestic Product
HAI	Hai Phong
ICT	Information and Communications and Technology
IMF	International Monetary Fund
JETRO	Japan External Trade Organization
JICA	Japan International Cooperation Agency
LCB	Laem Chabang
LLCs	Landlocked Countries
LLDCs	Landlocked Developing Countries
LOS	Level of Service
LPB	Luang Phabang
LPI	Logistics Performance Index
MICS	Model for International Cargo Simulation
OD	Origin and Destination
PAT	Preferred Arrival Time

SAV	Savannakhet
SCO	Shanghai Cooperation Organization
SD	Standard Deviation
SDE	Schedule Delay Early
SDL	Schedule Delay Late
SPECA	UN Special Programme for the Economies of Central Asia
SP	Stated Preferences
ST	Shipment Time
STAN	Strategic Planning of National Freight Transportation
SVC	Schedule Variability Cost
TIR	Transport International Routier
TRACECA	Transport Europe Caucasus Central Asia
TEU	Twenty-Foot Equivalent Unit
USSR	Union of Soviet Socialist Republics
USD	United States Dollar
UNECE	United Nations Economic Commission for Europe
VTE	Vientiane
WB	World Bank

CHAPTER 1

INTRODUCTION

1.0 Background

Landlocked Developing Countries (LLDCs) are usually marked by low economic development. Sachs and Warner (1997) revealed that, compared to coastal countries, Landlocked Countries (LLCs) have lower steady-state incomes, and hence lower economic growth from an initial level of Gross Domestic Product (GDP). Gallup *et al*. (1999) concluded that being landlocked reduces a country's growth by at least half a percentage point. According to the World Bank (2008), most LLDCs have two problems: poor neighbors and remoteness from large economic markets such as the United States, Europe, or Japan. This remoteness results in long and variable shipment times and, consequently, high shipment costs because the shipment included need for passing through border and seaport as bottlenecks of cross-border transport (Arvis *et al*., 2007). Furthermore, it results in LLDC products being less competitive in the global market, which has an adverse impact on the economic growth of these countries. Raballand (2003) found that being landlocked reduces trade by more than 80% because border crossing is a major part of the extra cost of freight transport.

Nowadays in the globalization, maritime transport is one of the most important transport modes for international trade due to its high economies of scale. The importance of maritime transport is not only for coastal and developed countries, but also for LLDCs for further economic growth. Nevertheless, LLDCs cannot directly access maritime transport in their own territories because of their geography nature. In order to transport goods by maritime transport, these countries need to use land transport to access to seaports in neighboring coastal countries. At least one border crossing is also needed for that shipment, however, border crossings are widely recognized as bottlenecks which violating shipment time and cost due to delay (Arvis *et al*., 2007). For instance, Mackellar *et al*. (2002) revealed that the cost of a border crossing in Africa is equivalent to approximately 1,600 km of land or 11,000 km of maritime transport. Shipment time of cross-border transport in developing countries is highly variable. Hanaoka and Kawasaki (2010) reported that 10–20 days are required for a 1,000 km cross-border haulage between Tashkent (the capital of Uzbekistan) and Ashgabat (the capital of Turkmenistan). The main contributor to this variability is the border crossing, because the truck operates at almost free-flow speed on inter-city and inter-national roads. In general, traffic volume in LLDCs and surrounding countries are very few. This fact is supported by existing survey result by Banomyong (2000), which shows slight difference of transport time between the best and worst case I several routes in Greater Mekong Subregion (GMS).

In addition to border crossings, Arvis *et al*. (2007) pointed out that the use of seaports also generates a considerable delay. For example, waiting time at the seaport in Mombasa, the gateway seaport of Uganda, is variable, sometimes more than 30 days. Banomyong (2000) surveyed best- and worst-case shipment times of cross-border transport between Vientiane (the capital of the Lao People's Democratic Republic [PDR]) and Laem Chabang seaport (the busiest seaport in Thailand). Huge differences were generated at the border (15 hours) and seaport (10 hours). Consequently, time reduction in border and seaport shall largely contribute on total transport time reduction.

Two bottlenecks adversely contribute on the variability of shipment time on cross-border transport between LLDCs and seaport in coastal countries. In order to solve or alleviate problems violating shipment time reliability, several investments on transport infrastructure is undergone in GMS region. For example, eight economic corridors (Figure 1.1) are being developed rapidly as well as several seaports as shown in Table 1.1. The three economic corridors, North-South, East-West, and Southern Economic Corridor, are identified to be invested intensively for facilitating cross-border transport in 8th GMS Ministerial Meeting in 1998. Investment is not only physical issues, but also institutional issues, for example, single stop of the trucks at the border, mutual truck use between the countries, etc (ERIA, 2010).

Here, one question arises that how much this type of investment affect on cargo flow in the region? In order to quantitatively understand the impact of several investment projects, inland cargo flow model on the basis of capturing characteristics of cross-border transport, such as two bottlenecks above is needed to be developed. In the field of cargo flow modeling, the most widely known model at this moment is Model for International Cargo Simulation (MICS) developed by Shibasaki and Watanabe (2009). The notable characteristic of this model is that interdependency between shipping lines and shippers is incorporated for seaport choice. The MICS considers border resistance as bottlenecks; however, shipment time variability is not explicitly included in the model. Since fluctuation of shipment time in developing countries is considerable large, shipment time variability might have big impact on the generalized cost of the haulage, which determines route choice of freight forwarders. Besides, seaport is not treated as a bottleneck in the model of Shibasaki and Watanabe (2009).

Figure 1.1 Eight Economic Corridors in GMS
Source: ADB (2011)

Table 1.1 Seaport Development Projects in Vietnam and Thailand

Country	Project	Implementation Schedule	Type
Vietnam	Da Nang seaport at Tien Sa	2001 - 2004	Upgrade
	Hai Phong seaport	1994 - ongoing	Upgrade
	Cai Lan seaport	1996 - ongoing	Upgrade
	Da Nang seaport (Phase 2)	2007 - 2008 (proposed)	Upgrade
	Lien Chieu seaport	Proposed	New seaport
	Vung Tau seaport rehabilitation	Ongoing	Upgrade
	Can Tho seaport	Proposed	Upgrade
	Cai Mep-Thi Vai deepwater seaport	Ongoing	Upgrade
	Van Phong seaport in Khanh Hoa	Proposed	New seaport
Thailand	Laem Chabang seaport, Phase 2, Construction of C and D terminals	2006 - 2010 (proposed)	Upgrade

Iwata *et al*. (2010)

1.1 Purpose and Objectives

The primary purpose of this dissertation is to observe how decrease in shipment time variability at two bottlenecks impacts on inland cargo flow and total shipment time cost reduction. This is observed by developing an inland cargo flow model considering cost of shipment time variability. For fulfilling the purpose, the problems lied in the field of freight transport in LLCs are firstly investigated through field survey for confirming factors contributes on route choice. In addition, due to the highly variable shipment time, one hypothesis has been established regarding the impact of shipment time variability for logistics decision maker for estimating next shipment time. The hypothesis will be examined as additional study in this dissertation.

1.2 Study Area, Scope, and Limitations

The study area of this dissertation in the model part is Lao PDR, with focus on surrounding countries, mainly Thailand and Vietnam. Regarding the transport mode, truck is only assumed in the region although railway development plan exists (ERIA, 2010). However, it is very likely to be rational assuming only truck since very few amount of goods currently transported in the region and for cargo volume from/to Lao PDR, it is negligible due to its low volume.

Regarding the cargo flow scenario analysis, transit cargo and potential demand generated due to improving the level of service are not considered in the model. For transit cargo, it is expected to be increased as border resistance diminished. Here transit cargo is mainly mentioned for between Thailand and Vietnam where cargo volume in the region is relatively high. In this case, cargo diversion from maritime transport since currently, relatively large number of cargo volume is transported by maritime transport between two capitals, Bangkok and Hanoi.

Objective 1:
To clarify problems on freight transport of LLDCs

- The important factors for both physical and institutional issues adversely contributing on freight transport of LLDCs are identified through field survey.
- Field survey is conducted in Central Asia and Lao PDR.

Objective 2:
To identify impact of shipment time variability on estimation of expected shipment time

- Estimation of next shipment time is modeled for different level of variability routes for comparison purpose.
- Generalized mean concept and multiple regression model as a supplemental analysis are applied for model development.

Objective 3:
To develop inland cargo flow model for LLDCs

- Cost of shipment time variability is incorporated distinguishing the impact of early and late arrival.
- The model should be dynamic with respect to change in the level of variability.

Objective 4:
To show an impact of improvement in shipment time variability on cargo flow

- The impact of cross-border transport facilitation projects on inland cargo flow and shipment time cost reduction is observed.
- The impact of seaport improvement is also observed.

1.3 Dissertation Outline

The dissertation has been organized into eight groups and organization of dissertation is presented in Figure 1.2.

Chapter 1 has explained the background, problem statement, and purpose and objective.

Chapter 2 has been illustrates the literature reviews regarding to freight transport issues of LLDCs. Reviews are separated into three groups, such as reviews based on international organization reports by United Nations, World Bank, etc., the field of development economics, and econometrics. In the review section for econometrics, it also illustrates the notable point of the model developed in this dissertation.

Chapter 3 dedicates to illustrate the problems related to freight transport learnt from field survey in Central Asia and GMS. Problems are examined in terms of not only physical issues but also institutional issues. Looking the system of international inland freight transport such as binomial agreement, multinomial agreement, etc, we qualitatively find a potential countermeasure for facilitating cross-border transport. The finding of this chapter serves as the basics to the rest of the dissertation.

Chapter 4 examines the impact of shipment time variability on estimating expected shipment time. In this analysis, the set up hypothesis is discussed using generalized mean formula and multiple regression model.

Chapter 5 deals with initial part of the inland cargo flow model, which is the valuation of shipment time variability distinguishing early arrival and late arrival. On the basis of valuation in this chapter, schedule variability cost in chapter 6 can be estimated.

Chapter 6 deals with core part of inland cargo flow model, which is the modeling of schedule variability cost. This cost is typical issue in terms of problems on freight transport of LLDCs accessing seaport in coastal countries. Several scenario analysis are conducted under several scenarios using developed model.

Chapter 7 has dedicated to mention the conclusions and recommendations and future scope of the dissertation.

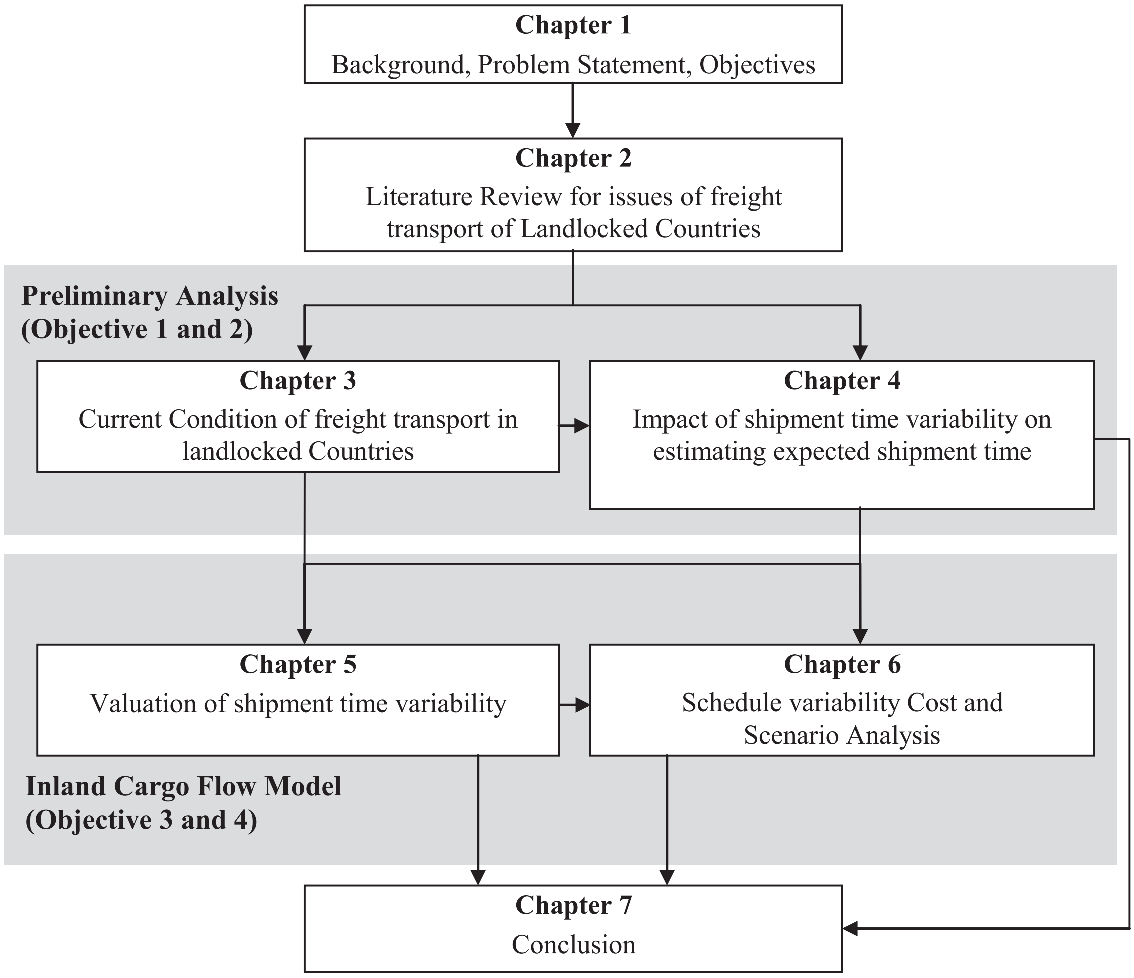


Figure 1.2 Organization of Dissertation

CHAPTER 2

LITERATURE REVIEW ON FREIGHT TRANSPORT IN LANDLOCKED COUNTRIES

2.0 Introduction

Issues on freight transport in LLDCs cannot be completed only within the field of transport engineering and transport economics. Because LLDCs are normally categorized into poor country, several international organizations tackling with freight transport problem as poverty reduction research. Their motivation is one of the factors to improve life level standard is improving freight transport condition since tremendous impact is expected on goods price. From the economics point of view, main two research areas are involved in this issue: development economics and econometrics. In development economics, most of the papers examining the disadvantage of being landlocked using simple regression analysis in regard to transport cost, time, etc. Some papers focus on the import and export volume as explanatory variable employing gravity model. In the field of econometrics, existing cargo flow model, MICS as briefly introduced in chapter 1, analyzed the economic impact of transport infrastructure development in the context of Asia including Lao PDR. This chapter addresses on the review on existing study and survey result on freight transport.

2.1 Reports of International Organization

The World Bank (WB) periodically releases Logistics Performance Index (LPI) which is one of the indicators of country's comparative logistics performance. LPI is scored on the basis of questionnaire survey to logistics related organization and individuals, such as freight forwarders, shipping liners, etc. by scaling 1(worst) to 5(best) relevant to the possible comparison groups. The following six factors are used as key dimensions;

(1) Efficiency of the clearance process
(2) Quality of infrastructure
(3) Easiness of arranging competitively priced shipments
(4) Competence and quality of logistics services
(5) Ability to track and trace consignments
(6) Timeliness of shipments

From the LPI, we can understand the broad condition of freight transport for each country. Table 2.1 shows the LPI of LLCs in Asia and top 10 countries in the world. Previous result of LPI told us that the best country in terms of logistics performance was Singapore, however, Germany receives the top rank in 2010.Comparing LPI score of top 10 countries an Asian LLCs, the gap is approximately 1.5 points in the range of 1 to 5. Among the LLCs, Central Asian nations are relatively in good score.

Table 2.1 LPI Score of Top 10 Countries and LLCs in Asia in 2010

Top 10			Landlocked Country in Asia		
Rank	**Country**	**LPI**	**Rank**	**Country**	**LPI**
1	Germany	4.11	62	Kazakhstan	2.83
2	Singapore	4.09	68	Uzbekistan	2.79
3	Sweden	4.08	91	Kyrgyzstan	2.62
4	Netherlands	4.07	114	Turkmenistan	2.49
5	Luxembourg	3.98	118	Lao PDR	2.46
6	Switzerland	3.97	128	Bhutan	2.38
7	Japan	3.97	131	Tajikistan	2.35
8	United Kingdom	3.95	141	Mongolia	2.25
9	Belgium	3.94	143	Afghanistan	2.24
10	Norway	3.93	147	Nepal	2.20

Source: World Bank (2010)

The World Bank (2011) estimated procedural requirements for exporting and importing standardized cargo, including maritime transport, based on Djankov *et al*. (2006). The time and cost of maritime transport are not included in shipment time and cost in Table 1; in other words, shipment time and cost are for land transport only. For exports, the procedure includes all steps, from packing the goods at the warehouse to shipping them from the port of exit. Shipment time and cost are estimated beginning from concluding a contract of trade till completing a shipment. This is estimated based on 20ft container of dry cargo. In export case, days accounted from packing the goods at the warehouse till seaport are estimated, whereas for import case, days from arriving at seaport till arriving at warehouse or logistics center are estimated as shipment time. The shipment cost does not include customs duties, international maritime transport cost, and illegal charging such as bribes on the road, which is unfortunately commonly found in developing countries (NELTI, 2009). This data is also estimated on the basis of questionnaire survey to trade-related companies, low office, and accounting office aggregating the shipment cost and time of following four processes.

1. Documents preparation (Documents preparation required for trade)
2. Customs clearance and technical control (Tasks done by middleman for inspection and customs clearance)
3. Ports and terminal handling (Transport cost in seaport, loading/unloading of goods, and necessary commission)
4. Inland transportation and handling (Transport cost from seaport to major city and unloading process)

Target companies of the model are assumed as followings;

- Companies located at the city with the highest population density in the countries
- More than 60 employees
- Private companies running based on commercial law of their countries
- Operation based on domestic capital
- Exporting more than 10% value of total sales
- Not operating in special zone for exporting or industrial park where not privilege for exporting granted

Transport conditions are assumed as followings;

- Full loading of 20ft dry cargo container, 10 tons, and 20,000USD for total trade value
- dangerous and military goods are not included and special transport equipment such as cold storage are not included
- Questions are asked in terms of USD or local currency

Using the data of LPI, logistics performance of both groups of countries, LLDCs and coastal countries is compared To maintain the equity of the comparison, we adopt the countries which are lower than Lower-Middle Income Countries (1,006 to 3,975 USD) defined by WB (2011). In total, the numbers of data are aggregated 20 for LLDCs and 45 for coastal counties, respectively. In average, LPI of LLDCs has been received as 2.43 and 2.55 for non-LLDCs. From this result, even though the difference is slight, which accounts for 0.12, the logistics performance gap between LLDCs and non-LLDCs is observed.

Figure 2.1 shows shipment time and cost for export case for the countries, which are compared LLCs with the non-LLCs (coastal countries). Here, long shipment time and high shipment cost of landlocked countries can be observed. In coastal countries, most of them are in the condition of shorter shipment time and lower cost required for import and export, whereas LLCs are widely distributed in the figure, and variation between countries is very large.

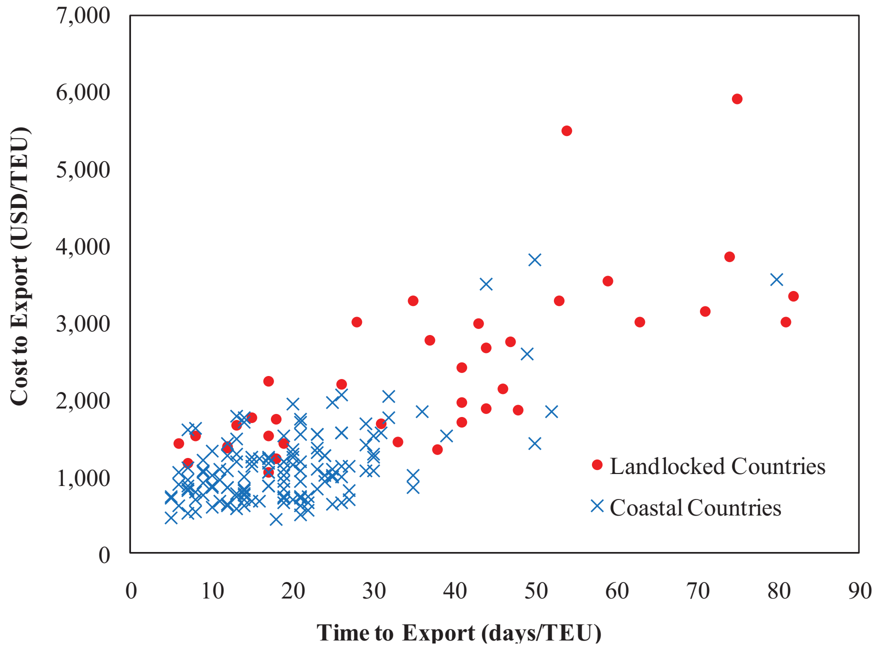


Figure 2.1 Shipment Time and Cost Required for Export for the Countries
Data Source: World Bank Doing Business (2010)

Export and import shipment time and costs in Europe are in higher ranking. Looking at export time, Luxembourg needs six days whereas Tajikistan is 82 days. There is a huge disparity. Also on shipment cost, Czech Republic is 1,060 USD/TEU whereas Chad bears 5,902 USD/TEU. A comparison among landlocked countries, countries located in Central Asia and Africa are in bad situation. It is considered that a number of trading processes are to be bottlenecks for trading. We can understand that most of the countries grouped into “the best” is European countries. On the other hand, European countries are not included in the group of “the worst” rankings in terms of transport time and cost. Most of the countries grouped into “the worst” are comprised of Central Asia, Africa and Lao PDR. Focusing on countries in Central Asia and Africa, despite the high rate of pavement Central Asia, the more time-consuming import and export can be observed. This may be due to the long distance of inland transport. In addition, in African countries, major problems are not found in terms of distance to seaport, however, underdeveloped transport infrastructure road and railway can be considered as causes of problems.

Table 2.2 Shipment Time and Cost to Export from Landlocked Country

Top 10 Countries				Worst 10 Countries			
Time to export (days/TEU)		**Cost to export (USD/TEU)**		**Time to export (days/TEU)**		**Cost to export (USD/TEU)**	
Luxembourg	6	Czech	1,060	Tajikistan	82	Chad	5,902
Austria	7	Austria	1,180	Kazakhstan	81	Central Africa	5,491
Switzerland	8	Hungary	1,225	Chad	75	Afghanistan	3,865
Macedonia	12	Bhutan	1,352	Afghanistan	74	Niger	3,545
Serbia	12	Macedonia	1,376	Uzbekistan	71	Tajikistan	3,350
Armenia	13	Serbia	1,398	Kyrgyzstan	63	Zimbabwe	3,280
Belarus	15	Luxembourg	1,420	Niger	59	Rwanda	3,275
Czech	17	Bolivia	1,425	Central Africa	54	Uzbekistan	3,150
Kosovo	17	Paraguay	1,440	Zimbabwe	53	Botswana	3,010
Slovakia	17	Slovakia	1,530	Lao PDR	48	Kyrgyz Rep.	3,010

Data Source: World Bank Doing Business (2010)

Lao PDR, an LLDC and study target country of this dissertation, suffers from long shipment times and high shipment costs in international trade. To make matters worse, more documents are needed for trade than in surrounding coastal countries except Cambodia, as shown in Table 2.3. Generally speaking, countries with lower GDPs have longer shipment times and higher costs. However, the shipment time and cost for Cambodia is much lower than that for Lao PDR, even though the Lao GDP per capita in 2010 was 189 USD higher than that of Cambodia (IMF, 2010). Compared to developed countries, for instance Japan, the Lao shipment cost is approximately 2 times higher, even though most goods price in Lao PDR is less than that of Japan. The need for a border crossing must contribute greatly to this relationship. Obviously, the need for a border crossing is one of the reasons for increasing LLDCs' documentation requirements. When exporting goods from Lao PDR through the Thai seaport, a customs declaration form, a bonded application form, and so on, should be submitted. The bonded form is required in order to avoid smuggling. After passing through the border, cargo is checked in the seaport of Thailand. These processes are, needless to say, not required in coastal countries.

Table 2.3 Export and Import Data for ASEAN+3.

Country[a]	Shipment Time (days)		Shipment Cost (USD/TEU)		No. of Documents	
	Exports	Imports	Exports	Imports	Exports	Imports
Lao PDR	**50**	**50**	**1,750**	**1,930**	**9**	**10**
Cambodia	37	46	722	852	11	11
Indonesia	21	27	667	623	5	6
Malaysia	18	14	432	385	7	7
Philippines	17	18	800	800	8	8
Singapore	5	3	416	367	4	4
Thailand	17	14	615	786	7	9
Vietnam	24	23	669	881	6	8
Japan	10	11	989	1,047	4	5
South Korea	8	8	742	742	3	3
China	21	24	390	430	7	6

[a]Data on Myanmar and Brunei are not available.

Source: World Bank (2011)

Arvis *et al*. (2007) concludes that the condition of roads is not a main reason for costly shipment. Most important problem lies in seaport as delay in coastal countries as well as border crossing point. As a result of delay at the seaport and border, increase in shipment cost would be generated as serious problem. Arvis *et al*. (2007) also mentioned that bribe-taking (unofficial payment) is also serious problem for long cross-border haulage in developing countries. As a research showing the disadvantage of landlocked country is Mackellar *et al*. (2002) mention that average cost of border crossing in Africa is equivalent to cost of inland transport of 1,600km or sea transport of 11,000km.

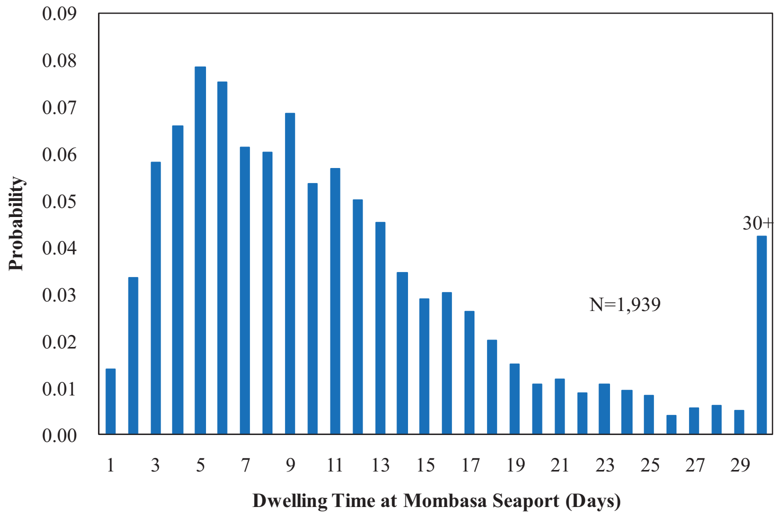


Figure 2.2 Dwelling Time at Mombasa Seaport in Kenya
Data Source: Arvis (2004)

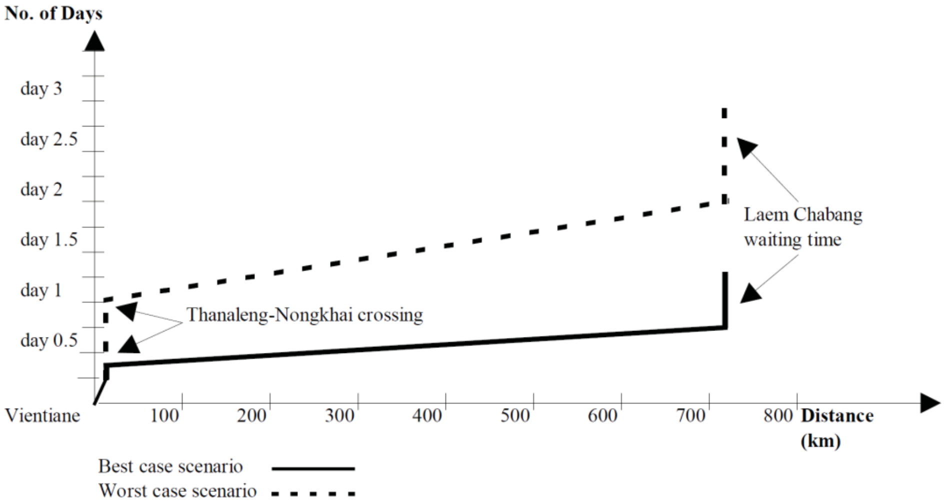


Figure 2.3 Distance-Time Model for Vientiane-Laem Chabang Seaport
Source: Banomyong (2001)

Cargo movement from Vientiane till the port of Laem Chabang seaport with shipment time is shown in Figure 2.3. As seen in Figure 2.3, the main contributors for the gap between the best and worst cases are border and seaport.

2.2 Literature on Development Economics

Several studies regarding landlocked countries related to freight transport applies gravity model for international trade in order to examine their economic disadvantage. Radelet and Sachs (1998), Stone (2001), and Mackellar *et al*. (2002) are focus on transport cost of LLCs and Limao and Venables (2001), Raballand (2003), and Grigoriou (2007) examined how being landlocked affects on trade volume. The researched comparing transport cost of landlocked country to coastal countries, higher transport cost of landlocked countries are highlighted. In Radelet and Sachs (1998), using CIF/FOB data for 97 developing countries including 17 LLCs, shipment cost and insurance cost of LLCs are approximately twice of that of coastal countries. Besides, it is proved that there is strong relationship between shipment cost and economic development. In the research of Stone (2001), shipment sharing issues are examined trade activities for 64 comparable LLCs and transit countries. It is revealed that shipment cost of transit countries is 75% lower comparing to that of LLCs. In 18 LLCs out of 30 LLCs, more than 10% of total exporting value occupies shipment cost. The situation in African LLCs is more serious situation, that is, 13 LLCs among 15 LLCs suffer from more than 10% shipment cost occupying total exporting value. Among 15 LLCs indicated above, 7 LLCs exceed 20% of total exporting value. There are several researches for analyzing determinants of shipment cost, for example, Brun *et al*. (2005), Micco and Perez (2002) and Martinez-Zarsoso (2003). In overall trend, following factors are defined as important factor to determine shipment cost of LLCs, such as distance to the countries of trade partner, type of goods transported, distance to the large economical market, for example US, Europe, and Japan, level of infrastructure development, total shipment cost and number of alternative routes.

Limao and Venables (2001) analyze both shipment cost and trade volume. Comparing LLCs and coastal countries, LLCs bears 50% more than that of coastal countries in average. The impact of infrastructure development on shipment cost is also analyzed. In case infrastructure condition in the countries of trade partner improve up to 75 percentile level from average LLCs, 12% cost reduction can be achieved. In case infrastructure condition in transit countries is increased till same level of that of trade partner, 7% improvement is observed. Besides, trade volume is estimated using gravity model. It is clarified that trade volume of LLCs is 30% lower comparing to coastal countries. The level of infrastructure development is very influential in trade activities. In case infrastructure quality goes down by one standard deviation, it is equivalent to the incensement in 6,500km of maritime transport and 1,000km of land transport. Moreover, shipment cost of land transport is revealed as to be 7 times higher than maritime transport. From this result, they also pointed out that one of the adverse factors for high shipment cost is to be long inland transport distance.

It is also stated that another reason to increase land shipment cost is due to the border crossing in several literatures. Grigoriou (2007) also highlighted that strong correlation between infrastructure condition and trade volume. Raballand (2003) revealed that the number of border crossing point for the trade highly influence on the trade volume of LLCs. As the border crossing points increases, the trade volume decreases. Thus, the number of border crossing required and trade volume has inverse proportional relationship. The problem of border crossing is not only for LLCs but also non-LLCs. Hence, there are several literature related to border crossing can be found, for example, MacCullum (1995) and Helliwell (2001). They develop a trade volume model by employing gravity model using trade data between US and Canada, and within US and Canada, respectively. As a result of comparing trade beyond the border with trade within the country under the standardized economies scale and shipment distance, domestic trade is 22 times more than international trade in terms of trade volume in Macllum (1995). Similarly, Helliwell (1996) also obtained the same trend, which domestic trade volume is much more than that of international trade. From this result, we found that the impact of the border crossing is negligible even in developed countries. We can postulate that the border impact on the trade in developing counties might be higher comparing to developed countries since trade system in terms of both physical and institutional issues in developing countries is less developed.

Another approach to the study of LLCs is Kawai *et al* (2011). They categorized LLCs into several groups because each LLC have country specific problems, which affect on the shipment time differently. Some country is in good condition of infrastructure condition, but some country is not. In this case, LLCs should be categorized into the groups based on their own problems. For example, Raballand (2003) developed trade volume model using gravity model as following Equation (2.1). Nevertheless, LLCs are treated as homogenous. It should be considered disparity among LLCs.

$$\begin{aligned} \ln IMP_{ijt} &= \alpha + \delta \ln GDP_{it} + \phi \ln GDP_{jt} + \lambda \ln Dist_{ij} + \xi \ln Instit_{it} + \tau \ln Access_{i} \\ &+ \kappa Landlocked_{ij} + \iota \ln Infra_{i} + \omega inInfra_{j} + \rho \ln Tariff_{it} + \varepsilon_{ijt} \end{aligned} \tag{2.1}$$

2.3 Literature on Econometrics

The most traditional method for forecasting cargo volume at several points such as seaport and borders is method which uses historical trend. In terms of accuracy of model result, it is not always bad. However, an explanatory variable in this method is normally to be socioeconomic data such as GDP. Thus, this method is not suitable for policy simulation study, which analyzes the impact of change in road network, etc. The same problems can be found in the forecasting model of multivariate analysis that is based on the econometrics theory. This problem originates in that the change in behavior of shipper and other related logistics actors corresponding to policy change are not considered.

The trip distribution model is developed for considering behavior of each individual. The simplest distribution model is the shortest path problem, which all cargo is distributed to the route that is the cost or time is the minimum among the all sets. The shortest path problem is sometimes called as all-or-nothing or deterministic distribution because this idea resulted in all cargo or zero for two routes. The disadvantage of this model is that the only slight difference leads the huge differences between the routes. Thus, it is also not suitable for policy simulation because the slight inversion in terms of lowest cost of the routes, extreme change in cargo distribution is generated.

Stochastic distribution model such as logit model and sacrifice model are developed in order to avoid extreme change in cargo flow pattern by policy changing. Important property of the stochastic model is that cargoes are assumed as flowing not only lowest cost route but also flowing routes of comparatively higher cost due to unobserved factors for analyzers. Sacrifice model considers variability between the routes in terms of freight value of time. To do this, several patterns for route choice is generated. These models are applied mainly practical purpose, for example, demand forecasting of seaport choice in Japan. However, the disadvantage of this model is that alternative potential routes are needed to be given to the model. In this case, two concerns arise study area would be limited to local, not global. However, all routes from large transport network cannot be provided because of the computational complexity.

On the basis of the problems above, several international cargo flow pattern model have been developed. The representative model considering interdependency between shippers and transport carriers are Strategic Planning of National Freight Transportation (STAN) (Crainic *et al*., 1990a, 1990b, 1997, 1999, 2007), Freight Network Equilibrium Model (FNEM) (Friesz *et al*., 1985a, 1985b, 1986) which is an incremental model of seaport choice and shipping line choice, and Generalized Spatial Price Equilibrium Model (GSPEM) (Harker *et al*., 1986, 1987). According to Friez and Kwon (2008), FNEM and STAN is currently used in the government of the US and Canada. However, in regard to the GSPEM is only applied to the case study of coal industry and railway transport because the enormous calculation process is required.

The notable characteristic of this model is that interdependency between shipping lines and shippers is incorporated for seaport choice. Shipping lines are assumed to be in the oligopoly market, thus, calculation process is somewhat small. The cost of border crossing, they divide into two; such as “border resistance in narrow sense” and “border resistance in broad sense”. In narrow sense, it is defined as resistance encountered in real border crossing point, on the other hand, in broad scene, it considers cost incurred at the stage of preparation of the shipment since large number of the documents are required particularly in the developing world. Border resistance is set by five grades which are determined based on the literature review and field survey. Subsequently, the estimated cost is included into the generalized cost of the haulage. However, this method does not explicitly include the shipment time variability which affects the route choice under heavily variable route.

Normally, these models are developed so as to analyze the cargo flow pattern by changing route availability or level of service. However, in this study, interest of this research is only for the change in cargo flow pattern in Lao PDR and surrounding countries. In the area surrounding LLDCs, routes for accessing seaport are very limited. Thus, relatively higher computational process is acceptable.

One paper regarding to the analysis of the impacts of international infrastructure development in GMS (Iwata *et al*., 2010) is found. This paper covers two types of impacts; the economic impacts on the GDP in the country and the impacts on interregional freight traffic flows crossing the country and results are estimated as reduction in transport cost as shown in Table 2.4.

Table 2.4 Estimated Benefits in Transport Cost by Implementing Transport Policy

Country	Rate of decreased transport cost			
	All Projects	**Maritime**	**Land**	**CBTA**
Philippines	3.7%	2.3%	2.5%	0.9%
Vietnam	12.3%	1.8%	7.1%	5.4%
Laos	22.6%	2.1%	-0.2%	19.2%
Cambodia	4.3%	0.3%	0.4%	2.8%
Thailand	12.9%	7.1%	10.6%	4.0%
Malaysia	6.6%	1.4%	2.2%	6.2%
Singapore	6.8%	2.0%	1.9%	4.2%
Myanmar	5.6%	1.3%	1.5%	3.6%
Indonesia	12.8%	8.3%	2.2%	5.7%
Brunei	9.0%	0%	0.9%	7.8%
ASEAN Subtotal	8.8%	3.9%	4.5%	4.2%

Source: Iwata *et al*. (2010)

Two econometric models are used for analyzing the impacts. The one is the standard Global Trade Analysis Project (GTAP) model. This is one of the spatial computable general equilibrium models with which the change in economic activities caused by transport projects is estimated. It covers multiple sectors in multiple regions with the assumptions of the perfect competition and constant returns to scale. Another is a MICS. Using MICS, the modal choice and route choice of freight transport is analyzed. The results of the impact analysis provide two insights. Firstly, the international transport projects in the GMS increases substantially GDP in Lao PDR in addition to the GDPs in other countries in the GMS. Secondly, although the current projects may increase slightly the land freight through-traffic crossing Lao PDR, they may not give the critical impacts on the local community in Lao PDR. Thirdly, the further cross-border trade facilitation would cause a drastic modal shift from maritime transport to land transport. Finally, the land freight traffic to and from China could increase substantially in the GMS if the further cross-border facilitation would be realized.

2.4 Chapter Conclusion

There are three main groups of the literature in this chapter. The first group (section 2.1) is about to describe works and surveys generally related to freight transport issues from the macro-scope of view in terms of shipment time and cost. They are introduced for better understandings for this dissertation. In addition to shipment time and cost, its variability is shown using two evidences, variability at Mombasa seaport (Figure 2.3) and on the route between Vientiane and Laem Chabang seaport (Figure 2.4). This is the main problem behind the motivation to build the model in this dissertation.

The second group of the literature (section 2.2) discusses the papers from the field of development economics. They lead to the conclusion that the problems on freight transport of cross-border transport exists and adversely affect on increase in shipment cost and decrease in trade volume using regression analysis and gravity model in principle. However, no study had been done as seaport is one of the bottlenecks for landlocked countries. In the first group of literature, several literatures highlight the adverse effect of shipment time variability at seaport. Nevertheless, in the field of development economics, cross-border effect was examined as prior concern.

The last group of the literature (section 2.3) describes the papers about cargo flow simulation model with brief history regarding forecasting model for seaport cargo volume. The most prominent model for this field is Shibasaki and Watanabe (2008). In that model, shipment time variability at border is roughly considered but rigorous theoretical background is somewhat in doubt. Besides, seaport is not treated as a bottleneck in his model.

CHAPTER 3

FIELD SURVEY IN CENTRAL ASIA AND LAO PDR

3.0 Introduction

Chapter 3 dedicates to illustrate the clarifying and confirming the problems related to haulage of LLDCs learnt from field surveys (interview surveys and site visits) in Central Asia and Lao PDR in order to fulfill objective 1. Problems extracted from the surveys would not be only physical issues but also institutional issues that include binomial agreement between countries, multinomial agreement, other treaties facilitating smooth inland cargo flow, etc. The finding of this chapter serves as the motivation and fundamental problem statements to the rest of the dissertation. Inland cargo flow model for LLDCs are going to be developed considering problems found in this chapter. As for basic data of Kyrgyzstan, it is omitted due to the reason that the main survey locations are Uzbekistan and Kazakhstan.

3.1 Field Survey in Central Asia

3.1.1 Overview of the Survey

The field surveys including interview survey and site visit in Central Asia were conducted between the period of September 27th and October 3rd, 2009 in three Central Asian countries, Uzbekistan, Kazakhstan, and Kyrgyzstan. Interview surveys were conducted with seven state-owned companies and governmental organizations from Uzbekistan, two private companies from Kazakhstan, and one governmental organization from Kyrgyzstan. In addition to interview survey, site visits were conducted, such as Uzbekistan/Kazakhstan Border (Yallama), Railway Container Terminal in Tashkent, Kyrgyzstan/Kazakhstan Border, Almaty I Railway Container Terminal, and logistics center of private company in Almaty.

Uzbekistan is one of the most severe-conditioned countries in terms of inland freight transport because of the geographical situation that the country are forced to pass across the border at least twice to access to seaport. Such countries are called as doubly landlocked country. Currently, doubly landlocked countries exist only two in the world, Uzbekistan and Liechtenstein. As reviewed several papers in chapter 2, the number of border crossing has negative impact on shipment time, cost, and trade volumes. Considering above factors, field survey in Uzbekistan were conducted. Accompanying with Uzbek survey, two neighboring LLCs, Kazakhstan and Kyrgyzstan were visited for field survey.

3.1.2 Basic Data of Uzbekistan

Prior to proceeding to detail discussion of the field survey, several basic data are reviewed in order to understand fundamental situation of Uzbekistan. The population of Uzbekistan is 27,606,007, which ranks 44th in the world, as of 2009 (CIA, 2009). Recently, economic condition looks somewhat good in terms of GDP growth rate as shown in Figure 3.1. Immediately after achieving independence from the former Union of Soviet Socialist Republics (USSR), Uzbekistan's level of economic growth declined. After passing through these difficult times, the country began, after 1996, to experience positive economic growth, and Uzbekistan finally achieved a +10% GDP growth rate in 2007. The GDP per capita in 2009 is estimated to have reached 2,805 USD (IMF, 2009). This indicates that the growth rate in 2009 against the previous year is +6.52%, which implies that Uzbekistan has not been widely affected by the recent economic crisis. On the other hand, the GDP growth rate in 2009 in Kazakhstan is expected to be negative because of the economic crisis.

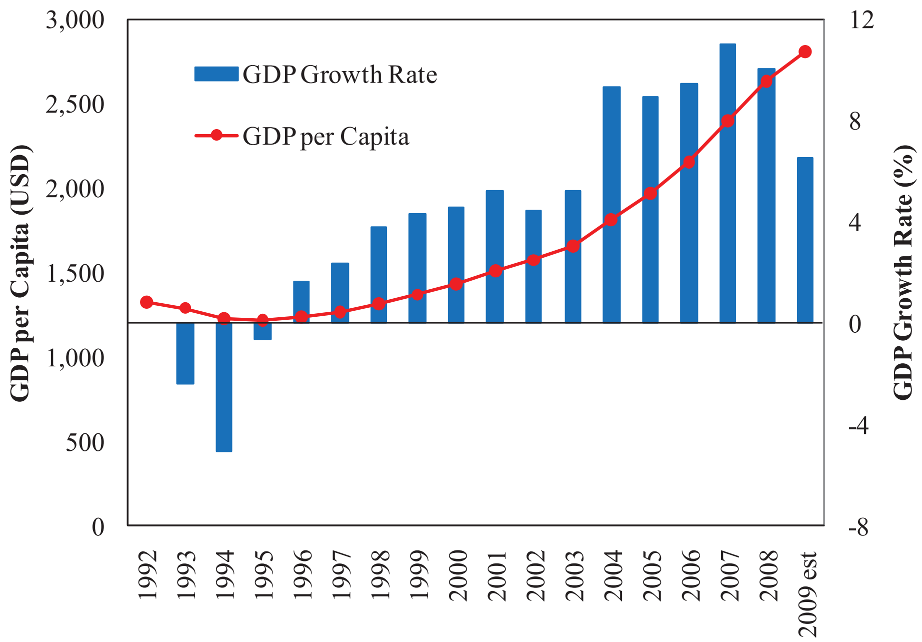


Figure 3.1 Change in GDP Per Capita and Economic Growth Rate in Uzbekistan
Data Source: IMF (2009)

Trade partners of Uzbekistan for both exporting and importing case are shown in Figure 3.2 and 3.3, respectively. Russia is the most trading country for both cases of export and import of Uzbekistan (25.3% and 27.6% of total trade). Total exporting value in 2008 accounts for 10.37 Billion USD whereas import value in 2008 is 7.07 Billion USD (CIA, 2009). Types of goods exporting in 2008 are cotton, gold, energy products, mineral fertilizers, ferrous and non-ferrous metals, textiles, food products, machinery and automobiles. Among them, primary exporting goods are cotton and natural resources (CIA, 2009). As for importing goods, machinery and equipment, foodstuffs, chemicals, ferrous and non-ferrous metals are treated. Recently, importation volume from China is rapidly increasing.

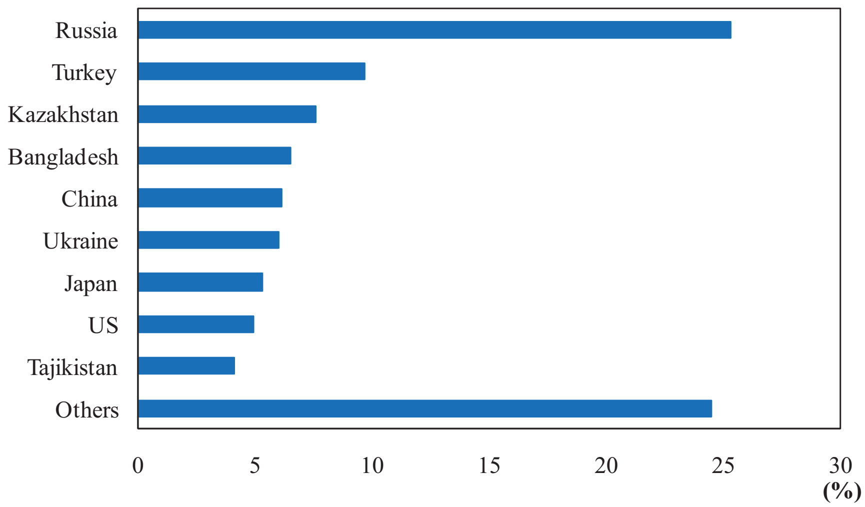


Figure 3.2 Trade Partners of Uzbekistan (Export)
Source: CIA (2009)

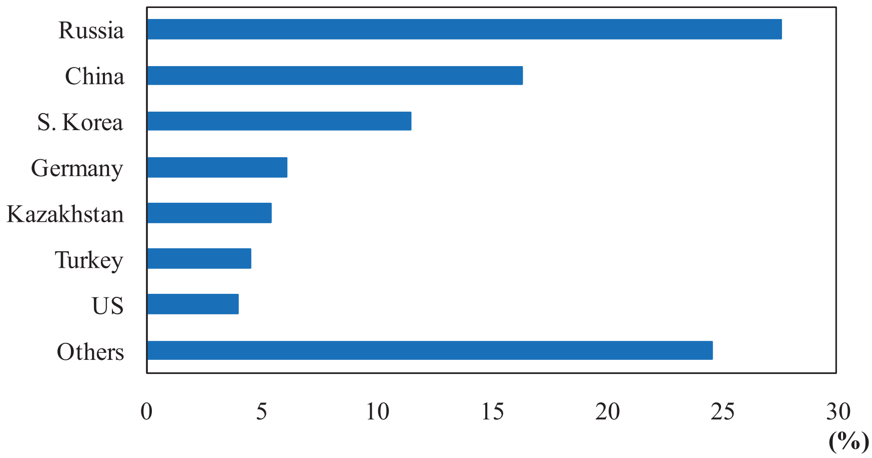


Figure 3.3 Trade Partners of Uzbekistan (Import)
Source: CIA (2009)

3.1.3 Basic Data of Kazakhstan

The population of Uzbekistan is 15,399,437, which ranks 64th in the world, as of 2009 (CIA, 2009). In a trend that is similar to Uzbekistan, in the years immediately after gaining independence from the former USSR, Kazakhstan's economic growth in terms of GDP was recorded as negative as shown in Figure 3.4. Subsequently, the country managed to achieve continuously high economic growth because of its abundant natural resources, particularly oil. In 2000, it reached the 10% mark (12.44%), and maintained an economic growth rate of over 10% until 2007. Nevertheless, the growth rate drastically decreased until it reached 5.30% in 2008 and finally, a negative rate is expected to have occurred in 2009. One of the reasons for this decline in economic prosperity could be that their industrial sectors, which are highly dependent upon oil production, have been affected by the relatively low price of crude oil recently.

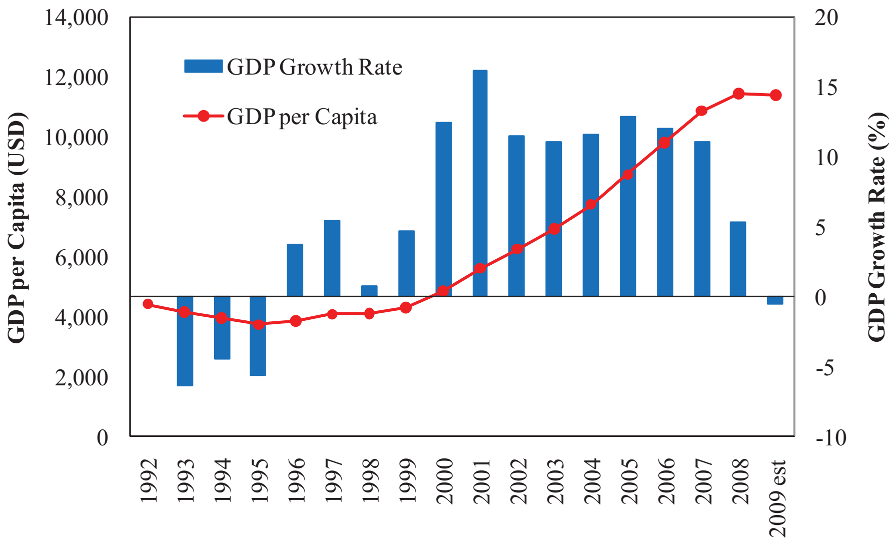


Figure 3.4 Change in GDP Per Capita and Economic Growth Rate in Kazakhstan
Source: IMF (2009)

Trade partners of Kazakhstan for both exporting and importing case are shown in Figure 3.5 and 3.6, respectively. Russia and China are the most trading country for total trade of import and export. Total exporting value in 2008 is 71.97 Billion USD and import value in 2008 is 38.45 Billion USD (CIA, 2009). Differing Uzbekistan, trade of Kazakhstan is export surplus. Types of goods exporting in 2001 are oil and oil products (59%), ferrous metals (19%), chemicals (5%), machinery (3%), grain, wool, meat, coal. The main exporting goods of Kazakhstan are natural resources (CIA, 2009). As for types of importing goods of Kazakhstan are machinery and equipment, metal products, foodstuffs, foodstuffs, chemicals, ferrous and non-ferrous metals.

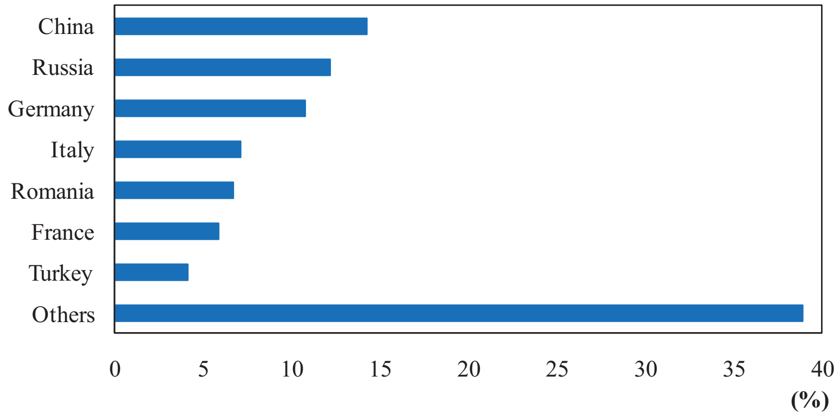


Figure 3.5 Trade Partners of Kazakhstan (Export)
Source: CIA (2009)

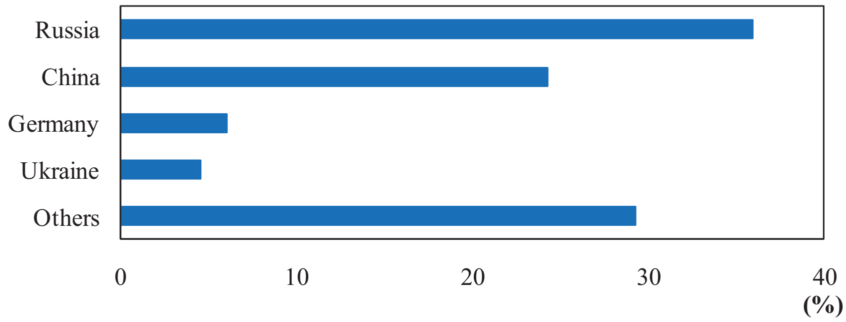


Figure 3.6 Trade Partners of Kazakhstan (Import)
Source: CIA (2009)

3.1.4 Routes of Inland Transport

In this section, routes for freight transport from/to Uzbekistan and Kazakhstan are addressed. Accompanying with the routes, several problems lied on the routes and haulage related treaties are presented. The haulage from Uzbekistan to Russia, which occupies the largest portion of trading amount in terms of monetary term for Uzbekistan is normally operated by trucks through Kazakhstan. For transit in Kazakhstan and Russia by Uzbek truck, permission for truck operation is not necessary. Types of exporting goods transported to Russia are daily goods, cotton, agricultural products, and automobiles whereas goods of import from Russia are wooden material and goods that are unavailable in Uzbekistan. Shipment time normally takes 2-5 days, 3 days can be variable for nearly 4,200km journey.

The haulage to China is normally conducted by rail transport through Dostyk/Alashankou border which is shown in Figure 3.7. In this route, total shipment time between Tashkent and Lianyungang seaport takes 14-20 days, which implies that 6 days can be varied. The type of export goods to China are mainly secondary materials such as oil, silk material, plastic, bottle, etc., whereas import goods from China is mainly daily goods, electrical goods, construction material, machinery, etc. At the border crossing point, cargo inspection is required since China is not a member of the Federation of International Trade Associations (FITA) but Uzbekistan is. Consequently, delay usually occurs at the border due to the several processes including cargo inspections. Regarding the haulage from/to European countries, it is dominantly conducted by truck through Kazakhstan and Russia. Railway operation for freight transport in this route is minor. The permission for Russian transit is not required according to the bilateral agreement. The attractive point of haulage by trucks is shorter shipment time, which takes 5days-1week, whereas shipment cost takes 4,000-5,000USD per a truck. The possible maximum variability of this route is 2days for two border crossing route. In case of seaport access from Uzbekistan, the route through Iran is normally chosen. In this case, Bandar Abbas seaport in Iran is normally used, and Caspian sea route is also rarely used. In case Iranian route, shipment time gets longer, approximately 20 days to Europe, however, shipment cost is lower than Russian route, which takes 2,500-3,000US per a truck. This is rational since maritime transport is lower cost in general. The final destinations of Iranian route are; Greece, Bulgaria, and Italy in general. In case of Caspian sea route, goods rarely transported till France but it is very few amount. Karachi seaport in Pakistan is not used mainly due to the reason that Afghanistan transit is impossible so far. In case goods are transported to/from South East Asia, the route is normally passing through Bandar Abbas seaport using maritime transport. The reason to use this route is that the shipment cost of land transport is relatively higher through China. The shipment time till Bandar Abbas seaport is to be approximately 7-10 days by truck. Between Uzbekistan and East Asia, Japan and Korea, it is normally relayed Vostochny (Vladivostok) seaport or Lianyungang seaport through Kazakhstan using China Land Bridge (CLB). The route through Bandar Abbas seaport is not used. The haulage to Afghanistan, which is neighbor country, is operated for transporting the goods such as daily goods, military goods, metal, oil, etc. The border is limitedly opened between 8am till 5pm.

Next, the route from/to Kazakhstan is addressed. As for from/to Russia, railway transport through Novorossiysk is mainly used for food products. The final destinations are normally large cities such as Moscow and Saint Petersburg. The distance transported between Almaty and Moscow is approximately 4,000km and shipment time is accounted as 3-4 days for trucks. In this case, shipment time variation is 1 day. Shipment cost is approximately 1.5 USD/km in average, however, it is varied depending on insurance, scale of companies, etc. The shipment time between Almaty and Moscow by railway takes approximately 10-12 days. Regarding shipment cost using container, 1.5 times higher than non-container haulages. The shipment time between Shanghai and Dostyk by railway transport, it requires approximately 1 week. One needs to take 1 day-3 days for transshipment for 500-600 rolling-stocks at the border Dostyk/Alashankou due to the differences of gauge size. The opening time of the border is limited between 8 am and 8 pm. In regard to haulage from/to Europe, Russian route by truck is the most common. To Japan, it is same route as haulage from/to Uzbekistan. They are using CLB for accessing to Lianyungang seaport. As a result of all interview survey, focusing on shipment time variability, it happens at border and almost no delay can be observed on the road. Thus, for developing inland cargo flow model, we can assume that the link is operated at almost free-flow speed.

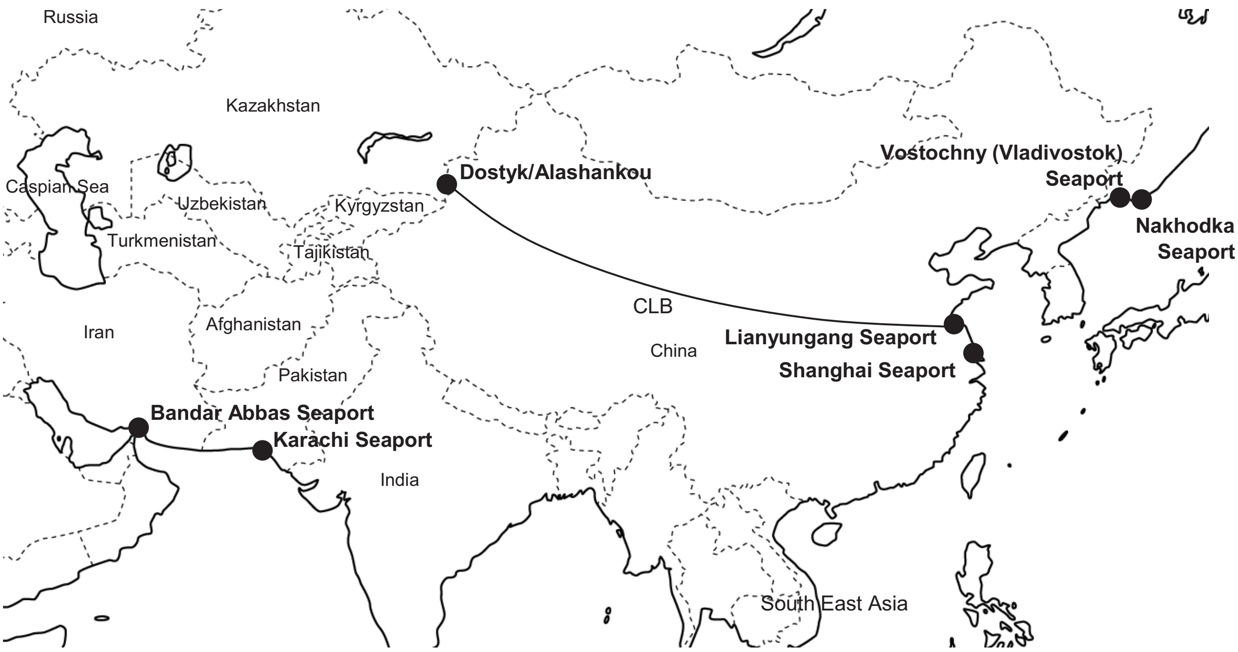


Figure 3.7 Location of Each Point of Asia

Figure 3.8 Location of Each Point of Central Asia and Europe

3.1.5 Treaties Related to Freight Transport

Treaty and agreement related to freight transport of Uzbekistan and Kazakhstan surrounding CIS countries are summarized as following (1)-(6). As supplemental information, several regional frameworks enforced are obtained from JICA (2007). These frameworks will contributes on further facilitation of freight transport between the countries.

(1) TIR (Transport International Routier)
United Nations Economic Commission for Europe (UNECE) manages TIR. After cargo are inspected and bonded at the departure location of the number countries of TIR, TIR sticker is put on the trucks. The trucks with TIR sticker are no longer take cargo inspection within the member countries. In general, customs clearance is separately prepared for such trucks. TIR would contribute on the decrease in unnecessary delay at the border.

(2) Agreement on Freight Transport
By this convention, cargo inspection process in the CIS country can be omitted in case more than two border crossing for one haulage. In the route of Uzbekistan-Kazakhstan-China, cargo inspection upon arrival at Kazakhstan is exempted. However, because China

is not acceded to this convention, cargo inspection process is required upon arrival at China. This convention is also effective in terms of reduction in transit cost and tariff between CIS and Russia, who are members of this convention.

(3) FITA (The Federation of International Trade Associations)
In order to export to countries in Central Asia from non-Central Asian countries, several numbers of procedures are required and authentication by FITA is required. In order to pass through countries non-FITA member countries, change of the carrier is required on all such occasions.

(4) SPECA (UN Special Programme for the Economies of Central Asia)
SPECA is one of the regional cooperation framework led by ESCAP and intended for integration of Central Asia into the global economy and the strengthening of regional economic cooperation in Central Asia. SPECA member is currently seven countries such as Afghanistan, Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

(5) Union of Common Customs Clearance
Union of Common Customs Clearance was jointly come into the force by three countries, Kazakhstan, Russia, and Belarus on January 1, 2010. It will finally become effective in June 2011. Among these unions, freight movement within the member countries is allowed one customs clearance thanks to common declaration form. Tajikistan and Kyrgyzstan is currently an observer, and are expected to be future members.

(6) Other country-base agreements
<u>China and Kazakhstan:</u>
In case exporting from Kazakhstan to China, it is prohibited to enter China by Kazakh trucks in principle. However, Kazakh truck can transport up to Urumqi and rail cargo can be transported up to Khorgos thanks to bilateral agreement of two countries. The border point is jointly managed as border cooperation center (neutral place).

<u>Kazakhstan, Uzbekistan, and Turkmenistan (Treaty of three countries):</u>
In case a foreign-flag truck (Kazakhstan and Turkmenistan) operated in Uzbekistan, it is necessary to declare transport route when entering to Uzbekistan. Subsequently, map with designated route will be distributed to truck drivers. The drivers are prohibited to drive non-designated route. There are similar treaties among Uzbekistan, Kyrgyzstan, and China.

(7) Other regional cooperation framework

According to JICA (2007), there are several regional frameworks in Central Asia and surrounding regions and countries as shown in Table 3.1. These frameworks are expected to enhance and facilitate efficient freight transport in the region.

Table 3.1 Regional Framework Surrounding CIS Countries Related to Freight Transport

	EEC	**SCO**	**CAF**	**CAREC**	**ECO**	**CACO**	**CIS**	**TRACECA**
Kazakhstan	yes	yes	yes	yes	yes	yes	yes	yes
Uzbekistan		yes	yes	yes	yes	yes	yes	yes
Kyrgyzstan	yes	yes	yes	yes	yes	yes	yes	yes
Tajikistan	yes	yes	yes	yes	yes	yes	yes	yes
Turkmenistan					yes		yes	yes
Russia	yes	yes					yes	
China		yes						
Iran					yes			
Azerbaijan					yes		yes	yes
Georgia							yes	yes
EU								yes
Others	Belarus				Pakistan, Turkey, Afghanistan		Belarus, Moldova	Armenia

Source: JICA (2007)

EEC: Eurasian Economic Community
SCO: The Shanghai Cooperation Organization
CAF: Central Asia Forum
CAREC: Central Asia Regional Economic Cooperation
ECO: Economic Cooperation Organization
CACO: Central Asia Cooperation Organization
CIS: Commonwealth of Independent States
TRACECA: Transport Europe Caucasus Central Asia

3.1.6 Summary of Freight Transport Problems

From the interview survey, typical transport risks which will contribute on additional cost which may be considered for their route choice are examined. Risks associated with freight transport in Kazakhstan and Uzbekistan (1) trivial problems, (2) serious problem, for violating stable transport supply are summarized. In the survey, potential freight transport risks, which are listed up prior to the interview survey, were asked. After that, other transport risks were answered by open-ended question method.

(1) Trivial problems

- damage on goods transported by railway container freight transport is few, in the case of cargo damage occurs, insurance can be applied
- cargo damage caused by vibration is few as far as following haulage regulation
- The regulation change in rail freight transport is managed by Central Soviet Union Railway Company located in the Moscow office. The information will be noticed to the country. Therefore, the problems caused by a sudden rule change are few.
- During the winter season, special container is used for transporting cargo in order to prevent freeze.
- No damage on the cargo due to rain, snow, and water leakage
- Lack of the container in Uzbekistan is only during the peak season, and can be coped with the problems by renting containers from Russia and Kazakhstan.
- Pilferage of cargo is problematic, however, the loss due to the pilferage can be covered by insurance. In case it happens in rail transport, railway company takes responsibility on it.
- The issue of terminal capacity at the terminal because of lack of space is not problematic.
- Negative impact due to language differences at the border is not also problematic.

(2) Serious problem

- Failure of the rail vehicle is problematic although no failure on track line. Among total domestic freight by rail in Uzbekistan from the beginning of 2009 till September 2009, the vehicle broke down about 20 times during the period. The total capacity of rail freight transport is approximately 240 million tons.
- There is waiting time caused by congestion in rail transport. Approximately 5% of total train does not comply with the timetable.
- Lack of equipment for scanning cargo at the border is causing the long delay
- Lack of resting place for drivers
- In Kazakhstan, the problem is engine failure due to entering the desert sands.
- Because of delays at the border affecting the fare increase, it should be improved. That delay occurs randomly, thus it is tough to predict the delay.
- On the haulage to Mersin in southern Turkey facing the Mediterranean Sea from Uzbekistan, the driver's visa is sometimes expired due to the waiting time for the ferry.
- Unofficial Payment may be illegally collected by the customs officials and border guards. It happens mainly at the border.
- Lack of tracing function (JICA, 2007)

3.1.7 Findings

From the field survey in Central Asia, several problems were found. They can be divided into two types of problems which are trivial and serious problems. As an overall trend, it can be observed that trivial problems are normally risks which are not regularly occurs, despite its impact. Also, they are normally covered by insurance. On the other hand, trivial problems are related to delay due to the low reliability of the route. For example, some answered that expiring driver's visa is problematic. In fact, this happens due to the shipment time variability and drivers are suffered from unexpected waiting time. Shipment time variability regularly occur, but it is difficult to predict the scale of it. Therefore, it can be concluded that one of the most serious concern for considering additional cost of inland route choice problem is shipment time variability.

3.2 Field Survey in Lao PDR

3.2.1 Overview of the Survey

The field survey was conducted between the period of September 15th and 21st, 2010 in Lao PDR, January 10th and 14th, 2011 in Bangkok, and January 17th and 20th, 2011 in Hanoi. Interview surveys were conducted with 51 freight forwarders in total. Since Lao PDR and surrounding coastal countries are target area for model development in chapter 4, 5, and 6, these three countries were selected as second field survey of this dissertation.

3.2.2 Basic Data of Lao PDR

The population of Lao PDR is 6,477,211, which ranks 103rd in the world, as of 2011 (CIA, 2011). As for economic condition, it shows similar trend to GMS surrounding countries, such as Thailand and Vietnam as shown in Figure 3.9. However, the scale of growth rate is much lower than those surrounding countries. GDP growth rate marked positive except the period of Asian Finance Crisis in 1997. Posterior to extinction of aftereffect of financial crisis, Lao PDR continuously achieves positive economic growth. In 2010, it reached nearly 1,000 USD per capita. However, again, the GDP growth rate is substantially lower than surrounding countries.

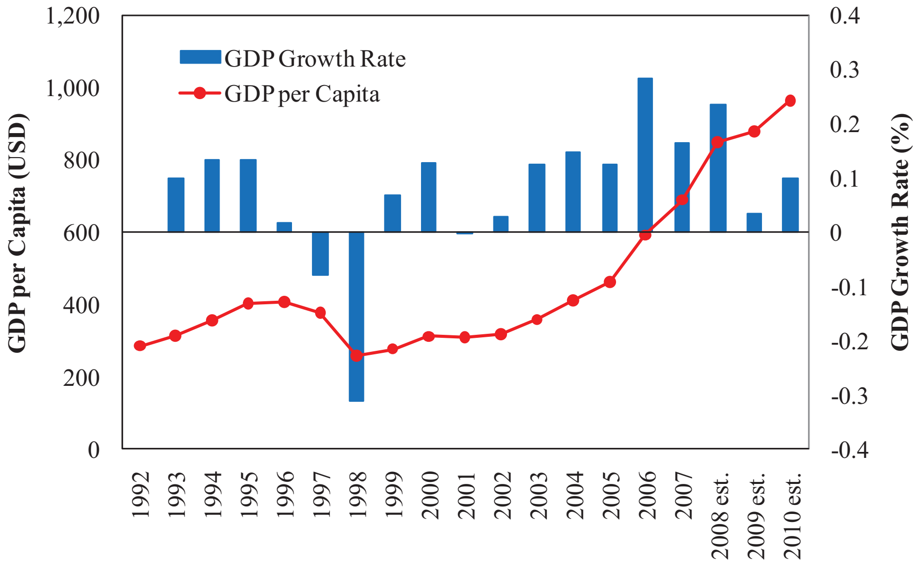


Figure 3.9 Change in GDP Per Capita and Economic Growth Rate in Lao PDR
Data Source: IMF (2009)

Trade partners of Lao PDR for both exporting and importing case are shown in Figure 3.10 and 3.11, respectively. Thailand is the most important country in terms of both cases of import and export (29% and 66% of total trade). Total exporting value in 2009 is 1.10 Billion USD and import value in 2009 is 2.03 Billion USD (CIA, 2010). Types of goods exporting in 2009 are wood products, coffee, electricity, tin, copper and gold whereas importing goods are machinery and equipment, vehicles, fuel, consumer goods.

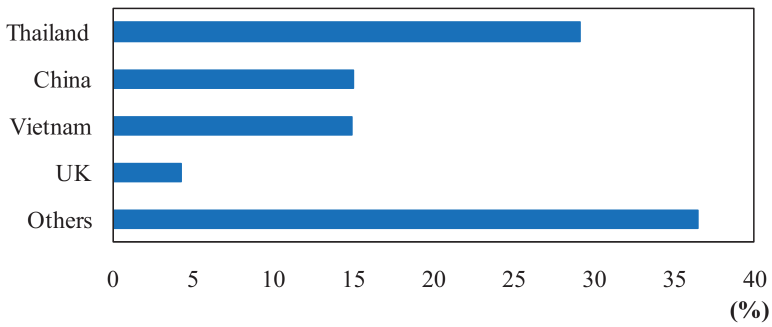


Figure 3.10 Trade Partners of Lao PDR (Export)
Source: CIA (2009)

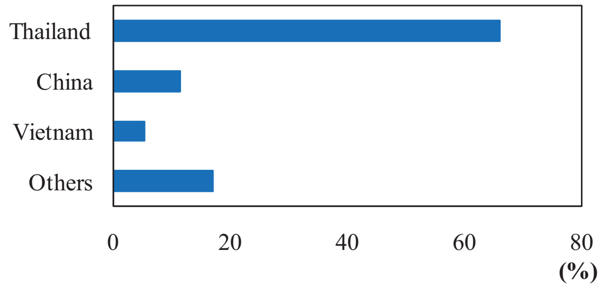


Figure 3.11 Trade Partners of Lao PDR (Import)
Source: CIA (2009)

3.2.3 Cross-Border Transport

The Thanaleng/Nong Khai border (Friendship Bridge, near Vientiane capital) is the busiest of all border-crossing points in Lao PDR, according to the interview survey. This is reasonable because Laem Chabang seaport deals predominantly with Lao cargo, and Vientiane is the largest city in terms of economic scale. The Savannakhet/Mukdahan border (Friendship Bridge II) is the second busiest border. Savannakhet is the second largest city in Lao PDR.

An exporter of Lao PDR is required to submit several documents, such as a bonded application form, an invoice, a packing list, and so on, to the Ministry of Industry and Commerce of Lao PDR. Subsequently, cargo must be inspected by the economic police (Department of Inspection, Ministry of Industry and Commerce), and a sticker from the Customs Department must be put on the container. These formalities must be completed on paper but not through electric devices. Thus, cumbersome processes by paper violate the shipment time reliability. Poor institutional aspects also contribute to difficulties predicting expected shipment times. According to the interview survey, early closings and different opening times of the border make cross-border haulage conditions worse. For example, the Lao side of the Thanaleng/Nong Khai border closes at 10 p.m., whereas the Thai side is open 24 hours. Two borders with Vietnam, Nam Phao/Cau Treo (route to Hai Phong seaport) and Dansavan/Lao Bao (route to Da Nang seaport), limit the times they are open to trucks (see Figure 3.12). The Lao side is open from 8 a.m. until 4 p.m., whereas the Vietnamese side is open from 8 a.m. until 11 a.m. and from 1 p.m. until 4 p.m. The Vietnamese side also restricts border crossings during lunchtime. In addition, open times sometime change without any prior notice.

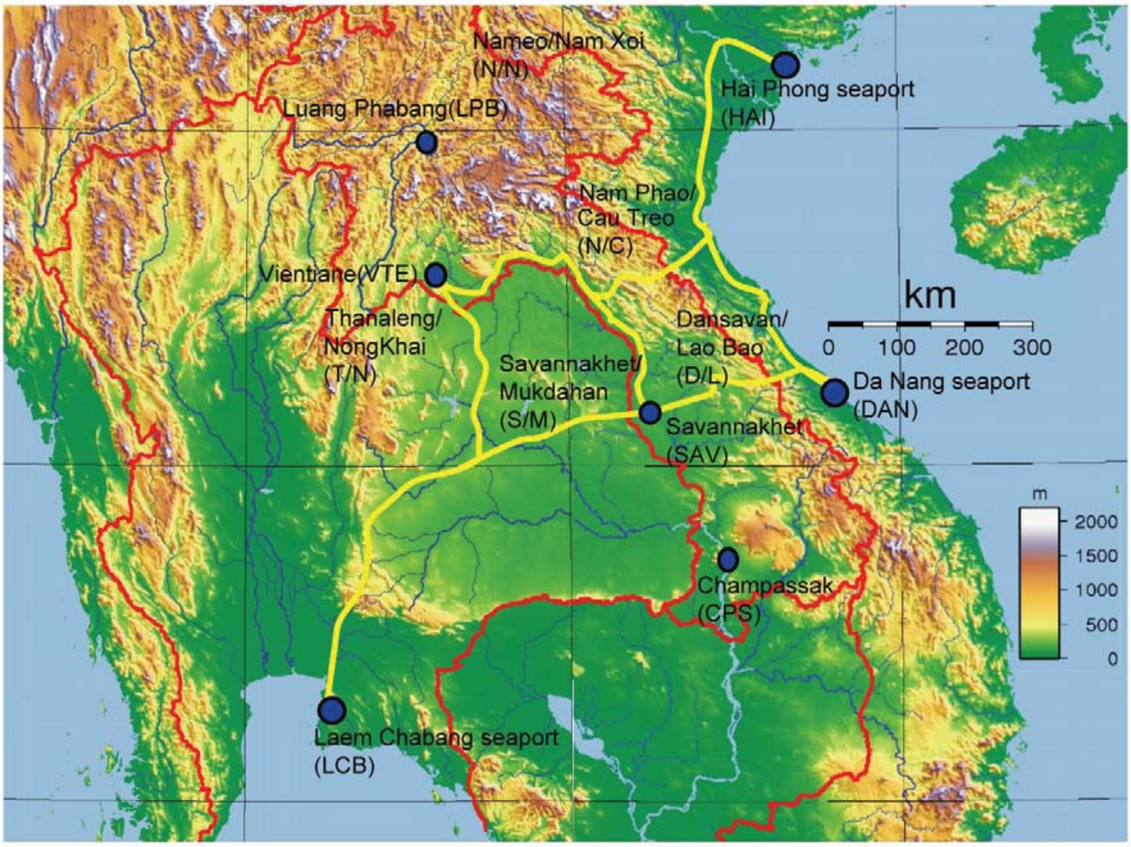


Figure 3.12 Road Map from Vientiane and Savannakhet to Seaports

ADB (2006) documented that freight modal share in Lao PDR is mostly truck, which accounts for 65.6% of the ton-km base. The rest (34.4%) is coastal shipment using the Mekong River. However, coastal shipments from Lao PDR cannot access the sea because of the Khone Phapheng Falls in the Champassak Province of Laos near the border with Cambodia.

3.2.4 Seaport Choice

Currently, overseas cargo from Vientiane and Savannakhet is bound primarily for the Thai seaport. According to the interview survey, the Laem Chabang seaport accounts for approximately 90% of the cargo volume of the Lao international maritime trade. The remaining 10% is bound for Vietnamese seaports, such as Hai Phong and Da Nang. 51 logistics companies (7 in Vientiane, 32 in Bangkok, and 12 in Hanoi) were asked by open-ended question style about the reasons for choosing a Thai seaport. The results are summarized in Table 3.2.

Table 3.2 Reasons for Choosing a Thai Seaport

No. (%) of answers	Reason
33 (64.7%)	Interdependency with shipping lines
33 (64.7%)	Low shipment cost
27 (52.9%)	Short shipment time
19 (37.3%)	Better infrastructure
13 (25.5%)	Severe geographic conditions on the Vietnamese side
11 (21.6%)	Low shipment time variability (including high punctuality)
10 (19.6%)	Ease of customs formalities
7 (13.7%)	Empty haulage problem
5 (9.8%)	Language
4 (7.8%)	Proximity to border

Interdependency with shipping lines and low shipment cost were the most important factors in choosing a Thai seaport. Several mother vessels are available in the Laem Chabang seaport. The cost of haulage between Vientiane and the Laem Chabang seaport is approximately 1,600 USD/TEU or 1,700 USD/FEU, whereas 1,800 USD/TEU or 2,000 USD/FEU is charged for access to the Hai Phong seaport, the gateway seaport of Hanoi. In contrast, 1,500 USD/TEU is charged for access to the Da Nang seaport, which is the lowest among the seaport choices. However, Da Nang seaport cannot currently compete with Laem Chabang and Hai Phong seaport because of the low level of its facilities. For example, Da Nang seaport has three gantry cranes, whereas Hai Phong seaport has six (Japan External Trade Organization, 2008). However, it should be noticed that Da Nang seaport is currently upgraded rapidly as designated seaport to be invested intensively by the government of Vietnam. Thus, the seaport would be the competitor of other two seaports in the near future. Shipment cost here is estimated on the basis of the interview survey and includes several fees, such as those for delivery ordering, terminal handling (freight station), transit customs formalities, loading/unloading, border clearance, and return haulage for containers.

Shipment time was the third most important reason for choosing a Thai seaport. Shipment time between Vientiane and Laem Chabang is approximately 13 hours, whereas that between Vientiane and Hai Phong is 19 hours. In addition to shipment time itself, shipment time variability was also important (11 companies mentioned this). In general, the Vietnamese route is more variable than the Thai route. Some companies pointed out that because logistics companies are sensitive to punctuality, there should be a tendency to avoid highly variable routes. 13 companies mentioned the severe geographical conditions on the Vietnamese side. The Vietnamese side contains the Annamite mountain range, which means more difficult conditions for smooth haulage compared to the Thai side. On the other hand, Thai side is almost all flat in terms of terrain.

3.3 Summary and Findings

From the interview survey in Lao PDR, several problems related to LLDCs' freight transport are identified. In any route of cross-border transport from/to Uzbekistan and Kazakhstan, shipment time is variable. Many of them are caused at the border. As identified in the field survey in Lao PDR, 21.6% of surveyed companies are recognized that shipment time variability is important factor in Lao PDR as well. In that sense, it is postulated that there should be adverse impact due to shipment time variability, and consequently, additional cost due to shipment time variability.

CHAPTER 4

IMPACT OF SHIPMENT TIME VARIABILITY ON ESTIMATION OF EXPECTED SHIPMENT TIME

4.0 Introduction

As can be seen till previous chapter, shipment time between LLDCs and seaports in neighboring coastal countries are highly variable because of delays at two bottlenecks: the border and the seaport. The logistics related organizations are recognized such problem lied at the seaport accessing is as serious problem to be solved. In general, information on delays at the border and the seaport is not provided and is difficult to predict prior to the departure. In such case, it can be considered that estimation of next shipment time is very likely to be difficult. This, it can be postulated that shipment time variability adversely affect on the estimation of expected shipment time for logistics related decision makers (in this study, freight forwarder). In order to clarify the impact of shipment time variability on estimation of expected shipment time for freight forwarder, one hypothesis is set up for estimating expected shipment time to examine the hypothesis. The objectives of this chapter are (i) to observe which type of shipment time significantly affects the estimation of expected shipment time and (ii) to compare parameter across the five different routes which involve different bottlenecks in terms of the level of shipment time variability. Subsequently, verification of hypothesis is examined on the basis of results obtained. In order to achieve these objectives, a case study on cross-border routes from Lao PDR to Thailand/Vietnam is presented. The result of this chapter is not methodologically related to chapter 5 and 6, which present inland cargo flow model development. The result of this chapter would be one of the motivations for developing inland cargo flow modeling in following chapters.

4.1 Literature Review for Methodology

Transport behavior models generally assume an individual traveler's evaluation function for expected travel time of mean, maximum, minimum, weighted average value, and so on of factors expressing traveler's behavior mechanism (Morichi *et al.*, 1995). Nevertheless, traveler's behavior in the real world varies according to place, scene, situation, etc. Thus, Morichi *et al*. (1995) attempted to develop a model for estimating shipment time in highly variable routes. In this context, the generalized mean concept can be applied to determine which experiences significantly affect the estimation of expected shipment time. The generalized mean incorporates several evaluation functions of an individual by changing parameters in the model. An operation that aggregates multiple values to one value can be expressed as following Equation (4.1):

$$h : [x_1, x_2, x_3, \cdots, x_n] \rightarrow \bar{x} \tag{4.1}$$

Among the aggregation operations, an operation that satisfies relationship of Equation (4.2) is called as a mean operation, which ranges between minimum and maximum values. Using Equation (4.3), the generalized mean can express various means by changing parameter α ($\alpha \neq 0$) as shown in Table 4.1.

$$\min(x_1, x_2, \cdots x_n) \le h(x_1, x_2, \cdots, x_n) \le \max(x_1, x_2, \cdots, x_n) \tag{4.2}$$

$$\bar{x} = \left(\frac{x_1^{\alpha} + x_2^{\alpha} + \cdots + x_n^{\alpha}}{n} \right)^{\frac{1}{\alpha}} \tag{4.3}$$

Table 4.1 Mean Operation by Equation (4.3)

Condition	Equation
a) Minimum value ($\alpha \to -\infty$)	$\bar{x}_{-\infty} = \min(x_1, x_2, \cdots, x_n)$
b) Harmonic mean ($\alpha \to -1$)	$\bar{x}_{-1} = \dfrac{n}{\dfrac{1}{x_1} + \dfrac{1}{x_2} + \cdots + \dfrac{1}{x_n}}$
c) Geometric mean ($\alpha \to 0$)	$\bar{x}_0 = (x_1 \cdot x_2 \cdot \cdots \cdot x_n)^{\frac{1}{n}}$
d) Arithmetic mean ($\alpha \to +1$)	$\bar{x}_{+1} = \dfrac{x_1 + x_2 + \cdots + x_n}{n}$
e) Maximum value ($\alpha \to +\infty$)	$\bar{x}_{+\infty} = \max(x_1, x_2, \cdots, x_n)$

To enable observation of the importance of each explanatory variable, weighted parameter w_i is introduced into Equation (4.3). Because the sum of the weighted parameter is equal to 1, the weighted generalized mean is formulated as following Equation (4.4):

$$\bar{x} = \left(w_1 x_1^{\alpha} + w_2 x_2^{\alpha} + \cdots + w_n x_n^{\alpha} \right)^{\frac{1}{\alpha}}$$
$$\sum_{i=1}^{n} w_i = 1 \tag{4.4}$$

4.2 Hypothesis

As clarified in literature review (chapter 2) and field survey (chapter 3), shipment time reliability is hugely violated by several uncertain problems at the border and seaport. The shipment time variability is not predictable in general. In addition, information of delay is not provided in any developing countries. Thus, in the highly variable route, the decision maker of logistics company might estimate the expected shipment time based on their past shipment experiences and exogenously given information such as timetable. In this dissertation, one hypothesis to be examined has been established, that is, the decision makers estimate expected shipment time based on several type of shipment time such as;

(i) experiences of recent shipment,
(ii) general shipment time,
(iii) and perception shipment time.

The detail explanation and definition of each type of shipment time above will be addressed in section 4.4. In case shipper's surrounded situation is very unstable and confidence on their perception to shipment time is rather low, shipper might rely on several information sources to increase their confidence level for the estimation. This hypothesis can be more imaginably explained considering the situation when people make trip from origins to destinations in developed country. In this case, people may refer only few information or one information sources since the shipment time is pretty stable. In this case, little information source is enough to predict expected travel time for next journey being going to be conducted. Oppositely, in case of trips in developing countries, people may need much information sources rather than those of developed countries since expected shipment time is difficult to be estimated due to the variable conditions. In this dissertation, the model is applied to five different routes so that the parameters of each variable are compared. If the hypothesis is correct, more reliable routes would receive the result that one specific parameter is dominant in terms of weighted factor since little information source is needed in theory. At this time, the parameters of more variable route would be more equally weighted comparing to those of reliable routes. If this hypothesis is verified as true, more variable routes impose additional cost on logistics companies due to the variable conditions. In this case, it would be rational that the shipment time variability is considered as one of the cost for route choice problem. Here, the model is developed based on freight forwarders behavior. On the basis of interview surveys in Lao PDR, it is clarified as common trend that shippers are heavily dependent upon freight forwarders in terms of decision making on route and departure time choice. Thus, data collection is done with freight forwarders in this dissertation.

4.3 Study Area

The model is developed for export case within the responsibility of land transport, following the rule of Free on Board (FOB). According to FOB, the seller (exporter) must bear any costs and risks of loss of or damage to the goods until the goods have been loaded onto the vessel from the departure points such as warehouse of logistics companies. On the other hand, the buyer (importer) takes responsibility for all costs incurred after the cargo has been on board. Therefore, in this dissertation, a shipment is considered starting at the shipper's warehouse or truck terminal in Lao PDR and continuing across one border till the loading of the goods onto a vessel at a Thai or Vietnamese seaport, as shown in Figure 4.1 (see Figure 3.12 in chapter 3 for the map of study area).

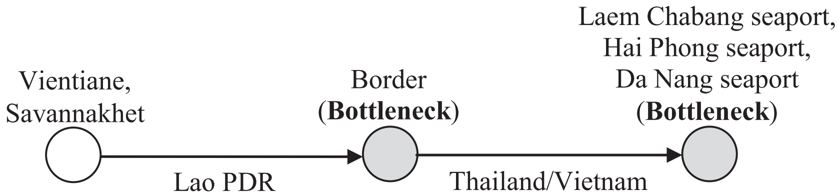


Figure 4.1 Study Range of Chapter 4

4.4 Model Formulation

As shown in Equation (4.5), expected shipment time, $E(st)$, is a set of four types of shipment time. Shipment times are not interviewed separately because interviewees are not likely to remember or record each time. For example, shipment time between border and destination is not obtainable. Therefore, interviewees were asked to answer the shipment time between the origin and the destination in the study range (Figure 4.1). The transport mode is assumed to be truck based on real condition (JICA, 2010).

$$E(st) = \sum_{i=1}^{4} x_i$$
$$x = \left\{E(lt^{lc}), E(bt), E(lt^{cc}), E(pt^{cc})\right\} \quad (4.5)$$

where

$E(st)$:	Expected shipment time (hr)
$E(lt^{lc})$:	Expected shipment time on the road in the LLDC (hr)
$E(bt)$:	Expected shipment time at the border (hr)
$E(lt^{cc})$:	Expected shipment time on the road in the coastal country (hr)
$E(pt^{cc})$:	Expected shipment time at the seaport in the coastal country (hr)

In general, it can be postulated that the most recent and second most recent shipment experiences as well as the average and maximum perception shipment times are not likely to be of the same importance for inferring expected shipment time. Thus, the weighted generalized mean formula, shown in Equation (4.4), is applied so that the differences in importance of recent experiences can be examined. The shipment time estimation model based on past shipment experiences is formulated as a nonlinear regression model as following Equation (4.6):

$$E(st) = A \cdot (\sum_{i=1}^{n} w_i st_i^{\alpha} + w_{gen} st_{gen}^{\alpha} + w_{\min} st_{\min}^{\alpha} + w_{ave} st_{ave}^{\alpha} + w_{\max} st_{\max}^{\alpha})^{\frac{1}{\alpha}} + C$$

$$\sum_{i=1}^{n} w_i = 1 \tag{4.6}$$

where

st_i:	Recent shipment time *i* times before (hr)
st_{gen}:	General shipment time (hr)
st_{min}:	Minimum perception shipment time (hr)
st_{ave}:	Average perception shipment time (hr)
st_{max}:	Maximum perception shipment time (hr)
α:	Parameter
A:	Scale parameter
C:	Constant
w_i:	Weighted coefficient

As parameter α increases, expected shipment time comes close to the maximum value. Conversely, expected shipment time comes close to the minimum value as α decreases. Thus, in addition to weighted coefficient, parameter α can be an indicator of which shipment experiences (relatively long or short shipment time) are important for estimating expected shipment time. Furthermore, attitude toward risk of delay can also be inferred. When α is small, the decision maker is relatively risk loving, because a shorter shipment time is more important for expected shipment time; however, when α is large, the decision maker may be risk averse, because a longer shipment time is more important.

With regard to the most recent and second most recent shipment experiences, a higher coefficient is expected to be associated with the most recent one. In order to analyze this trend, one needs to include actual recent shipment time taken in reality (st_i) Here, i = 1, 2, and 3 denote the most recent, 2nd most recent, and 3rd most recent actual shipment time, respectively. In reality, the shippers/freight forwarders interviewed did not remember or record actual shipment times occurring a long time ago (e.g., 10 or 20 shipments past). Furthermore, the impact of long-ago experiences is very likely to be low. Therefore, in this dissertation, shipment times for the three most recent shipments were collected in order to secure the reliability of the collected data.

General shipment time (st_{gen}) is also included in the model. This is the shipment time that is indicated on the time schedule of each company. Companies are generally operating schedule cargo, and thus they normally have a time schedule. Unless the companies have a time schedule, they simply refer to the book. General shipment time is usually used to estimate generalized shipment time on haulage for the purposes of calculating cargo flow in international logistics. It can be postulated that logistics decision makers might first refer to the general shipment time in order to make a decision on how long a shipment takes in general. For example, one logistics decision maker in Bangkok estimated the shipment time from Savannakhet to Dansavanh in Lao PDR as 4 hour and 30 minutes as provided by JETRO (Japan External Trade Organization, 2008). This possibly affects the time estimation process.

Perception shipment time (st_{min}) (st_{ave}) (st_{max}), which is individually perceived shipment time based on any sources, such as past shipment experiences, information in books or on the internet, rumors, and so on, is also included in the model as a variable. Shippers might have their own perception shipment time based on all of their experiences. For example, people who have experienced a terrible delay are going to have a relatively longer perception shipment time.

4.5 Data Collection

Data collection on each shipment time was conducted simultaneously with the interview survey in Lao PDR, Bangkok, and Hanoi (section 3.2 of chapter 3). The following eight types of shipment time were asked in following order:

1. Average perception shipment time (st_{ave})
2. Maximum perception shipment time (st_{max})
3. Minimum perception shipment time (st_{min})
4. General shipment time (st_{gen})
5. Most recent shipment time (st_1)
6. Second most recent shipment time (st_2)
7. Third most recent shipment time (st_3)
8. Expected shipment time

Perception time was asked first. If perception time is asked after actual time, then perception time is likely to be biased because of the aftereffects of answering about the actual shipment time. Subsequently, the most recent, second most recent, and third most recent shipment times were asked based on their historical records. The companies interviewed took place the shipment to/from seaports weekly-monthly; thus, the timing of the shipment experience differed across the companies. The companies dealt with daily goods such as beer, tobacco, shoes, shirts, and so on; however, the type of commodity was not considered separately. All cargo was transported in 20- or 40-feet containers without exception because maritime transport was used hereinafter. Thus, no significant difference among the types of commodities in terms of shipment time would be observed.

Five cross-border routes were selected: Vientiane to Laem Chabang (VTE-LCB), Savannakhet to Laem Chabang (SAV-LCB), Savannakhet to Hai Phong (SAV-HAI), Vientiane to Hai Phong (VTE-HAI), and Vientiane to Da Nang (VTE-DAN). The profiles of each route are shown in Table 4.2. The routes differed in terms of the level of variability in shipment time as well as frequency of shipments. Variability is leveled according to the standard deviation of distribution of shipment time variability. The derivation method of standard deviation of each bottleneck will be mentioned in chapter 6. Shipment frequency is also asked for each route.

Table 4.2 Routes Profile

Route	Distance (km)	Standard deviation (hour)			Frequency (shipments/month)
		Border	Seaport	Convoluted	
VTE-LCB[a]	700	0.479	1.186	1.275	5.43
SAV-LCB[b]	700	0.599	1.186	1.320	3.72
SAV-HAI[c]	1,150	0.625	1.519	1.630	2.23
VTE-HAI[d]	880	0.674	1.519	1.657	1.21
VTE-DAN[e]	780	0.625	1.612	1.742	1.40

[a]Vientiane to Laem Chabang.
[b]Savannakhet to Laem Chabang.
[c]Savannakhet to Hai Phong.
[d]Vientiane to Hai Phong.
[e]Vientiane to Da Nang.

4.6 Correlation Analysis

In order to select variables including in the model, Pearson's correlation analysis was conducted. Results are shown in Table 4.3.

First of all, since frequency is varied in terms of route and company, three recent shipment times are impossible to discuss season specific effect. For instance, some companies conducted last shipment one week before the interview survey; others did one month before the interview survey. As for three recent shipment experiences, the variables are highly correlated one another (0.493, 0.483, and 0.456). High correlation can also be found between minimum perception shipment time and general shipment time (0.541). Here, general shipment time tends to be close to free-flow shipment time since delay due to congestion is tended to be normally excluded from the shipment time. Therefore, it can be considered that high correlation between these variables was observed. The correlation related to maximum perception shipment time is low. One of the reasons to this is that the maximum shipment time answered by respondents was highly fluctuated. Some answered more than 2 days, and some answered very close shipment time to average perception shipment time. The fluctuations of their perception on maximum time possible affect on this result.

Table 4.3 Result of Correlation Analysis

N=141	**Most recent ST (st_1)**	**2^{nd} most recent ST (st_2)**	**3^{rd} most recent ST (st_3)**	**General ST (st_{gen})**	**Ave. perception ST (st_{ave})**	**Max. perception ST (st_{max})**	**Min. perception ST (st_{min})**
st_1	1	**0.493**	**0.483**	0.354	0.292	0.118	**0.447**
st_2		1	**0.456**	0.344	**0.524**	0.033	**0.555**
st_3			1	0.315	**0.584**	0.301	**0.430**
st_{gen}				1	0.254	0.048	**0.541**
st_{ave}					1	0.028	**0.617**
st_{max}						1	-0.048
st_{min}							1

*Bold-faced values receive more than 0.4

As a result of correlation analysis, minimum perception, second most recent, and third most recent shipment times were excluded from the model. Minimum shipment time has a significant correlation with general shipment time. Moreover, the average values of general and minimum perception shipment time are relatively close. The three recent shipment experiences (most recent, second most recent, and third most recent) were highly correlated with one another, and thus only the most recent one remains in the model. Most recent, general, average perception, and maximum perception shipment times are selected as variables in the model. Thus, the model in Equation (4.6) has been re-written as Equation (4.7).

$$E(st) = A \cdot (w_1 st_1^{\alpha} + w_{gen} st_{gen}^{\alpha} + w_{ave} st_{ave}^{\alpha} + w_{\max} st_{\max}^{\alpha})^{\frac{1}{\alpha}} + C$$
$$\sum_{i=1}^{n} w_i = 1 \qquad (4.7)$$

4.7 Model Specification and Discussion

After testing correlations among the explanatory variables in order to avoid problems like multicollinearity among the variable sets, and after fitting several models, one model of the five routes in Table 4.4 is presented. Convergence calculation was conducted using SPSS 18.0 to estimate the parameters of the nonlinear regression model presented in Equation (4.7).

Table 4.4 Expected Shipment Time Model

	VTE-LCB[a]	SAV-LCB[b]	SAV-HAI[c]	VTE-HAI[d]	VTE-DAN[e]
Parameter (α)	0.432 (2.46[*])	0.331 (2.37[*])	2.698 (4.35[**])	6.741 (2.67[**])	18.011 (2.43[*])
Scale parameter (A)	0.332 (1.68)	0.471 (2.23[*])	0.573 (2.89[**])	1.388 (2.54[*])	2.969 (2.34[*])
Constant (C)	4.439 (3.67[*])	11.253 (3.71[**])	10.023 (5.12[*])	10.023 (4.34[**])	-0.885 (3.12[**])
Most recent ST[f] (w_1)	0.014 (2.12[*])	0.035 (1.64)	0.046 (2.24[*])	0.196 (1.91)	0.248 (2.11[*])
General ST (w_{gen})	0.005 (1.88)	0.054 (1.79)	0.136 (2.34[*])	0.190 (2.43[*])	0.200 (2.87[**])
Average perception ST (w_{ave})	0.978 (3.87[**])	0.838 (2.23[*])	0.699 (2.56[*])	0.433 (2.18[*])	0.329 (2.25)[*]
Maximum perception ST (w_{max})	0.003 (1.78)	0.073 (2.10[*])	0.119 (2.19[*])	0.181 (2.21[*])	0.223 (1.81)
R^2	0.711	0.583	0.767	0.673	0.591
Sample number	37	36	22	20	20

Coefficient (t-value)
[a]Vientiane to Laem Chabang
[b]Savannakhet to Laem Chabang
[c]Savannakhet to Hai Phong
[d]Vientiane to Hai Phong
[e]Vientiane to Da Nang
[f]Shipment time
[*]Significant at the 5% level
[**]Significant at the 1% level

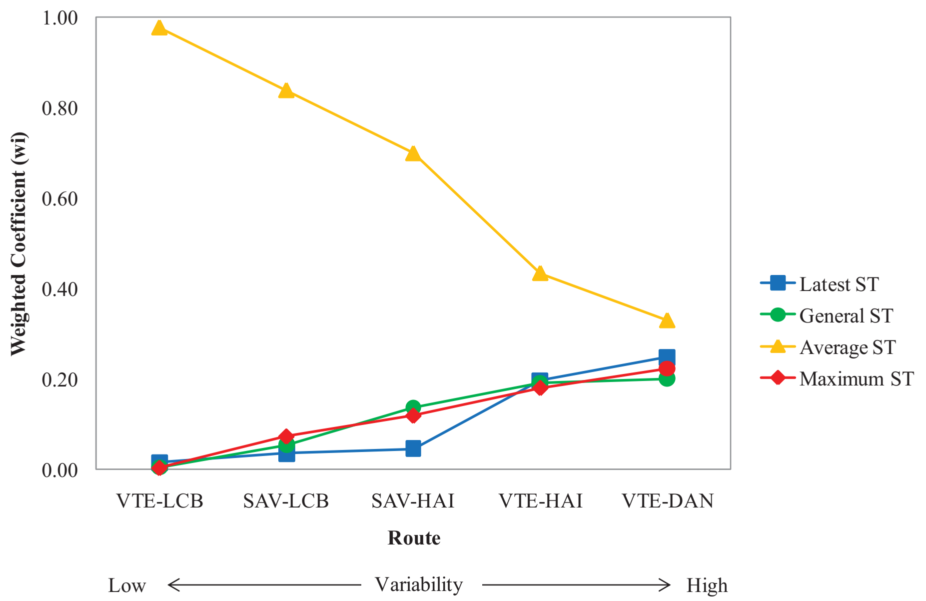
Several significant trends are found among the five routes (Table 4.4) for verifying proposed hypothesis addressed in section 4.2. The coefficient for average perception shipment time in any route receives the highest value among all of the coefficients. From this result, it can be inferred that average perception shipment time is the most important factor in estimating expected shipment time at any level of variability. As shipment time variability increases, the coefficient of average perception shipment time decreases, as graphically shown in Figure 4.2. This implies that on highly variable routes, one information source, average perception shipment time, is not sufficient for estimating expected shipment time. Instead, other shipment times become relatively more important for inferring the expected shipment time on highly variable routes. From the set up hypothesis point of view, we can also understand that average perception time is primary used as inferring expected shipment time. In comparatively high reliable route, one information source, which is average perception shipment time, is enough, however, Other shipment time gradually increase its importance for estimating next shipment time. Here, we should interpret that in highly variable route, one information is not enough to explain shipment time estimation since several types of shipment time are gradually increasing its weight. Thus, hypothesis is verified as true. In other words, as shipment time gets higher variability, shippers need more information sources since the confidence level for shipment time estimation is low.

The trends of two coefficients, the most recent and maximum perception shipment times, are as expected. The most recent shipment time is obviously less important in less variable routes than more variable routes. In less variable routes, shipment time is stable. In this case, the most recent experience is not always necessary. The high coefficient for maximum shipment time in more variable routes is also the proper result. Because logistics companies hate to be late to their destination, they tend to put more importance on maximum perception shipment time than companies on less variable routes.

Regarding general shipment time, which is highly correlated with minimum perception shipment time, we can postulate that general shipment time would become a somewhat more important factor as shipment time variability decreases. This is because shipment time on less variable routes is closer to free-flow shipment time, which is the minimum shipment time. This means that general shipment time would be expected to decrease as variability increases. However, Figure 4.2 shows the opposite result. Among the four shipment times in the model, general shipment time is the only shipment time that is not based on past experience. It can be inferred that logistics companies rely on the time schedule rather than experience because estimating shipment time is difficult for highly variable routes.

In addition to shipment time variability, the frequency of shipment might also affect the estimation of shipment time. For example, we obtained unexpected results for general shipment time: dependency on general shipment time increases as variability increases. From the viewpoint of frequency, because general shipment time is indicated in the timetable, dependency on general time increases as frequency decreases. In lower frequency routes, average perception shipment time is not relied on for estimating shipment time because of insufficient shipment experiences. However, in high-frequency routes perception time might be reliable because of the large number of previous experiences.

Thus, shippers rely on their own perception time rather than the time schedule, most recent experiences, and maximum perception shipment time, particularly in the highly variable routes. Parameter α increases as variability increases. This trend shows that a relatively long shipment time is weighted in the highly variable routes. Thus, it can be postulated that decision makers are somewhat risk averse when it comes to estimating expected shipment time toward risk of delay. The constant value is somewhat high in three routes (SAV-LCB, SAV-HAI, and VTE-HAI). The constant terms in this non-linear regression analysis is regarded as the set of unobserved factors in the model. Therefore, relatively high constant terms that are more than 10, imply that there might be high interpretability of factors which are not included in the model. In order to develop robust model in this case, one needs to modify the model, for example, adding or excluding variables, introducing interaction terms, etc. However, the model in this chapter is developed for the objective of comparing weighted factors across the routes. Thus, we admit that there is further potential improvement of the model robustness and finally specify the model presented Table 4.4. The coefficient of determination (R^2) of the model is high enough to explain expected shipment time. The R^2 of the Savannakhet to Laem Chabang model is somewhat smaller than those of the other models. Nevertheless, it is not too low to reject the robustness of the model.



ST, shipment time
VTE-LCB, Vientiane to Laem Chabang
SAV-LCB, Savannakhet to Laem Chabang
VTE-HAI, Vientiane to Hai Phong
SAV-HAI, Savannakhet to Hai Phong;
VTE-DAN, Vientiane to Da Nang

Figure 4.2 Result of Estimated Weighted Coefficient

In theory of generalized mean concept, as α increased, the weighted coefficient of maximum value (in this model, maximum shipment time) in the model would get to be high. However, as a result of the parameter estimation, the highest weighted coefficient is on average perception shipment time, not maximum perception shipment time. Here, maximum perception shipment time is meant the shipment time occurring due to the event which rarely occurs by unusual event such as an accident causing very long shipment time. The values of α in the two highest variability routes (VTE-HAI and VTE-DAN) are comparatively larger than those of other routes. However, maximum perception shipment time receives relatively small weight. We interpret such trend as that maximum shipment time does not regarded as very important due to the its rareness of the occurrence in any five routes. Instead, we interpret as average shipment time which is second largest value is regarded as important. Focusing only on the relationship between maximum shipment time and parameter α, as variability increases, both parameters also increase, which is consistent with the theory. Considering all above factors, we conclude that maximum perception shipment time is the shipment time occurred by sudden unexpected accident and it does not regarded as very important. Even though Maximum perception shipment time is rather higher than other three shipment times, which are relatively similar magnitude, maximum perception shipment time receives relatively large weight. This is interpreting due to the high value of α. In case simple multiple regression model, which will be presented following and excluding α, simple regression model receives higher weight in the highest route.

Table 4.5 Expected Shipment Time Model by Multiple Regression Model

	VTE-LCB	SAV-LCB	SAV-HAI	VTE-HAI	VTE-DAN
Most recent ST (w_1)	0.010 (2.43*)	0.037 (2.10)	0.045 (2.54*)	0.185 (2.21)	0.234 (2.51*)
General ST (w_{gen})	0.007 (2.15)	0.057 (2.03)	0.142 (2.87*)	0.183 (2.76*)	0.198 (2.99**)
Average perception ST (w_{ave})	0.966 (4.64**)	0.823 (2.57*)	0.663 (3.15*)	0.411 (2.49*)	0.297 (2.24)*
Maximum perception ST (w_{max})	0.017 (2.35)	0.083 (2.54*)	0.150 (2.41*)	0.221 (2.32*)	0.271 (2.91)
Constant (C)	4.612 (3.54*)	12.091 (3.34**)	10.321 (5.00*)	10.531 (4.21**)	-2.182 (3.67**)
R^2	0.710	0.591	0.756	0.664	0.592
Sample number	37	36	22	20	20

In order to certify the trend of weighted coefficient, multiple regression analysis is implemented using following model (4.8) and confirms that the trend obtained from multiple regression models is almost identical to generalized mean model. The results are shown Table 4.5.

$$E(st) = w_1 st_1 + w_{gen} st_{gen} + w_{ave} st_{ave} + w_{\max} st_{\max} + C$$
$$\sum_{i=1}^{n} w_i = 1 \tag{4.8}$$

4.8 Chapter Conclusion

In all of the routes, average perception shipment time received the highest weight among the four types of shipment time. Because average perception shipment time is based on past shipping experiences, past shipment experiences clearly influence the estimation of expected shipment time. Nevertheless, recent shipment experiences do not significantly affect the estimation of expected shipment time, particularly for less variable and higher frequency routes. In particular, recent experience is not an important factor in estimating expected shipment time in low-variable routes. It can be postulated that shippers basically make their decisions about shipment time on their rich shipment experiences. In this study, data were collected from interviewees who experienced a high frequency of shipments (1.40-5.43 shipments/month). The frequency of shipments might also affect the weighting of each shipment time in estimating the expected shipment time. As frequency decreases, the importance of general shipment time and recent shipment experiences increases.

The results of this study also imply that general shipment time might not be suitable for estimating the generalized cost of cross-border haulage in LLDCs. Generalized cost is used for route choice models that are often used for cargo flow simulation. General shipment time is normally shorter than average perception time. Thus, there is a possibility of underestimating the generalized cost of LLDC cross-border haulage.

We can also understand that average perception time is primary used as inferring expected shipment time. In comparatively high reliable route, one information source, which is average perception shipment time, is enough, however, other shipment time gradually increase its importance for estimating next shipment time. Here, we should interpret that in highly variable route, one information is not enough to explain shipment time estimation since several types of shipment time are gradually increasing its weight. Thus, hypothesis is verified as true. In other words, as shipment time gets higher variability, shippers need more information sources since the confidence level for shipment time estimation is low.

CHAPTER 5

VALUATION OF SHIPMENT TIME VARIABILITY

5.0 Introduction

This chapter lays out the process of the valuation of shipment time variability of the cross-border transport activities of GMS region. It is organized into 6 sections. The first section addresses the literature review related to the method for valuation of shipment time variability. In this research field, most of those are related to people's transport activity, and application to freight transport field is limited. Thus, literature review has been done with mostly non-freight transport issues. However, fundamental idea to tackle with this issue is basically same. The second section discusses the formulation for utility function which estimated marginal utility, which shall be the parameter of several values specification taking marginal rate of substitution. The third section presents the design of Stated Preference (SP) questionnaire survey in Vientiane, Bangkok, and Hanoi with freight forwarders. As mentioned in chapter 4 section 4.2, data collection is done with freight forwarders. This questionnaire survey was taken place simultaneously with interview survey in section 3.3 of chapter 3. The fourth and fifth sections illustrate model specification and discussion on the basis of estimated outcomes. The chapter concludes with the explanation of the significant findings. The work flow diagram of this chapter is shown in Figure 5.1. As can be understood from Figure 5.1, this chapter is a part of inland cargo flow model which fulfills objective 3 and 4.

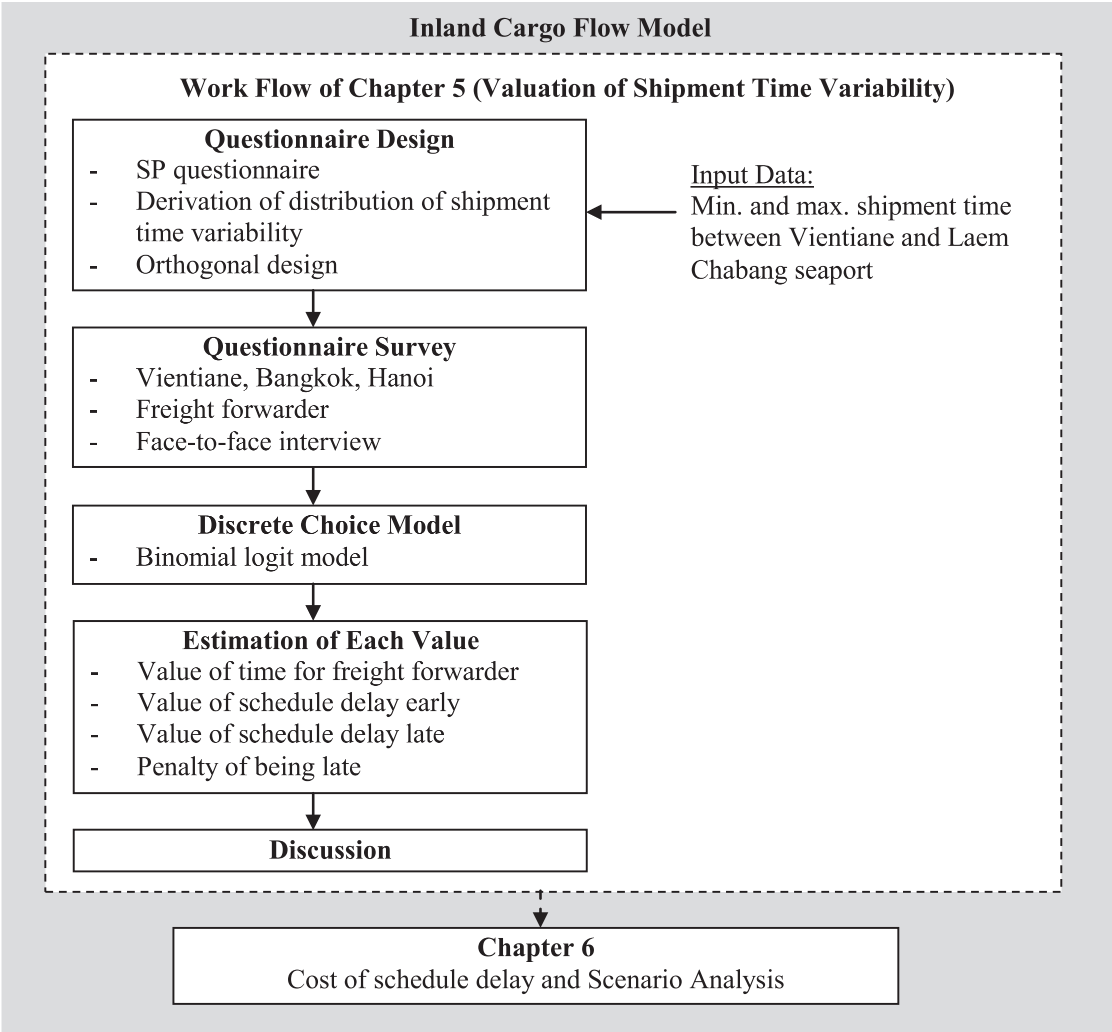


Figure 5.1 Work Flow Diagram of Chapter 5 in Inland Cargo Flow Model

5.1 Literature Review

5.1.1 Valuation on Travel Time Reliability

Within the field of transport economics, the impact of unreliability is often in regard to travel time. Of course, there are other aspects of the transport phenomena which may be the cause of unreliability. For example, according to Bates *et al*. (2001), whether or not it is possible to gain a seat on a crowded train, whether or not a buffet service will be provided and adequately stocked, etc. Nevertheless, the most usual reference of reliability is to possible late arrival, spending longer in certain activities than expected, as well as the stress associated with uncertainty itself. The cause of travel time unreliability is mostly due to the congestion. In this dissertation, cause of unreliability is to be defined as two bottlenecks such as border and seaport. The concept of shipment time variability refers to the freight forwarders inability to forecast how long their shipment will last. Following Bates (2001), shipment time is defined as variable when random factors may have an impact on the duration of the shipment in such a way that actual arrival time does not coincide with the desired one. In general, one needs to estimate marginal utilities that are base parameter for valuation of shipment time variability so that schedule delay early and late due to shipment time variability converts to cost. In this dissertation, such cost is called as schedule variability cost, being marginal cost of freight forwarders against extent of shipment time distribution.

5.1.2 Mean-Variance Approach

For the valuation of shipment time variability, there are three approaches used in general. First approach is called mean-variance approach. This approach does not differentiate how long he/she arrives at destination earlier or later to their Preferred Arrival Time (PAT). According to several literatures (Bates *et al.*, 2001; Lam and Small, 2001; Small *et al.*, 2005), this model simply depicts the “inconvenience” of the shipper due to the shipment time variability. Shipper’s utility is determined by several variables such as shipment cost, average shipment time, and shipment time variability, as the simplest structure. The indicator of shipment time variability is often expressed by several values, such as standard deviation and percentile values. In general, standard deviation is more widely used. In this model, value of variability can be estimated taking marginal rate of substitution of the parameters with respect to cost and standard deviation parameter. In practice application, particularly big project, mean-variance approach has inevitably widely been applied due to its easiness and clearness of the analysis method. In Netherlands, the benefit brought by increase in travel time reliability is expected to be incorporated into the guideline of the Cost Benefit Analysis (CBA). Nevertheless, the rationale of micro economics for use of statistical measure such as mean and standard deviation of the shipment time distribution for the parameter of utility function is not clearly clarified. In short, mean-variance approach is the method on the basis of the view of supply side since how long he/she arrives at destination earlier/later is not accounted. The utility of shipper can be formulated as Equation (5.1) as basic formula to mean-variance approach. Shipper’s utility is dependent on shipment cost C, average shipment time ET, shipment time variability σ_T.

$$U = \delta C + \alpha ET + \rho \sigma_T \tag{5.1}$$

where δ, α, and ρ are marginal utility of shipment cost, time, and its variability, respectively. Value for travel time variability can be estimated taking the marginal rate of substitution obtained from Equation (5.1) as following Equation (5.2) and (5.3), respectively.

$$\text{Value of Travel Time Variability} = \frac{\rho}{\delta} \tag{5.2}$$

$$\text{Value of Travel Time} = \frac{\alpha}{\delta} \tag{5.3}$$

The mean-variance approach is not suitable to apply to this dissertation purpose. As mentioned, mean-variance approach does not distinguish between late arrival and early arrival. However, particularly in the field of transport logistics, the impact of late arrival and early arrival is totally different. In general, late arrival receives more adverse impact on the disutility of individuals. Therefore, it is required that the model which can express the asymmetry of their values.

5.1.3 Scheduling Approach

The second approach for valuation of shipment time variability is scheduling approach. Scheduling approach is formulated under the assumption of that shipper who has PAT (shipper with time constraint) make a decision on departure time so as to minimize their disutility considering shipment time variability (Bates *et al*., 2001; Noland and Polak, 2002; Noland and Small, 1995). Shipper's utility is determined by shipment cost, shipment time, schedule delay late, and schedule delay early. Regarding to the last two terms, schedule delay late and early will be explained in detail. These affects on departure time choice. In general, piecewise linear function is used to visualize schedule delay as shown in Figure 5.2. The magnitude of schedule delay late is normally larger than that of early in several experimental results (Bates *et al*., 2001; Noland and Polak, 2002; Noland and Small, 1995). The typical model for scheduling approach is formulated in Equation (5.4). SDE denotes schedule delay early, defined as Max(0, PAT-[t_h+$T(t_h)$]), whereas SDL denotes the schedule delay late defined as Max(0, [t_h+$T(t_h)$]-PAT) where t_h is departure time and $T(t_h)$ is shipment time between t_h and PAT. Ignoring the pure disutility due to shipment time T, the remaining contributes to utility, which we may refer to as "schedule disutility". At the earliest departure times considered, the traveler arrives too early, and suffers disutility as a result of non-zero values of SDE. As t_h increases, this disutility declines up to point where the traveler arrives exactly at his PAT, thus at this point t_h=PAT-$T(t_h)$. Immediately thereafter, the traveler will arrive late, and the disutility jumps up by the value of θ (Figure 5.2). As the value of t_h increases, SDL contributes increasingly to disutility which is to be expected that the coefficient γ is greater in absolute value than β since people will normally prefer to arrive earlier than late.

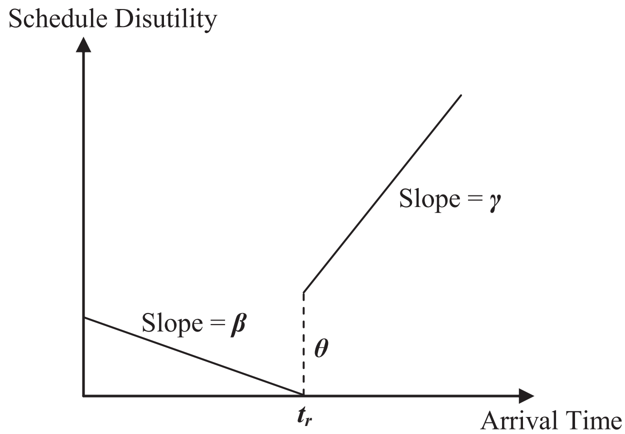


Figure 5.2 Typical Schedule Disutility

Noland and Small (1995) extend the model to departure time choice under travel time variability. In this framework, value of schedule delay early and late are obtained by dividing each marginal utility with respect to cost. This approach is consistent with axioms of micro economic theory because the outcome of individual's behavior, such as early arrival, late arrival, and travel time, is included as parameter in utility function (Fukuda 2010). In general, the utility of the shipper is determined based on the factors of shipment cost (*C*), shipment time (*T*), schedule delay early (*SDE*), and schedule delay late (*SDL*) as the simplest form. In case of shipment time can be regarded as random variable, scheduling approach can be treated as maximization problem of expectation utility of the shipper. The utility function can be expressed as Equation (5.4).

$$EU = \delta C + \alpha ET + \beta E(SDE) + \gamma E(SDL) + \theta P_L \tag{5.4}$$

P_L is denoted as penalty of being late, which is incorporated into the model in order to expand the difference between the value of schedule delay early and late. As indicated in the section of mean-variance approach, value of each shipment time variability can be estimated taking marginal rate of substitution as following equation (5.5), (5.6), (5.7) and (5.8).

$$VT(ST) = \frac{\alpha}{\delta} \tag{5.5}$$

$$VT(SDE) = \frac{\beta}{\delta} \tag{5.6}$$

$$VT(SDL) = \frac{\gamma}{\delta} \tag{5.7}$$

$$VT(PEN) = \frac{\theta}{\delta} \tag{5.8}$$

The penalty of being late is not marginal value since it is imposed no matter the scale of late arrival. In this way, two values related to shipment time variability can be specified. In the mean-variance approach, values between marginal value of schedule early and late are not distinguished because indicator to express shipment time variability is simply standard deviation of distribution of travel time variability, which is based on statistical measurement. Because this dissertation considers each individual's behavior, the distinguishing between early and late arrival is necessary in order to estimate more accurate schedule variability cost. In this reason, scheduling approach is preferable comparing to mean-variance approach.

5.1.4 Integrated Approach

In addition to mean-variance and scheduling approach, another approach is recently developed by Fosgerau and Karlstrom (2007) and Fosgerau and Fukuda (2008). This approach is called integrated approach. The background behind to build integrated approach is mainly two reasons. First one is the lack of rigorous theoretical background on mean-variance approach although practical application is relatively easier due to its simplicity. The mean-variance approach includes the statistical measurement of travel time variability using standard deviation into the utility function. Another reason is difficulty in data collection and a doubt on the assumption on distribution of travel time variability in regard to scheduling approach. However, the utility on scheduling approach is determined by early arrival or late arrival. In that scene, integrated approach can be regarded as complemented model of each approach.

Integrated approach is expansion of Noland and Small (1995) and prove that shipper's maximum expectation utility under any type of distribution of travel time is to be resulted in form of mean-variance approach. Initial utility function is formulated by scheduling approach. At this moment, traveler's PAT is not explicitly stipulated. Besides, because formulation is simple mean-variance type, practical application is relatively easier. The traveler's PAT is standardized to be "0". The utility is determined by actual travel time (T) and departure time ($-d$). Based on actual travel time and the magnitude of early arrival and late arrival, the utility function is specified as Equation (5.9).

$$U(d,T) = \eta D + \omega T + \lambda (T - D)^{+} \tag{5.9}$$

According to Fukuda (2010), the interpretation of each term of Equation (5.9) are first term: disutility due to early departure anticipating shipment time variability, second term: disutility due to shipment time itself, and third term: disutility due to late arrival to PAT. $(T\text{-}d)^{+}$ is equivalent to time of late arrival, returning value of late arrival if positive value, otherwise, 0. The η, λ, and ω are parameters expressing marginal utility of each variable. This model is reformulation of Equation (5.4). In this case, the relationships of $\eta=\beta$, $\omega=\alpha-\beta$, $\lambda=\beta+\gamma$ are established (Fosgreau *et al.*, 2008; Fosgreau and Karlstrom, 2010).

5.2 Model Formulation

In case treating the problem on travel time variability, several terminologies, such as "variability", "reliability", "regularity", "punctuality" are frequently used alternatively (Takahashi, 2010). Particularly in case of economic evaluation, the expression of "travel time reliability" is frequently appeared in several papers because primary unit is often expressed as "Value of Reliability". The "punctuality" is mainly used for evaluation of public transport service such as bus and railway. In this dissertation, the target is not passenger transport, but freight transport. In addition, the primary problem of the dissertation is additional cost induced by the variability of shipment time. Thus, "shipment time variability" is used for expressing primary unit for economic evaluation in this dissertation. Besides, "shipment time reliability" is used as an antonym of shipment time variability. However, one needs to pay attention to its treaty. The high shipment time variability is equivalent meaning to low shipment time reliability. Similarly, the low shipment time variability is indicating the high shipment time reliability.

This chapter covers a part of inland cargo flow model development. In several simulation model of international cargo flow (i.e. Shibasaki and Watanabe, 2008), shipper is treated to be a main player of international freight transport market, whose behavior is focused on for modeling. This dissertation focuses on shipper's behavior, however, it can be often observed that haulage-related decision making such as route choice and departure time choice are dependent upon freight forwarders. This type of phenomena can be observed particularly in developing countries like Lao PDR. Therefore, decision maker related to cross-border haulage in GMS region is set as freight forwarder in this dissertation. Route choice decision process is specified with a logit model. Under random utility theory assumptions, the deterministic component of the utility function for forwarder *i* when choosing alternative *j* is based on schedule delay function and can be expressed as Equation (5.10)

$$\begin{aligned} V_{ij}(d) &= V(C_{ij}, ST_{ij}, SDE_{ij}, SDL_{ij}, P_{Lij}) \\ &= \delta C + \alpha E(ST_{ij}) + \beta E(SDE_{ij}) + \gamma E(SDL_{ij}) + \lambda P_{Lij} \end{aligned} \tag{5.10}$$

C_{ij}: Monetary cost of the alternative *j* for freight forwarder *i*
ST_{ij}: Average shipment time of the alternative *j* for freight forwarder *i*
SDE_{ij}: Schedule delay early of the alternative *j* for freight forwarder *i*

SDL_{ij}: Schedule delay late of the alternative *j* for freight forwarder *i*
P_{Lij}: Penalty of being late of the alternative *j* for freight forwarder *i*

Monetary cost is the variable which is all expenses for alternative *j*. Shipment time is the average time required for alternative *j*. Schedule delay early and schedule delay late are variable which is explained in section 5.1.4. Penalty of being late is the variable which is introduced in order to expand the asymmetry of disutility between schedule delay early and late. Penalty of being late captures additional impact on utility, which is independent from the magnitude of the delay. The model is structured as simple as possible following axiom of Occam's razor which implies us that in order to explain matters being interested in, one does not need to assume more than needed. Thus, variables only needed for estimating schedule variability cost are included in the model. The expectation operator $E(\cdot)$ is applied to the shipment time, schedule delay early, and schedule delay late because shipment time can be regarded as random variable in such route in this study area. As Arvis (2007) mentioned, shipment time of the cross-border transport in developing country is characterized by lognormal distribution. In this context, scheduling approach can be treated as expected utility maximization problem. Binomial logit model is applied to estimate the parameters. All explanatory variables are expressed as the difference between their values in route A and B, which are both hypothetical routes in SP context. As mentioned before, taking marginal rate of substitution, each value for shipment time variability can be estimated as Equations (5.11), (5.12), (5.13), and (5.14). P_L is expressed as 0-1 without unit. Since λ is disutility of late arrival, marginal utility of λ and shipment cost C is defined as willingness to pay for avoiding disutility of being late. The unit of PEN is USD/TEU since the unit of shipment cost C and λ are USD/TEU and nothing, respectively.

$$VT(ST) = \frac{\alpha}{\delta} \tag{5.11}$$

$$VT(SDE) = \frac{\beta}{\delta} \tag{5.12}$$

$$VT(SDL) = \frac{\gamma}{\delta} \tag{5.13}$$

$$PEN = \frac{\lambda}{\delta} \tag{5.14}$$

In the concept of scheduling approach, it is assumed that among the available departure time, it is chosen so as to maximize the utility of Equation (5.10). In case departure time is chosen earlier time as usual, disutility due to decrease in time for non-shipment task. However, this disutility is ignored in scheduling approach (Small *et al.*, 2001). This study follows the idea of scheduling approach for specifying utility function. Here, it is assumed that the distribution of arrival time is independent from departure time. Thus, the distribution of arrival time is identical in regard to choosing any departure time.

5.3 SP Questionnaire Survey

5.3.1 Estimation of Shipment Time Distribution

In the questionnaire, two routes are presented to respondents. Respondents are asked to choose one of them, which maximize their satisfaction. Each route (alternative) consists of five scenarios with respect to arrival time. Five scenarios are obtained from 1st, 3rd, 5th, 7th, and 9th deciles of the distribution of shipment time variability. Let each i^{th} deciles denote t_i (i=1, 3, 5, 7, 9). As mentioned in previous section 5.2, shipment time from LLDC to seaport in coastal country can be regarded as random variable following lognormal distribution. Thus, t_i should be extracted from the distribution of shipment time variability which is characterized by lognormal distribution. The characteristics values, mean (1st moment) and variance (2nd moment) of lognormal distribution of shipment time variability is specified by steps shown in Figure 5.3.

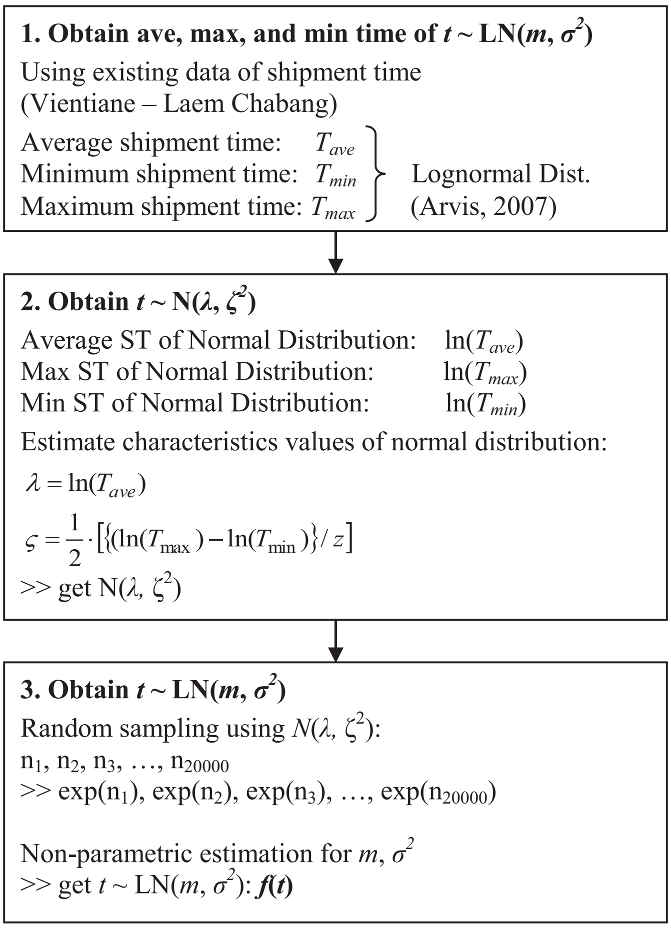


Figure 5.3 Steps to Obtain 1st and 2nd Moments of Lognormal Distribution

Firstly, using the results of survey on shipment time between Vientiane and Laem Chabang seaport for the best and worst cases (Banomyong, 2000), average, minimum, and maximum shipment time required for this route are obtained. These extracted shipment time with natural logarithm are assumed to be corresponded to minimum and maximum time within a range of 99.7% of standard normal distribution shown in Figure 5.4. In this case, standard deviation of normal distribution can be obtained by Equation (5.15) (Ang and Tang, 1975).

$$\sigma = \frac{1}{2}\left\{\frac{\ln(ST_{mac}) - \ln(ST_{min})}{z}\right\} \tag{5.15}$$

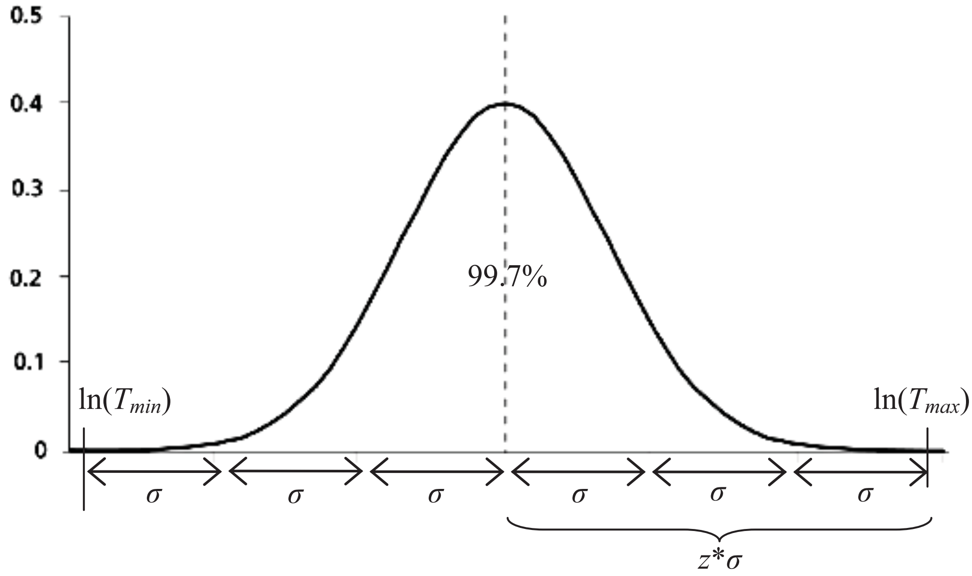


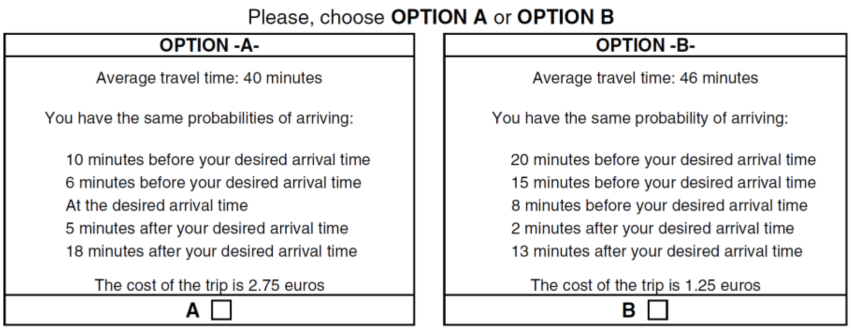
Figure 5.4 Concept of Minimum and Maximum Time in Standard Normal Distribution

The value of z equals to 3 because it is assumed that extracted maximum and minimum values are corresponded to maximum and minimum within 99.7% range. 1^{st} and 2^{nd} moments of the normal distribution can be estimated using relationship showing Equation (5.16) or (5.17)

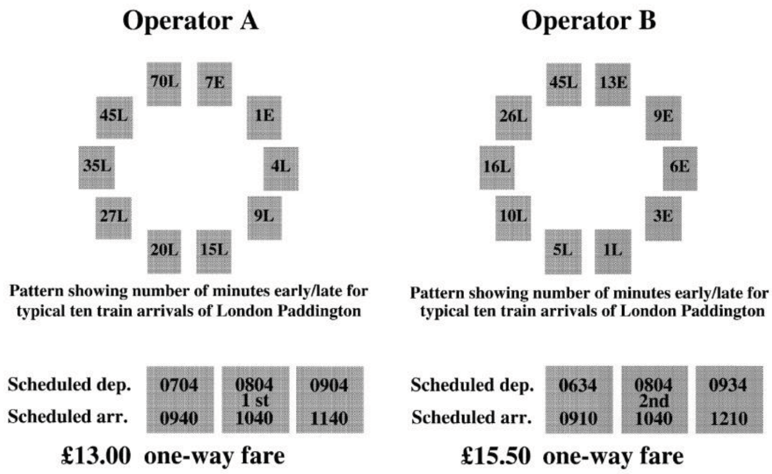
$$\ln(ST_{min}) = \mu - \sigma \tag{5.16}$$

$$\ln(ST_{max}) = \mu + \sigma \tag{5.17}$$

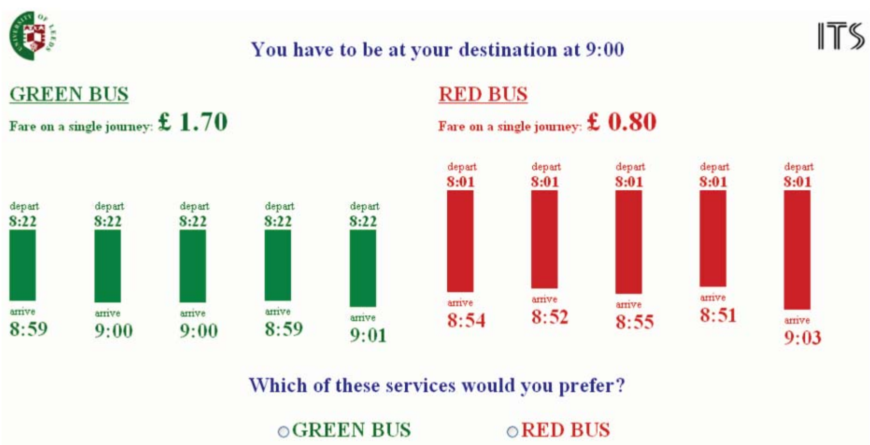
Secondly, 20,000 samples are randomly extracted from the obtained standardized normal distribution. The generated samples are returned into an antilogarithm taking and exponential function. Because these returned samples follow lognormal distribution in theory, 1^{st} and 2^{nd} moments can be estimated non-parametrically. This method would be useful for the specification of shipment time variability in LLDCs where few data and little information are available. In this method, interview survey is only required to obtain input values. This implies that this method is applicable enough in other LLDCs.



(i) Text format (Asensio and Matas, 2008)



(ii) Clock panel format (Bates *et al.*, 2001)



(iii) Bar graph format (Hollader, 2006)

Figure 5.5 Presentation of SP Questionnaire

Regarding the type of graphical design of questionnaire form for illustrating shipment time variability, several ways have been attempted. For example, clock-format and bar-chart designs are used as shown in Figure 5.5. As a result of several attempts, simple text format would generate the least errors and mistakes by respondents (Bates *et al.*, 2001). Therefore, text format is applied to present the choice sets of the questionnaire survey in this dissertation.

5.3.2 SP Questionnaire Design

This section provides details about the design of the stated preference survey used to obtain the data needed for model calibration. The survey was carried out September 2010 in Vientiane and January 2011 in Bangkok and Hanoi. Freight forwarders were contacted in their offices where face-to-face interview survey was conducted. Freight forwarders were asked to complete the survey at that time. The survey on route choice questionnaire is consisted of a set of 18 choice questions, characterized by monetary cost, average shipment time, departure time, and shipment time variability. For each variable, six possible variables are considered referring survey result of Banomyong (2000). In this study, because inland transport which premises the maritime transport posterior or prior to inland transport, twenty feet container (TEU) is used for freight transport. Thus, unit is used as USD/TEU for shipment cost. Monetary cost and average shipment time variables are also related to the fact that in every choice scenario presented in the questionnaire, for example, the fastest alternative is also the most expensive. In this way, choices are developed as similar situation as possible to usual shipment of freight forwarders.

The level of values for average shipment time and cost were set six for each, referring to survey results of Banomyong (2001) for shipment time and cost in GMS region. For the early departure time, one value is that which would result in punctual arrival if there was no variability of travel times, while other five imply departing earlier. In this study, values themselves have six levels but three values for difference between scenario A and B. In this case, the full factorial of a stated preference experiment designed in this was has 3^3 scenarios which can be reduced to a fractional factorial of 18 scenarios (Louviere *et al.*, 2001). Table 5.1 shows the level of all variables used in the choices for each group. The differences between alternatives in terms of average shipment times, monetary costs, and early departure time only take three possible values, were used in the presentation of the characteristics of each alternative to avoid complexity.

Table 5.1 Scenarios for Questionnaire

	Route	Monetary cost	Average shipment time	Early departure	Distribution of possible shipment time				
Scenario 1	A	1700	14	5	12	13	14	16	18
	B	1400	19	2	16	17	19	21	24
Scenario 2	A	1900	16	2	14	15	16	18	20
	B	1300	24	7	20	22	24	28	32
Scenario 3	A	1700	16	5	14	15	16	18	20
	B	1400	24	5	20	22	24	28	32
Scenario 4	A	1700	12	2	10	11	12	13	15
	B	1400	23	7	19	21	23	26	30
Scenario 5	A	1900	12	0	10	11	12	13	15
	B	1300	23	3	19	21	23	26	30
Scenario 6	A	1900	14	2	11	12	14	16	18
	B	1300	19	2	16	17	19	21	23
Scenario 7	A	2100	12	0	10	11	12	13	15
	B	1200	23	3	19	21	23	26	30
Scenario 8	A	2100	14	3	11	12	14	16	18
	B	1200	19	0	16	17	19	21	23
Scenario 9	A	2100	16	0	14	15	16	18	20
	B	1200	24	3	20	22	24	28	32
Scenario 10	A	2100	12	4	10	11	12	13	15
	B	1200	23	4	19	21	23	26	30
Scenario 11	A	1900	14	2	11	12	14	16	18
	B	1300	19	2	16	17	19	21	23
Scenario 12	A	1700	14	0	11	12	14	16	18
	B	1400	19	0	16	17	19	21	23
Scenario 13	A	1700	16	0	14	15	16	18	20
	B	1400	24	3	20	22	24	28	32
Scenario 14	A	1900	16	5	14	15	16	18	20
	B	1300	24	0	20	22	24	28	32
Scenario 15	A	1700	12	2	10	11	12	13	15
	B	1400	23	2	19	21	23	26	30
Scenario 16	A	2100	16	7	14	15	16	18	20
	B	1200	24	2	20	22	24	28	32
Scenario 17	A	1900	12	5	10	11	12	13	15
	B	1300	23	0	19	21	23	26	30
Scenario 18	A	2100	14	2	11	12	14	16	18
	B	1200	19	7	16	17	19	21	23

Average shipment time is specified from distribution of shipment time variability. In the study area, shipment time is heavily variable. Therefore, freight forwarder possibly departs earlier in order to arrive at destination before arrival restriction time. Early departure time is set and formulating schedule delay (SD_i) which indicates arrival time variability from target arrival time, shown in equation (5.18).

$$SD_i = (d + t_i) - t_e - (d + st) \\ = t_i - t_e - st \tag{5.18}$$

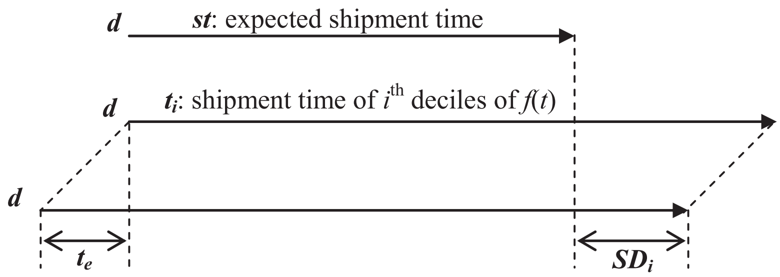


Figure 5.6 Relationship among *SD*, t_i, and *st*

t_i denotes shipment time including schedule delay extracted from shipment time variability following lognormal distribution. *st* denotes average shipment time. In case letting departure time be *d*, the point of *d*+*st* would be target arrival time, which is corresponding to t_a. If SD_i is positive value if the shipment is late arrival, otherwise, early arrival. In this way, SD_i is estimated five values for scenario setting. Referring to Small *et al.* (1999), model imputation values of *SDE*, *SDL*, and P_L are formulated as equation (5.19) – (5.21). K_i is dummy variable returning to 1 if shipment is late arrival, otherwise, 0.

$$SDE = \frac{1}{5}\sum_{i=1}^{5} SD_i \cdot (K_i - 1) \tag{5.19}$$

$$SDL = \frac{1}{5}\sum_{i=1}^{5} SD_i \cdot K_i \tag{5.20}$$

$$P_L = \frac{1}{5}\sum_{i=1}^{5} K_i \tag{5.21}$$

$$K_i = \begin{cases} 1 & SD_i > 0 \\ 0 & SD_i \le 0 \end{cases} \qquad (i = 1, \ldots 5) \tag{5.22}$$

In this study, the utility of Equation (5.10) is assumed to be changed as departure time is changed. In addition, since disutility due to early departure time is ignored in this study, the choice of departure time is not stipulated in questionnaire form as shown in Figure 5.7. Instead, the utility of *E*(*SDE*), *E*(*SDE*), P_L is considered for total utility of Equation (5.10) as changes of departure time. In this way, the consistency of the idea of scheduling approach and SP survey of this study is maintained.

ROUTE A	ROUTE B
Average shipment time: **23 hours** The shipment cost is **1,300 USD/TEU**	Average shipment time: **17 hours** The shipment cost is **1,500USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **8 hours early** - **6 hours early** - **4 hours early** - **2 hours early** - **5 hours late**	- **4 hours early** - **2 hours early** - **on time** - **5 hours late** - **8 hours late**
A ☒	**B** ☐

Figure 5.7 Presentation of Choice Set
(*see all choice sets in Appendix A)

5.3.3 Questionnaire Survey

Using SP questionnaire form developed employing the method showed till previous section, questionnaire survey has been conducted with freight forwarder including Third Party Logistics (3PL) by face-to-face interview survey, 5 companies in Vientiane, 31 companies in Bangkok, and 12 companies in Hanoi. The survey periods are 16th-22nd September, 2010 for Vientiane and 10th-14th January, 2011 for Bangkok, and 17th-20th January, 2011 for Hanoi. Valid answers are 860 and 4 invalid answers.

5.4 Specification of the Model

Using BIOGEME1.8 (Bierlaire, 2003), parameter estimation was conducted. In the analysis, correlation between variables was low. Thus, model can be regarded as robust in terms of variable correlations.

The results of parameter estimation and statistical test are shown in Table 5.2. The sign of the all parameters except constant value is negative, which is expected and reasonable result. The t-value is also high enough to satisfy statistical significance at 99% confidence level. Considering all above results, the reliability of specified model is high enough to obtain necessary values such as each value for shipment time variability.

Table 5.2 Result of Parameter Estimation

	Estimate	t-value
Monetary cost (δ)	-0.00311	-8.68
Shipment time (α)	-0.235	-7.08
Schedule delay early (β)	-0.806	-5.80
Schedule delay late (γ)	-1.34	-2.99
Penalty of being late (λ)	-3.67	-2.71
Constant	0.366	1.28
Null log likelihood	-596.107	
Final log likelihood	-491.608	
Likelihood ratio test	208.997	
Adjusted rho-square	0.165	
Sample number	860	

5.5 Results and Discussion

As mentioned before, each value of shipment time variability can be estimated by using the theory of marginal rate of substitution of the model. Estimated each value is shown in Table 5.3. The relationship of $VT(SDE)<VT(SDL)$ is expected result and matching with previously demonstrated results in several literatures (i.e. Small *et al*., 1999). Nevertheless, the difference of them is extremely large, which marginal value of late arrival is 5.7 times larger than normal value of shipment time. This implies that reduction in 1 hour late arrival is equivalent to reduction in 5.7 hours of shipment time in case the condition of late arrival is conserved. Because average shipment time between Vientiane and Laem Chabang is approximately 18 hours (Banomyong, 2001), 5.7 hours occupies approximately 30% of total shipment time. From the interview survey, it was implied that late arrival is totally unacceptable for freight forwarders, thus, huge difference between $VT(SDE)$ and $VT(SDL)$ is understandable result. Similarly, huge value of penalty of being late can be appropriate result.

Regarding to early arrival, this is a time which is not expected before the departure. Due to this reason, according to the interview survey, freight forwarders recognize that early arrival has more adverse contribution to shipment cost. Therefore, the relationship of is $VT(ST)<VT(SDE)$ also appropriate.

Table 5.3 Results of Each Value of Shipment Time

Value of Shipment Time	Estimated value (USD/TEU-hr)
Value of shipment time: *VT*(*ST*)	75.56
Value of schedule delay early: *VT*(*SDE*)	278.14
Value of schedule delay late: *VT*(*SDL*)	430.87
Penalty of being late: *PEN*	1,180.06 (USD/TEU)

In order to examine the reliability of parameters estimated based on SP data, it is preferable to calculate hit ratio using RP data. In this dissertation, SP questionnaire survey is conducted in Vientiane, Bangkok, and Hanoi. The freight forwarders in Bangkok and Hanoi chooses Laem Chabang and Hai Phong seaport, respectively and they are not in the situation to choose the route. Therefore, only seven forwarders in Vientiane are in the choice situation for seaport and RP data can be used. Out of seven forwarders, only four RP data were obtained. Thus, hit ratio is not calculated due to the low number of data.

In order to increase the reliability of parameters based on SP data, one needs to set the value of each attribute as appropriate value. For fulfilling this, they were set based on real data, and inspected by an expert of GMS logistics and confirmed the appropriateness of the values set. In addition, since the survey was conducted by face-to-face method, unclear point of the questionnaire form was properly explained to interviewee. Considering all above factors, the reliability of the estimated parameter might be relatively high.

5.6 Chapter Conclusion

In this chapter, the effect of shipment time variability on estimation of expected shipment time is examined by applying the model separately for five routes, which own different levels of variability. The applied model for this is on the basis of generalized mean concept and multiple regression model as a supplemental analysis. From the results, significant difference in trend for estimating expected shipment time variability is observed quantitatively.

The results imply that as variability of shipment time increases, the more information sources are needed for estimation of shipment time. In this case, it might be possible to conclude that logistics companies are suffered from variability because in general, it can be postulated that if the situation is very uncertain, people need more number of information sources. Vice versa, little information is sufficient to be relieved in case situation is stable.

CHAPTER 6

SCHEDULE VARIABILITY COST AND SCENARIO ANALYSIS

6.0 Introduction

This chapter explains the freight forwarders' behavior on cross border transport under the shipment time variability. The behavior is depicted on the basis of problems found up to chapter 3, several literature reviews and field surveys. The main objective in this dissertation is to develop inland cargo flow model considering shipment time variability for cross border freight transport and estimating impact of improvement in shipment time reliability, which is corresponding to chapter 5 to 7. Up to chapter 4, it had been showed that cross-border transport in developing countries is suffered from shipment time variability due to two bottlenecks; border and seaport. In chapter 4, it is implied that shipper's burden by shipment time variability is getting higher as shipment variability increases. Thus, such additional cost should be incorporated into the generalized cost of cross border transport. However, there has been no model so far proposed for route choice model.

As seen in literature reviews (chapter 2), seaport is also a cause of shipment time variability. For instance, dwelling time at Mombasa seaport in Kenya, being gateway seaport of Uganda, is much fluctuated. It sometimes requires more than 30 days (Arvis, 2007). Comparing the difference between maximum and minimum time required on the route between Vientiane and Laem Chabang seaport, it comes out that approximately 10 hours and 15 hours difference at the border and seaport, respectively (Banomyong, 2000). As seen in chapter 4, trucks can be operated at almost free-flow speed on the inter-city and -national road due to the low traffic volume. The fact that no big difference exists between the best and worst cases of the shipment time survey (Banomyong, 2000) can support this assumption is rational. Thus, shipment time would also be reduced if shipment time variability at the border and seaport is decreased. In this way, on cross-border route accessing to seaport, two bottlenecks hugely contribute on shipment time variability. In order to solve or alleviate problems related to shipment time variability in GMS, several facilitation plans have been launching such as single stop, common use of trucks, etc. Here, one need to develop inland cargo flow model considering characteristics mentioned above in order to quantitatively understand the impact of impact of several policies. In this field, MICS developed by Shibasaki and Watanabe (2009) is the representative model. The notable characteristic of this model is that interdependency between shipping lines and shippers is incorporated for seaport choice. Shipping lines are assumed to be in the oligopoly market, thus, calculation process is somewhat small. The cost of border crossing, they divide into two; such as "border resistance in narrow sense" and "border resistance in broad sense". In narrow sense, it is defined as resistance encountered in real border crossing point, on the other hand, in broad scene, it considers cost incurred at the stage of preparation of the shipment since large number of the documents are required particularly in the developing world. Border resistance is set by five grades which are determined based on the literature review and field survey. Subsequently, the estimated cost is included into the generalized cost of the haulage. However, this method does not explicitly include the shipment time variability which affects the route choice under heavily variable route. In this dissertation, inland cargo flow model is developed considering cost of shipment time variability which is estimated on the basis of objective input values such as shipment time. Using developed model, we will discuss how facilitation plans for cross-border transport have impact on reduction in shipment cost and cargo flow in the route between Lao PDR and seaports in Thailand/Vietnam.

6.1 Overview of the Model

6.1.1 Study Area and Target

In several international cargo flow simulation model (i.e. Shibasaki and Watanabe, 2009), model are developed focusing on shippers which is as one of the main players in international freight transport market. This study also focuses on the behavior of shippers as previous study done, however, decision making related to route choice and departure time choice is often seemed to be dependent upon freight forwarders particularly in developing countries like Lao PDR. Therefore, the term freight forwarder is denoted as decision maker of freight transport in this study.

The study range is within between LLDCs and large international market for example, US, Europe, etc. However, in this dissertation, the range of land transport which is prior or posterior to maritime transport from/to seaport under the condition of FOB as terms of trade is considered into the cost function. Maritime transport is very long travelling and thus, three designated seaport in this dissertation would not significantly affect on cost differences. Thus, they are treated as homogenous and consequently, this model is virtually regarded as seaport choice problem. In case of FOB, the seller (exporter) must bear the all cost and risks such as pilferage, damage on transported goods between the range of their departure point (i.e. warehouse, logistics center, …) until loading goods onto the vessel at seaport. Hereafter, buyer (importer) bears the all cost and risks of the shipment. Hence, this study focus on cross-border routes between departing warehouse or truck terminal of freight forwarders in Lao PDR until loading goods at the seaport in Thailand or Vietnam through one border as shown in Figure 6.1. The origins are set as four; Vientiane (VTE), Savannakhet (SAV), Luang Phabang (LPB), and Champassak (CPS) whereas the destinations are Laem Chabang seaport (LCB) in Thailand, Hai Phong (HAI), and Da Nang (DAN) seaport in Vietnam (see Figure 6.2). Here, in the case of import by Lao PDR, the origins and destinations are set as opposite.

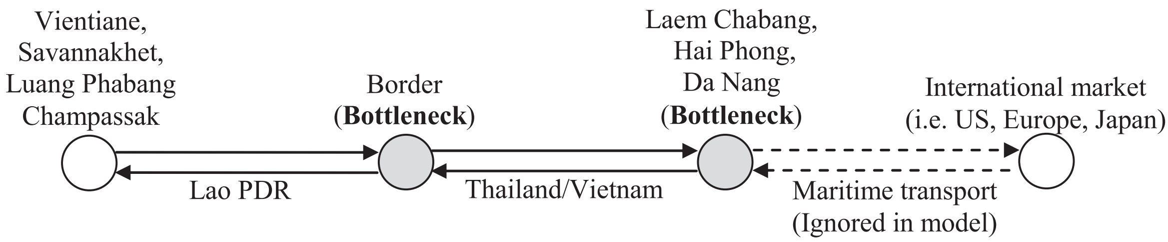


Figure 6.1 Study Range for Inland Cargo Flow Model

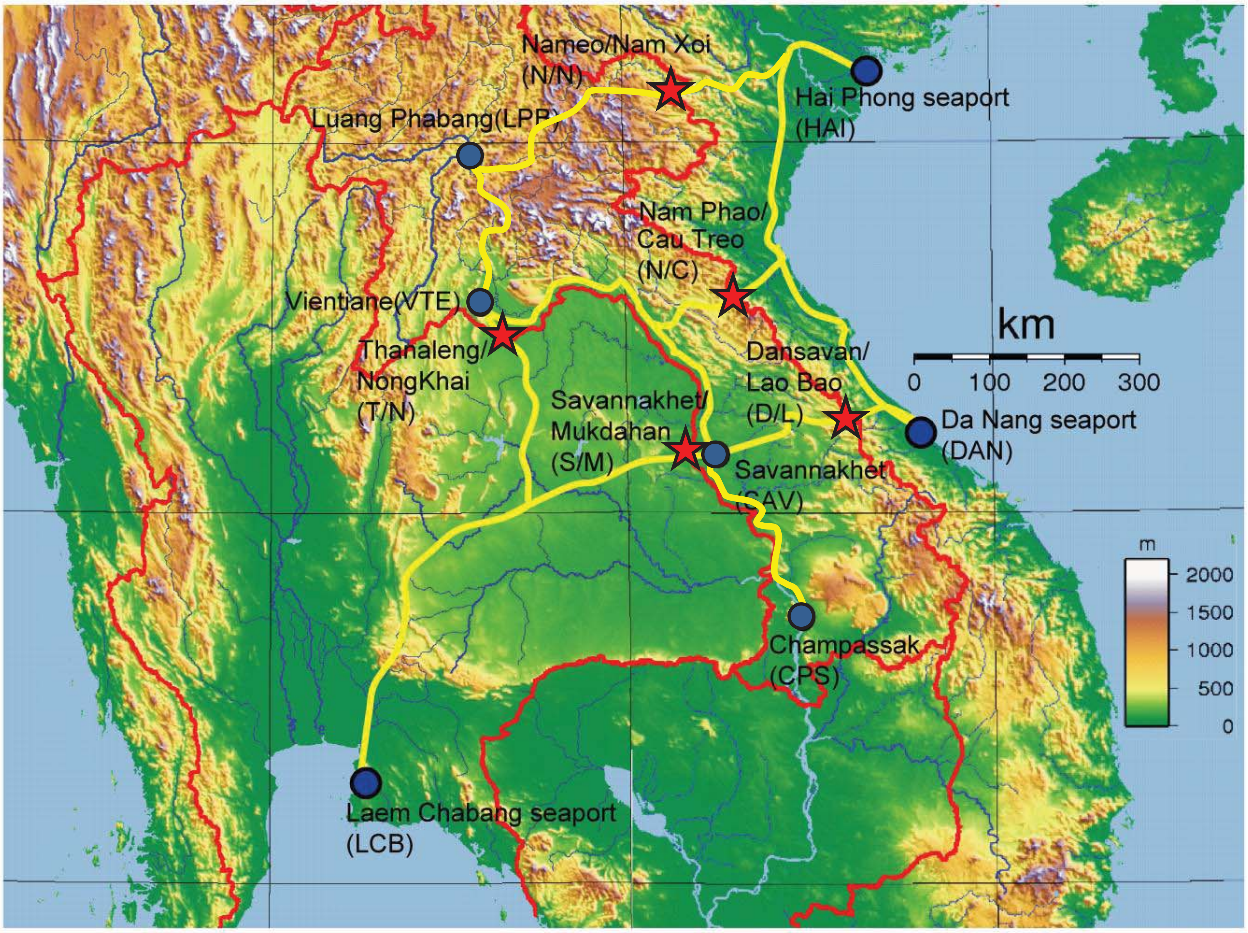


Figure 6.2 Road Network of Study Area

In real field of seaport accessing in developing world, normally only one route is possible choice for one seaport. Thus, route and seaport are chosen simultaneously. Consequently, this study is route choice problem on the basis of route choice, not link base choice problem. The inland cargo flow model will be developed between Lao PDR and seaport in Thailand or Vietnam as cargo volume of export and import using maritime transport prior or posterior to inland transport is given.

In the route between LLDCs and seaport in coastal countries, the common characteristic in terms of bottlenecks is basically shipment time variability exposed at border and seaport. The prominent point of this model is considering border and seaport as bottlenecks, which is basically applicable for other LLDCs. As for application for landlocked developed countries such as Switzerland, Austria, etc. mainly in European countries, since variability at border is very small or zero which implies that border resistance can be ignored, one needs to exclude the border variability term in the model. On the other hand, in LLDC having terrible political risk, like Central African Republic, shipment time variability is expected to be hugely apart from existing probabilistic distribution. In addition, according to Collier (2007), road condition from Central African Republic is extremely poor. For example, paved road is not almost available on inter-city and -national road. Thus, road is impassable during the rainy season. In such situation, shipment time variability would be generated on the link due to the poor road condition, and therefore, this model is no longer applicable in such case even the country is classified as LLDCs.

In this case study, all roads at all sections in Lao PDR, Thailand and Vietnam are the part of Asian Highway (AH). Therefore, huge delay due to the reason of insufficient road condition is not highly expected. In the field survey in Lao PDR, trial run is conducted on the part of AH 12. Some of the holes had been found in the road of AH 12. However, roads are paved and uncongested. Thus, the delay which significantly affects on shipment time variability can be assumed to occur. As for shipment time variability at bottleneck, although no statistical data exists, 45 interviewed companies (88.2%) out of 51 companies answered that border variability is the problematic based on survey in Chapter 3. Regarding the variability at seaport, number of companies pointed out is decreased up to 38 companies (74.5%). Considering all above factors, it can be concluded that the model is applicable to Lao PDR. Based on the interview survey, the border crossing from/to Lao PDR is recently not very tough comparing to other LLDCs. This can be also understood comparing to shipment time at the border in East Europe, South America, and Africa. These data are based on Arvis *et al*. (2007). This relatively easiness border crossing might be due to the contribution of recent effort such as Cross Border Trade Agreement and infrastructure development.

Besides, this model is applicable to countries which have no accessible seaport within the countries. In such countries like East Timor, Haiti, semi-LLCs one needs to across the border for accessing to the seaport in neighboring countries.

6.1.2 Freight Forwarder's Behavior

The freight forwarders chose a route for export or import so that expected generalized is minimized. Although the interdependency with shipping lines is important factor to choose a seaport, the shipping lines are treated as homogenous in this study because of the reasons that the impact of the infrastructure development is to be difficult to be observed and it would be expected that as Vietnamese seaport increases their LOS, behavior of shipping lines would be also changed. In general, it is very tough to capture all effect. The forwarders involving freight transport in LLDCs might make a decision on the route considering time cost of arrival time variability generated due to the low reliability of shipment time in the route. In general, reliability of the shipment time is expressed as "low" in case shipment time variability is high, and vice versa (Bates *et al.*, 2001).

It is assumed that the behavior of freight forwarder is followed by stochastic distribution model. Here, there is a stochastic variability in generalized cost perceived by freight forwarders. In other words, perceived generalized cost $\tilde{C}^{k}$ is composed of measureable generalized cost GC^{ik} and stochastic error term ε^{ik} as shown in Equation (6.1).

$$\tilde{C}^{ik} = GC^{ik} + \varepsilon^{ik} \tag{6.1}$$

Assuming Gumbel distribution of scale parameter θ on error term ε^{ik} of utility function, distributed cargo volume q^{ik} for route k can be expressed as equation (6.2) as is logit type model.

$$q^{ik} = Q^{i} \frac{\exp\left[-\theta \cdot GC^{ik}\right]}{\sum_{k \in \Omega} \exp\left[-\theta \cdot GC^{ik}\right]} \tag{6.2}$$

where

q^{ik}: Cargo volume of route k from/to city i (TEU)

Q^{i}: Cargo demand from/to city i (TEU)

θ: Scale parameter

GC^{ik}: Shipment cost of route k from/to city i (USD/TEU)

Scale parameter is always positive unknown parameter which cannot be observed by the analyzer, and is estimated to reproduce current situation as much as possible. The generalized cost (GC^{ik}) is denoted as all the cost of inland freight transport of route k from/to city i, which is estimated by Equation (6.3).

$$GC^{ik} = E(st^{ik}) \cdot VT(ST) + E(SVC^{ik}) + USC \cdot D^{ik} + BC^{ik} + TC^{ik} \tag{6.3}$$

where

$E(st^{ik})$: Expected shipment time of route k from/to city i (hr)
$VT(ST)$: Value of time of freight forwarder (USD/TEU-hr)
$E(SVC^{ik})$: Expected schedule variability cost of route k from/to city i (USD/TEU)
USC: Unit shipment cost (USD/TEU-km)
D^{ik}: Shipment distance of route k from/to city i (km)
BC^{ik}: Border crossing cost of route k from/to city i (USD/TEU)
TC^{ik}: Terminal cost at seaport of route k from/to city i (USD/TEU)

The notable characteristics of this model is the second term of the Equation (6.2), which considers the cost due to variability of shipment time caused at the border and seaport. In this study, it is assumed that variability is found at the destination, which generates two types of delay, such as schedule delay early (SDE) and schedule delay late (SDL). This additional cost generated due to SDE and SDL is defined as schedule variability cost (SVC).

Equation 5.10 and 6.3 are equal relationship even though the expression is different. "$USC*D+BC+TC$" of Equation 6.3 is to be monetary cost other than time consuming cost. This is corresponding to δC in Equation 5.10. $\alpha E(st)$ and "$\beta SDE+\gamma SDL+\lambda P$" are corresponding to expected time consuming cost $st*VT(ST)$ and schedule variability cost $E(SVC)$, respectively. Since V=-GC, the right-hand-side of Equation 6.3 and 5.10 is equal relationship.

6.1.3 Formulation of Schedule Variability Cost

Schedule variability cost is defined as weighted cost of early and late arrival by probabilistic distribution of arrival time variability. Following this definition, schedule variability cost can be formulated as following Equation (6.4).

$$E(SVC) = \int_{-\infty}^{t_a} u(t) \cdot f_k(t)dt + \int_{t_a}^{t_r} s(t) \cdot f_k(t)dt + \int_{t_r}^{\infty} g(t) \cdot f_k(t)dt \tag{6.4}$$

where

$u(t)$: Function of schedule early arrival cost ($t < t_a$)
$s(t)$: Function of value of time of freight forwarder ($t_a < t < t_r$)
$g(t)$: Function of schedule late arrival cost ($t_r < t$)
t_a: Target arrival time
t_r: Arrival restriction time
$f_k(t)$: Function of arrival time probabilistic distribution [$t \sim LN(m_{ck}, \sigma_{ck}^2)$]

The cost function of $u(t)$, $s(t)$, $g(t)$ can be formulated as Equation (6.5) to (6.7).

$$u(t) = VT(SDE) \cdot (-t + t_a) + (VT(ST) \cdot T_b) \tag{6.5}$$

$$s(t) = VT(ST) \cdot (-t + t_r) \tag{6.6}$$

$$g(t) = VT(SDL) \cdot (t - t_r) + PEN \tag{6.7}$$

t, t_a, T_b, and t_r indicates time, target arrival time, arrival buffer time, and arrival restriction time, respectively.

Using Figure 6.3, the detail of the concept of Equation (6.4) is explained. Target arrival time t_a of the freight forwarders is defined as the mode of distribution of arrival time $f_k(t)$ for route k. In the route where shipment time has strong variability, freight forwarders are not likely to choose departure time d to arrive at the destination at precisely same as arrival restriction time because the late arrival would contribute on their disutility. In this case, freight forwarder seems to choose departure time incorporating arrival buffer time T_b in order to avoid late arrival. In this way, freight forwarders might attempt to arrive at the destination T_b before arrival restriction time. The target arrival time is located at the mode of shipment time distribution. In case freight forwarders are set their arrival time t_a, it is very likely to arrive at the time of t_a with the highest probability comparing to other time. Thus, target arrival time is assumed to be corresponded to the mode of arrival time distribution. Here, the target arrival is defined as limit time of the availability of the use of scheduled maritime transport in exporting case. In case target time is exceeded, freight forwarders miss the opportunity of use of maritime transport. In case of importing case, this is also defined as the limit time to avoid stopping production line or stock expiration. Arrival buffer time is defined as the time difference between arrival restriction time t_r and target arrival time t_a. In the next section, the detail explanation of how to determine the scale of T_b will be addressed. T_b is previously expected time before the departure. Thus, for estimating the cost, normal value of time [$VT(ST)$] is corresponded to this time. In case arriving at the destination before target arrival time (t_a), the cost due to time consumption is estimated using value of early arrival [$VT(SDE)$]. The slope of buffer time and early arrival is different. This is because of the difference of expected or unexpected time before the departure. Obviously, unexpected time has more impact on the cost, thus earlier arrival than target arrival time has steeper slope comparing to buffer time. Similarly, value of late arrival [$VT(SDL)$] is applied for cost estimation due to time consumption of late arrival. In regard to relationship of impact of early and late arrival on scheduling problem, several researches have been demonstrated the results of that larger impact of late arrival comparing to early arrival (Bates *et al*., 2001; Noland and Small, 1995). In the field of logistics, this type of asymmetry between the differences of is very likely to be higher impact rather than trip f people. By introducing the penalty of being late (λ), the asymmetry can be expended.

In general, the cost of penalty of being late and late arrival is fairly high in case freight forwarders encountered late arrival in reality. However, this study is route choice problem prior to the departure. In this case, the decision maker might be use expected value which is weighted by the probability that they encounter the events. To do this, expected schedule variability cost that is the product of cost function and probability would be comparatively lower than pure cost. Similarly, probability corresponding to late arrival is only few percent of upper shipment time of long tailed probabilistic distribution; thus, the values obtained would be small enough. In summary, although the cost of late arrival itself is enormously large, the expected cost of late arrival is estimated small enough value due to setting arrival buffer time. The $f_k(t)$ is the probabilistic distribution function in terms of shipment time following lognormal distribution which is convoluted distribution of two lognormal distribution such as shipment time at the border [$t \sim LN(m_{bk}, \sigma_{bk}^2)$] and seaport [$t \sim LN(m_{sk}, \sigma_{sk}^2)$]. Hereafter following section, specification method for each unknown parameters are addressed.

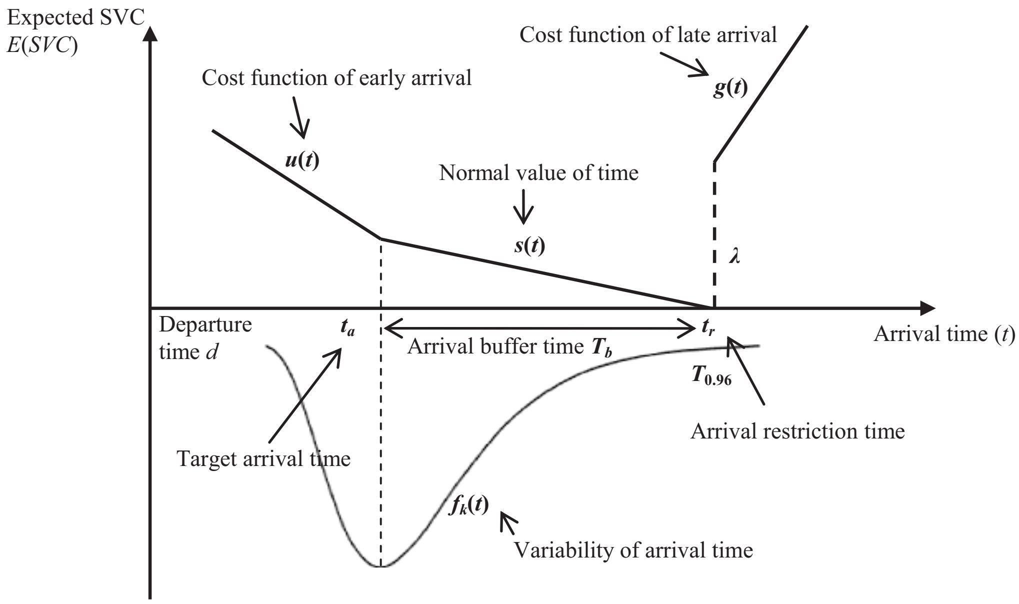


Figure 6.3 Expected Cost Function for Early and Late Arrival

In terminal, there are several processing required, such as customs clearance and cargo inspection. Transshipment is also sometimes required at the border. At this time, incomplete documents, trouble in machinery, congestion, and laziness of customs officials. Here, there are more reasons to make shipment time lengthy rather than that of making shipment time shorter. In case for the shortest shipment time, due to the physical constraints, lower limit exists. Therefore, it is understandable that the distribution of right tail would be longer.

In regard to the assumption that distribution is following lognormal density, total 22 empirical results are presented in East Europe (Bulgaria, Albania, Bosnia, and Croatia), South America (Argentina and Brazil), and Africa (Kenya). The lognormal distribution is detected using Kernel density estimation and Arvis *et al*. (2007) mention that this is the stylized fact. However, these data are not based on the data from Lao border and seaport of Thailand and Vietnam. Thus, in order to examine application of above results to Lao practice, steps at the border and seaport are compared between above data and Lao context. In above obtained data, discharge, customs clearance (paper-based), transshipment of truck and besides, waiting time is included. On the other hand, processing at seaport includes devanning of cargo from vessel, declaration of transit at customs office, and cargo inspection and besides, waiting time due to congestion. Comparing to Lao border, the processing is almost same except weight inspection in Lao PDR, which is not considered obtained data. Regarding to seaport process, the prominent differences are not found.

In this dissertation, shipment time at border and seaport were not able to be obtained. Thus, Kolmogorov-Smirnov test which examines goodness-of-fit for distribution shape and Karnel density estimation which estimate the probability density function from the sample data were not conducted. However, it is needed to examine and confirm that shipment time at border and seaport is following lognormal distribution from the actual data.

In many border, opening time is fixed for passing the border. In principle, in case failing to pass across the border before closing it, border crossing would be after tomorrow. In this case, there are some possibilities to occur “second” distribution for shipment time probabilistic distribution. However, all freight forwarders interviewed well understood this problem, thus, it can be postulated that freight forwarders are choosing departure time not to encounter such stuck. Considering all above, “second” distribution would be quite small and ignorable for estimating generalized cost.

6.2 Estimation of Schedule Variability Cost

6.2.1 Specification of Distribution of Arrival Time

In order to specify the characteristics values for the lognormal distribution which is convoluted, each distribution of border and seaport should firstly be identified. Using maximum and minimum time required at the border and seaport obtained from interview survey, distribution characteristic values of lognormal distribution are estimated following the method showing in chapter 5. Estimated results are shown in Table 6.1 with interviewed minimum and maximum times (see Figure 6.2 for the location of each border and seaport).

Table 6.1 Distribution Characteristics Value for Each Bottleneck (unit: hour)

	Values based on interview survey			Distribution characteristics value (Estimated)	
	Max (SD)	**Min (SD)**	**Mean (SD)**	**Mean**	**SD**
Thanaleng/Nong Khai (T/N) [N=40]	5.4 (0.98)	2.4 (0.71)	3.5 (0.88)	3.5	0.479
Savannakhet/Mukdahan (S/M) [N=38]	6.8 (1.13)	2.5 (1.45)	3.5 (1.21)	3.5	0.599
Nameo/Nam Xoi (N/N) [N=30]	9.4 (2.71)	1.4 (1.56)	4.4 (1.42)	4.6	1.500
Nam Phao/Cau Treo (N/C) [N=33]	7.8 (1.67)	3.1 (1.14)	4.3 (1.27)	4.3	0.674
Dansavan/Lao Bao (D/L) [N=35]	4.3 (1.74)	3.3 (1.11)	4.1 (1.41)	4.0	0.625
Laem Chabang seaport (LCB) [N=40]	12.9 (2.23)	5.3 (1.94)	7.9 (2.09)	8.0	1.186
Hai Phong seaport (HAI) [N=35]	15.1 (3.42)	6.9 (3.21)	8.5 (2.82)	8.8	1.519
Da Nang seaport (DAN)[N=31]	17.1 (3.74)	6.8 (3.54)	10.3 (3.10)	10.4	1.612

Next, convolution of two independent lognormal distributions at the border and seaport for shipment time variability is attempted. The convoluted distribution of two distributions at border and seaport is to be the distribution of arrival time variability since both shipment time distribution is generated independently in the route *k*. According to Crow and Shimizu (1988), convoluting dependent M number of lognormal distribution (L_k) would be approximated to normal distribution by the Central Limit Theorem in case M=∞. However, in case M is small enough like in this study which is M=2, Λ can be approximated to lognormal distribution. Therefore, convoluted distribution is assumed to be lognormal distribution considering equation (6.8).

$$\Lambda = \sum_{k=1}^{M} L_k = \sum_{k=1}^{M} e^{Y_k} = e^{Z} \tag{6.8}$$

For the method of convolution two lognormal distributions approximating lognormal distribution, one needs to obtain 1st and 2nd moment (mean and variance) of Λ. The method to get these values has been actively developed in the field of wireless communication technology (i.e. Schwartz and Yeh, 1982; Beanlieu and Xie, 2004; Lam and Le-Ngoc, 2006). For example, Wilkinton' moment-matching method (Schwartz and Yeh, 1982), Fenton-Wilkinton approximation (Fenton, 1960), Schwartz-Yeh's recursive method (Schwartz and Yeh, 1982), Farley method (Schwartz and Yeh, 1982), mini-max approximation method (Beaulieu and Xie, 2003), least-square approximation method (Zhao and Ding, 2007) are widely recognized. For all approximation method here, it is assumed that more than two lognormal distributions are approximated into lognormal distribution. Arvis *et al*. (2007) concluded that total shipment time in a route of passing through two bottlenecks such as border and seaport, which is following lognormal distribution can be experimentally approximated into lognormal distribution. However, existing approximation method is all the results in other research field. Thus, it is not clear whether existing method can be applicable to transport field. In addition, According to Nadarajah (2008), the convoluted distribution of lognormal distributions can be generally approximated to lognormal distribution, which is the most widely used assumption. In this assumption, lognormal distribution that will be convoluted should be independent each other. Consequently, the required condition to assume lognormal distribution is approximated to lognormal distributions is that (i) the distributions should be independent each other and (ii) number of distributions are small enough, otherwise, convoluted distribution would be normal distribution by central limit theorem. However, there has been no established method developed in the field of transport studies. Therefore, this study take place a simulation of actual situation encountered in the real field to obtain Λ. Figure 6.4 graphically shows the overview of the simulation. Freight forwarders are firstly exposed to shipment time variability at the border crossing point in the cross-border route. At this time, one sample can be extracted from the distribution of shipment time variability at the border. Let this sample denote n_{bk}. Secondly, another sample is extracted from the distribution at the seaport where is the second bottleneck in case of exporting. Let this sample denote n_{sk}. In route k, since bottleneck which violating the stability of shipment time is only two points, border and seaport, schedule variability affected by freight forwarder is $n_{bk}+n_{sk}$. 20,000 samples are generated randomly by using the method addressed above. Finally, nonparametric estimation for obtaining 1st and 2nd moments was done. The distribution characteristics values for convoluted lognormal distribution of each bottleneck are shown in Table 6.3 and one graphical example of convolution is shown in Figure 6.5.

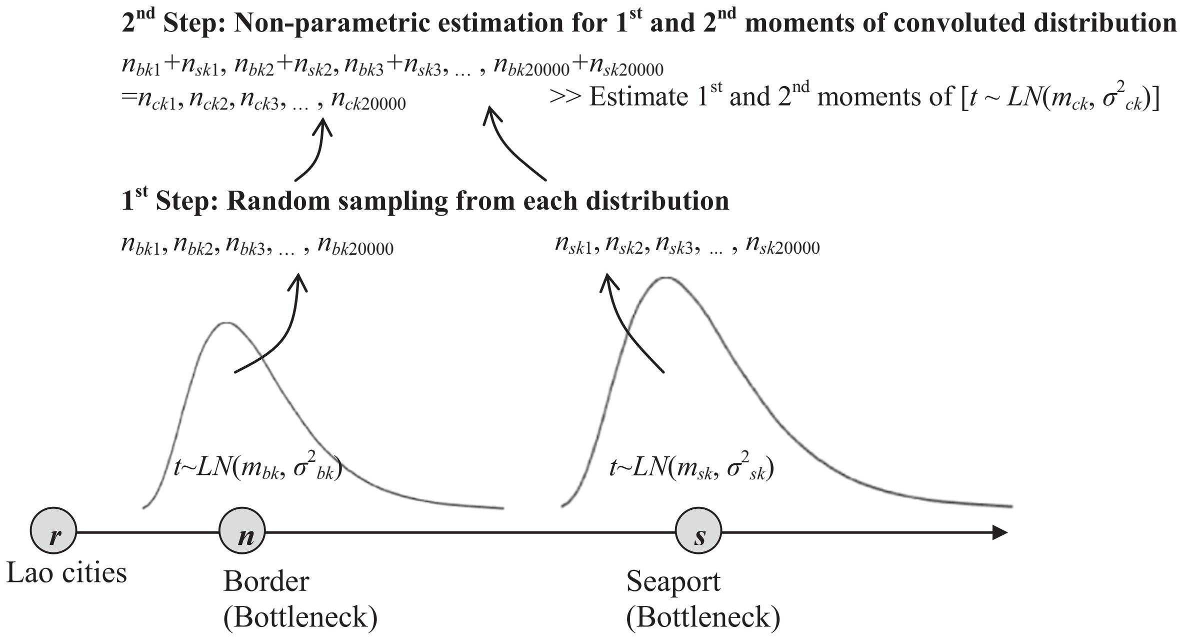


Figure 6.4 Steps to Obtain 1st and 2nd Moments of Convoluted Lognormal Distribution

Table 6.2 Distribution Characteristics Value for Convoluted Distribution (unit: hour)

Border and seaport	Mean	Standard Deviation
Thanaleng/Nong Khai – Laem Chabang (T/N-LCB)	11.5	1.275
Nam Phao/Cau Treo – Hai Phong (N/C-HAI)	13.2	1.657
Dansavan/Lao Bao - Da Nang (D/L-DAN)	14.5	1.742
Savanakhet/Mukdahan - Laem Chabang (S/M-LCB)	11.5	1.320
Nameo/Nam Xoi - Hai Phong (N/N-HAI)	13.4	2.141
Nam Phao/Cau Treo – Da Nang (N/C-DAN)	14.8	1.750
Dansavan/Lao Bao – Hai Phong (D/L-HAI)	12.8	1.630

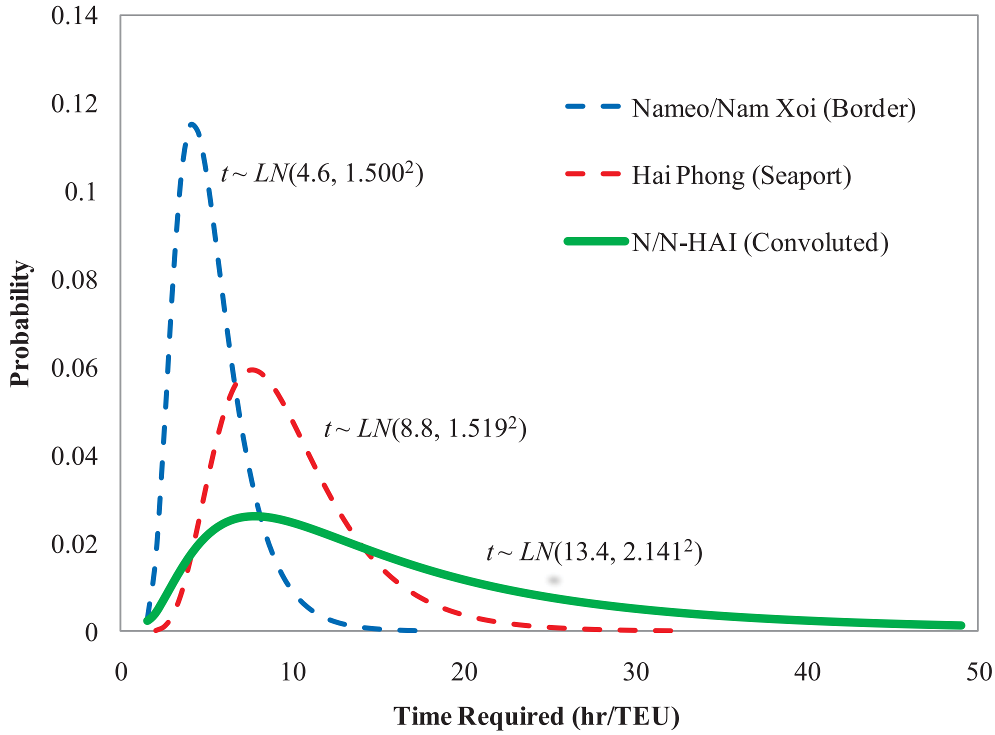


Figure 6.5 Graphical Example for Convolution of Lognormal Distribution

Using maximum likelihood method, the parameter of lognormal distribution can be formulated as following equation (6.9) and (6.10);

$$\hat{\mu} = \frac{\sum_k \ln x_k}{n} \tag{6.9}$$

$$\hat{\sigma}^2 = \frac{\sum_k (\ln x_k - \hat{\mu})^2}{n} \tag{6.10}$$

Using the 20,000 data obtained from above method, the parameter of lognormal distribution is estimated for validation. As a result, the estimated parameters using above two equations are very similar, which means the error is less than 1%. Thus, the method to estimate 1st and 2nd moments of lognormal distributions applying in this dissertation is acceptable.

In case other distribution is assumed, the probability of occurrence of schedule early and late arrival would be increased or decreased. Thus, comparing to assuming lognormal distribution, generalized cost would be changed. The specific value is dependent on the shape of distribution that is assumed. In case exponential distribution is assumed, the occurrence probability of early arrival would be increased due to its characteristics of the shape. In this way, the magnitude of generalized cost would be changed according to assumed distribution. However, magnitude relation of generalized cost is conserved among the routes, thus, the trend of the result of scenario analysis is not significantly violated.

6.2.2 Determination of Arrival Buffer Time

In this section, the detail of how to determine arrival buffer time T_b is addressed. Arrival buffer time should be values to be determined endogenously since it might be variables dependent on scale of variability. It is determined on the basis of values obtained from interview survey. For the route between Vientiane and Laem Chabang seaport, average shipment time is clarified as 21.0 hours in average from the interview survey (see Table 6.4 for values appeared in this section). This is approximately 3 hours shorter than existing study (Banomyong, 2000). In this dissertation, shipment time for exporting case includes time until loading freights onto a vessel, on the other hand, Banomyong (2000) accounts shipment time until arriving at seaport. This seems to be a reason of the difference between both shipment times. Regarding to departure time, it is obtained that freight forwarders are departing 24.5 hours before the arrival restriction time, which is final available time for taking maritime transport. From this result, arrival buffer time is implicitly calculated as 3.5 hours. At the same time, the mode till 95% upper point of convoluted lognormal distribution of shipment time in the route between Vientiane and Laem Chabang seaport is 3.84 hours. This time is pretty close to arrival buffer time clarified by the interview survey. Regarding the route between Vientiane and Da Nang seaport, average shipment time is 24.3 hours and departure time is 30.0 hours before the arrival restriction time. At this time, arrival buffer time can be calculated as 5.7 hours. In this route, shipment time between the mode and 96% point of the convoluted distribution of arrival time variability is 6.07 hours. Here, Root Mean Square (RMS) error of arrival buffer time between actual value (T_b^A) which is based on interview survey and time between the mode and 99% point of arrival time distribution (T_b^E) as shown in Equation (6.11) is calculated.

$$\mathrm{RMS\,Error} = \frac{1}{N}\sqrt{\sum_{i=1}^{N}(T_b^E - T_b^A)^2} \tag{6.11}$$

where N denotes number of cases. As a result of error calculation, minimum RMS error of three routes has been obtained at the point of 96% upper point. Consequently, arrival buffer time is defined as arrival time between the mode and 96% upper point of convoluted distribution of shipment time variability in the model. A beneficial point of this is that arrival buffer time can be determined on the basis of the scale of the variability (standard deviation) of border and seaport. In this way, as bottlenecks variability getting larger, departure time is set as earlier. We can also understand that in this model, determination of the arrival buffer time is regarded as dynamic problem. Supposed reduction in shipment time variability due to some transport related policy, the scale of shipment time variability would be decreased and consequently, both risks of early and late arrival would also be decreased. In this case, arrival buffer time is estimated smaller since shipment time reliability gets improvement. In this way, this model can account for impact of reduction in shipment time variability for each bottleneck.

Table 6.3 Difference between Arrival Restriction Time and Departure Time, and Average Shipment Time (unit: hour)

	VTE-LCB [N=40]	**VTE-HAI [N=32]**	**VTE-DAN [N=28]**
Difference between Arrival Restriction Time and departure time	24.5 (2.17)*	36.2 (3.13)*	30.0 (3.15)*
Average Shipment Time	21.0 (0.86)*	30.2 (1.11)*	24.3 (1.29)*
Arrival Buffer Time	3.5	6.0	5.7
Time between Mode and 96% point of $f_k(t)$	3.84	5.64	6.07

*(Standard Deviation)

6.3 Specification of Scale Parameter θ

6.3.1 Setting Input Values

In order to estimate cargo volume of each route using this model, one needs to prepare several input variables both exogenously and endogenously for Equation (6.2). Among them, values given endogenously are $VT(ST)$ and $E(SVC)$. The method for estimation process has already been addressed up to previous chapter. Other input values are all exogenously given. In this section, data preparation is illustrated.

$E(st)$, USC, and BC are estimated based on interview survey with 51 companies. $E(st)$ denotes average expected shipment time for each route. As shown in Figure 6.5, the time between D and t_a is corresponded to $E(st)$. USC is the cost per one kilometer in the route except the cost required at the border and seaport. Regarding to BC, there is unfortunately no reliable data, thus, average value of interview results are used. However, slight variability of the obtained data was observed among the interviewed companies. The reason might be the difference of license owned by companies, document preparation prior to arriving at border, type of goods transported, etc. These differences would affect on the procedure at the border. In summary of interview survey, necessary processes at the border for all freight forwarders are submission of necessary documentations, payment for the toll and tariff, immigration of driver and truck itself, inspection of truck weight by weight bridge, cargo inspection. Submission of the documentation includes invoice, cargo list, purchase order, affidavit, and passport are generally required. Certificate of origin, which is called Form D, and HS code in ASEAN are sometimes required to submit as needed. Thus, the required process is varied border by border, and unfortunately, requirement is changeable by person in change. Considering all above situations, regarding to *BC*, 100 USD/TEU and 80 USD/TEU are set for all Thai border and all Vietnamese borders, respectively.

TC and *D* are determined referring JETRO (2008). Although various processes are included in *TC*, charge in loading and unloading, document preparation, customs declaration, and cargo inspection are almost common price among the domestic seaport in Thailand and Vietnam, respectively. Among the domestic seaport, terminal handling charge only generate difference in the price. Considering all above factors, 1,400 USD/TEU for Laem Chabang seaport, 800 USD/TEU for Hai Phong seaport, and 850 USD/TEU for Da Nang seaport are set as input value of *TC*. All input values determined here is assumed as common amount for import and export case. In Figure 6.5, exogenously determined input values are shown.

Table 6.4 Input Values Exogenously Given

Variable	Explanation	Method	Values		
$E(st^{rsk})$	Expected shipment time of route *k* between OD pair *rs*	Average shipment time for each route including expected time at border and seaport	LPB-LCB: 20.2 hr VTE-LCB: 21.0 hr SAV-LCB: 20.8 hr CPS-LCB: 23.7 hr	LPB-HAI: 19.7 hr VTE-HAI: 30.2 hr SAV-HAI: 34.5 hr CPS-HAI: 26.6 hr	LPB-DAN: 29.1hr VTE-DAN: 24.3 hr SAV-DAN: 19.3 hr CPS-DAN: 24.4hr
USC	Unit shipment cost	Average unit shipment time obtained from interview survey	2.3 USD/TEU-km		
D^{rsk}	Distance of route *k* between OD pair *rs*	JETRO[22)]	LPB-LCB: 1,000 km VTE-LCB: 700 km SAV-LCB: 700 km CPS-LCB: 950km	LPB-HAI: 690 km VTE-HAI: 880km SAV-HAI: 1,150 km CPS-HAI: 1,300 km	LPB-DAN: 1,150km VTE-DAN: 780 km SAV-DAN: 430 km CPS-DAN: 880 km
BC^{rsk}	Border processing cost of route *k* between OD pair *rs*	Average border processing cost obtained from interview survey	All border with Thailand: 100 USD/TEU All border with Vietnam: 80 USD/TEU		
TC^{rsk}	Terminal cost of route *k* between OD pair *rs*	JETRO[22)]	Laem Chabang seaport: 1,400 USD/TEU Hai Phong seaport: 800 USD/TEU Da Nang seaport: 850 USD/TEU		

6.3.2 Estimation of Cargo Generation and Attraction

One of the conditions to confirm the reliability of developed model would be reproduction of current condition with high accuracy. The data of cargo volume between each Lao city and seaport is required in order to reproduce the current cargo flow. However, there is unfortunately no such data. In this study, therefore, the required data for reproduction is estimated.

The target type of goods is cargoes transported by containers, such as daily goods. As far as cargoes are transported by containers, there would be no difference for rushing. Thus, the prominent differences in value of time across a type of goods are not expected. The container cargo volume (TEU/year) from/to Lao PDR to/from all over the world in 2003 estimated by Shibasaki and Watanabe (2008) is used to estimate required data. From this data, cargo volume of from/to Lao PDR to/from Thailand, Vietnam, Cambodia, and Southern China (Yunnan, Guangxi, Guangdong, Guizhou, and Funan) which might be transported by land transport are excluded and regarded as cargo volume of Lao PDR-seaport in Thailand or Vietnam. In Shibasaki and Watanabe (2008), zoning of Lao PDR is three zones, such as Northern, Middle, and Southern part of Lao PDR. In this study, it is assumed that most of cargo in Northern and Southern part are generated and attracted in Luang Phabang and Champassak, respectively. Northern cargo volume and Southern cargo volume are respectively allocated to Luang Phabang and Champassak where are denoted as centroids. Thus, cargo volume of Luan Phabang and Champassak are estimated as many as those of Vientiane and Savannakhet. Regarding the cargo volume from/to middle part, Vientiane and Savannakhet occupies large portion. Using cargo generation data (JICA, 2010), which is based on ton/year for each city of Lao PDR, cargo volume generated in middle part is proportionally distributed to Vientiane and Savannakhet. The cargo volume data of Shibasaki and Watanabe (2008) is converted as 10 tons = 1 truck = 1TEU. Besides, air cargo and non-containerized cargo of maritime transport are excluded from the estimation of cargo flow generation. Using this method, cargo volume of each centroid can be estimated as Table 6.5.

Table 6.5 Result of Cargo Generation Estimation (TEU/year, 2003)

Centroid	Export (Q^{iek})	Import (Q^{iik})
Luang Phabang (*k*=1)	5,968	7,603
Vientiane (*k*=2)	4,736	10,805
Savannakhet (*k*=3)	8,525	4,698
Champassak (*k*=4)	3,856	4,978

Excluding Savannakhet, the results are well reflected the current state that is import surplus Lao PDR (JICA, 2010). Savannakhet has a large amount of copper exports that are produced in Sepon mine, thus, export is surplus (JICA, 2010). Since copper exports from Laos are dominant in Savannakhet, export surplus in Savannakhet is a reasonable result.

Next, the cargo volume from each city to each seaport is estimated. However, since there is no such data, we estimate the cargo volume to each seaport using ratio of choosing seaport in Thailand and Vietnam which were obtained from interviews. The trend of seaport choice obtained in the interviews is found almost no variation among companies. For example, cargo volume from/to Vientiane is occupied by Thai seaport by 85%. Among the seaports in Thailand, because Laem Chabang seaport deals almost exclusively from Lao PDR. Laem Chabang seaport cargo volume from from/to Lao PDR is to be $0.850Q^{i2}$. Among Vietnamese seaports, Hai Phong and Da Nang seaport are heavily used, and the use of ratio was obtained as 7 : 3. Therefore, the volume of cargo heading to the Vietnam's seaport of Hai Phong and Da Nang are set as $0.105Q^{i2}$ and $0.045Q^{i2}$, respectively.

Rerouting in the city might often be conducted according to the traffic condition, however, it may have only minor impact on seaport choice in approximately 1,000 km distance cross-border route. Therefore, assumption of setting one route for one destination is likely to be considered reasonable. Should shipment time at the border is to be very long due to some reason, freight forwarder change a seaport choice itself rather than route change. Since the network covered in this study is cross-border long-haul transport, route change under fixing seaport choice is accompanied by a very large additional shipment cost.

6.3.3 Specification of Scale Parameter θ

Parameter θ is specified to reproduce the current states as high accuracy as possible. To put it concretely, RMS errors of estimated (Q^{ikE}) and actual cargo volume (Q^{ikA}) is minimized under the assumption that one destination is assigned one route. The probability of choosing the route k has already been estimated. Here, since the network is assumed as flow independent states, it is not expected that any delays due to for example, traffic congestion, occurred on the link connecting each nodes in the study area. Hence, route change posterior to the departure due to the congestion is not considered. Even though route change has possibly been done in the city due to the traffic congestion, the impact of this type of route change is very likely to be too low to consider in the model in very long-distance shipment which lies nearly 1,000km for each route. Therefore, this study treats flow independent cargo assignment problem, not flow dependent which considers the effect of traffic congestion. Queuing or waiting time can be easily observed at the border and seaport, however, such cost due to the queuing is considered as a part of the generalized cost. Freight forwarders assumed to determine the route before departure considering its congestion cost.

$$\text{RMSError} = \frac{1}{N}\sqrt{\sum_{i=1}^{N}(Q^{rakE} - Q^{rakA})^2} \quad (6.12)$$

Among the total cargo volume treated at seaport in coastal countries, the occupancy rate of cargo volume from/to Lao PDR is very low. Hence, increase in cargo volume due to some reason such as improvement of LOS would not generate congestion. For example, outbound cargo volume at Laem Chabang seaport in 2003 is 1,573,176TEU (Bangkok Shippers and Agents Association, 2003), whereas actual cargo volume estimated in this study is 11,934.90TEU, which accounts only 0.008% of total cargo volume treated. Therefore, change of cargo volume from/to Lao PDR would not affect on the waiting time and congestion at the seaports in coastal countries.

Using Equation (6.1), non-linear simultaneous equation is formulated for each centroids, which include Luang Phabang, Vientiane, Savanakhet, and Champassak and subsequently, scale parameter θ is deduced to minimize square error of estimated and actual values. The reason to estimate scale parameter θ for each centroid is because each centroid can be regarded as independent. Actual cargo volume for centroid i route k (Q^{iek}) has already been estimated, thus generalized cost of route k ($E(GC^{ik})$) can be estimated using the proposed model.

As a result, scale parameter θ is estimated as 0.0026-0.0282. The transport network of this study is approximately 1,000km that is long-distance network. In such case, generalized cost of the route is estimated fairly high. As the scale of generalized cost increases, factors contributing the variability of generalized cost are also increased. Thus, each freight forwarder's perception on generalized cost would be differed. In this case, the gap of generalized cost of the routes would not be accurately perceived. Consequently, scale parameter is estimated as small value since the sensitivity on the route choice is decreased.

Using estimated scale parameters for reproducing cargo flow, the result were obtained as shown in Table 6.6 and Figure 6.6. The accuracy seems to be pretty good.

Table 6.6 Comparison of Actual and Estimated Cargo Volume (TEU/year)

	Laem Chabang seaport	Hai Phong seaport	Da Nang seaport
		from/to Luang Phabang	
Estimate	5,361.8	359.0	247.1
Actual	5,371.2	477.4	119.4
Error	-0.2%	-24.8%	107.0%
		from/to Vientiane	
Estimate	4,044.8	278.8	412.4
Actual	4,025.6	528.3	142.1
Error	0.5%	-50.9%	190.2%
		from/to Savannakhet	
Estimate	6,905.3	1.32*10^-18	1,619.8
Actual	6,820	170.5	1,534.5
Error	1.2%	-	5.6%
		from/to Champassak	
Estimate	3,122.7	0.6	732.7
Actual	3084.8	77.12	694.1
Error	1.2%	-99.2%	5.6%

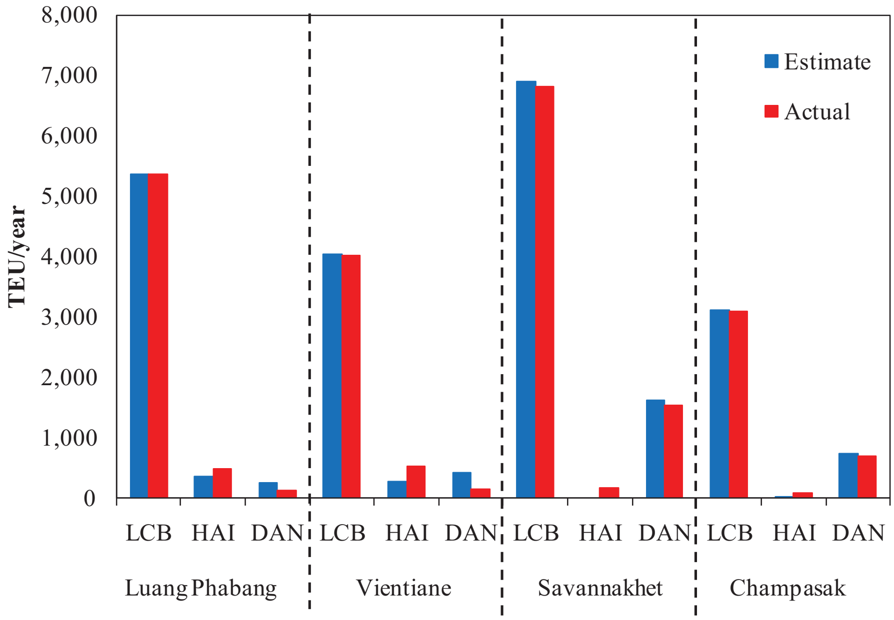


Figure 6.6 Actual and Estimated Cargo Volume (TEU/year)

6.4 Scenario Analysis

In this chapter, inland cargo flow model for Lao PDR is developed, which fulfilled objective 3. The forth objective will be fulfilled in this section, which is several scenario analysis using a model developed from chapter 5 to previous section. In the scenario analysis, standard deviation of border or seaport shipment time variability distribution is decreased. In other words, reliability of border and seaport are increased. Besides, the mean of arrival distribution is reduced at border and seaport for comparison purpose.

6.4.1 Improvement in Reliability of Border

As a first scenario analysis, reliability of border crossing time is increased. At this time, change in schedule variability cost and cargo volume of each seaport is analyzed. The scenarios are made up 10% reduction till 90% reduction by 20% interval for the standard deviation of shipment time variability of the border. Figure 6.7 shows change in schedule variability cost as a result of increasing border reliability. As an overall trend, the reduction in schedule variability cost can be observed. Particularly, reduction rate of Nameo/Nam Xoi – Hai Phong seaport is the highest. This is because original value of standard deviation is the highest by far among the all distributions. At the 90% reduction of standard deviation, the variability of each border becomes almost similar resistance. Therefore, schedule variability cost is heavily dependent on seaport variability in case 90% decrease in border resistance. In 90% decrease case, the order of schedule variability cost is in same order of scale of seaport variability.

At present status, average schedule variability cost is 1,811 USD/TEU, and at 90% reliability increase, 1,219 USD/TEU in average. This teaches us that increase in 90% border reliability benefits 32.7 cost reduction in schedule variability cost. Schedule variability cost at the present status occupies 29.3% of total generalized cost. It is going to decrease up to 20.6% of schedule cost and 9% of total cost. Average schedule variability cost is 1,441 USD/TEU for 90% shipment time reduction case which still occupies 23.2% of total generalized cost, which contributes only 6.1% total cost reduction. The results of shipment time reduction of bottlenecks are shown in Appendix C.

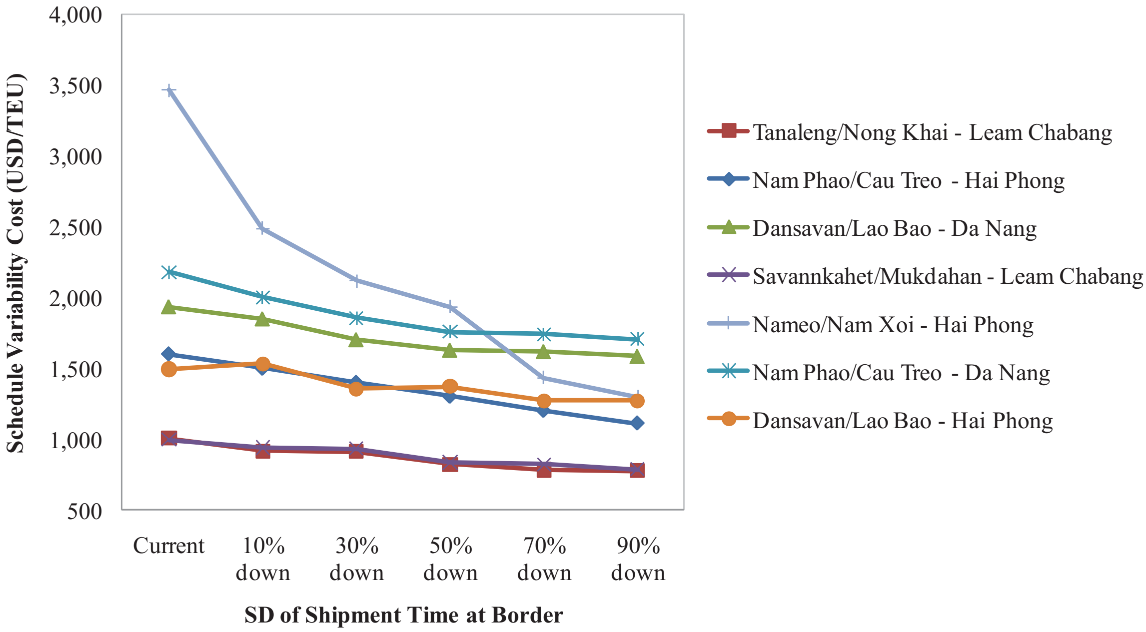


Figure 6.7 Change in Schedule Variability Cost due to Decrease in Border Variability

Figure 6.8-6.11 show change in seaport choice. In any cities, as the gap between each border variability decreasing due to decreasing shipment time variability, cargo volume of Laem Chabang seaport is turned to seaport in Vietnam. In Figure 6.8 for Luang Phabang – Hai phone seaport, Nameo/Nam Xoi border is originally to be recognized as serious bottleneck for accessing Haiphong seaport since its border resistance is very strong. As such bottleneck is dissolved, cargo volume of Hai Phong seaport where advantage point is shorter distance is dramatically increased. In cargo flow from/to Vientiane shown in Figure 6.9, although slight increase in cargo volume bound for Vietnamese direction can be observed, however, cargo volume from/to Laem Chabang seaport where the reliability and distance has advantage is still the highest. As for cargo flow from/to Savannakhet shown in Figure 6.10, cargo volume of Da Nang seaport where distance advantage owns is dramatically increased as border resistance decreases. For cargo volume from/to Champassak shown in Figure 6.11, it is structured that cargo always pass through Savannakhet on the transport network. Comparing to Savannakhet, total shipment distance between Champassak and seaport is longer and distance advantage is diminished. Thus, cargo volume incensement in Da Nang seaport is as much as that of cargo volume of Savannakhet. In the view of total cargo volume from/to Lao PDR, cargo volume sharing at each seaport at 90% variability reduction is almost equal amount as shown in Figure 6.12.

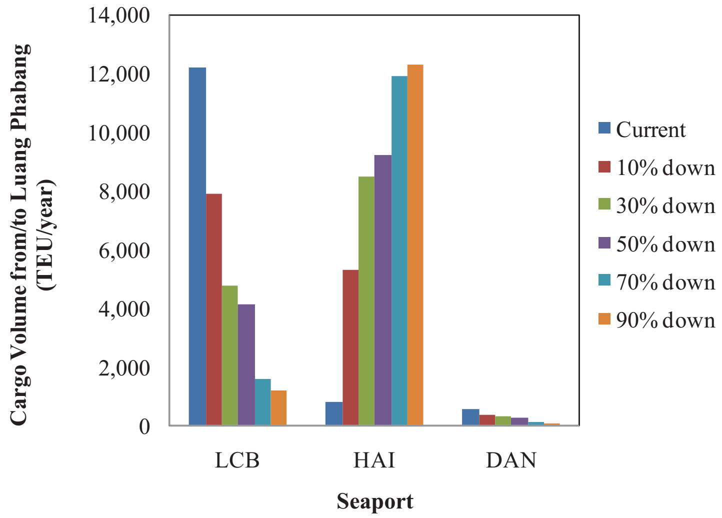


Figure 6.8 Change in Seaport Choice from/to Luang Phabang due to Decrease in Border Variability

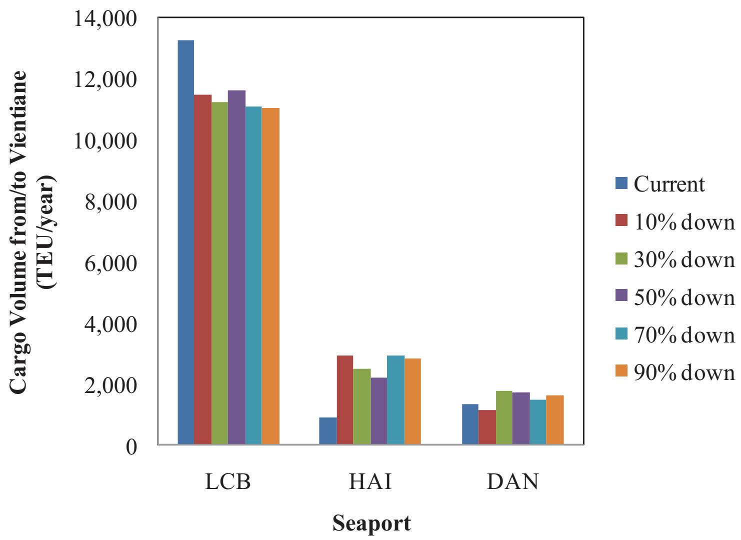


Figure 6.9 Change in Seaport Choice from/to Vientiane due to Decrease in Border Variability

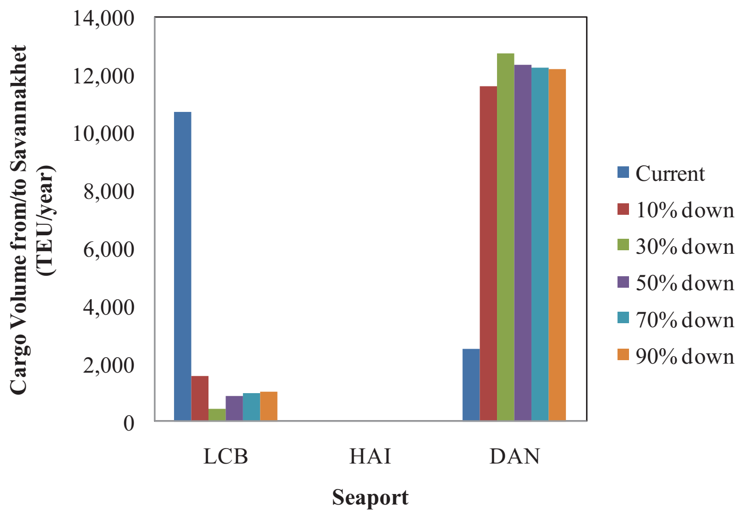


Figure 6.10 Change in Seaport Choice from/to Savannakhet due to Decrease in Border Variability

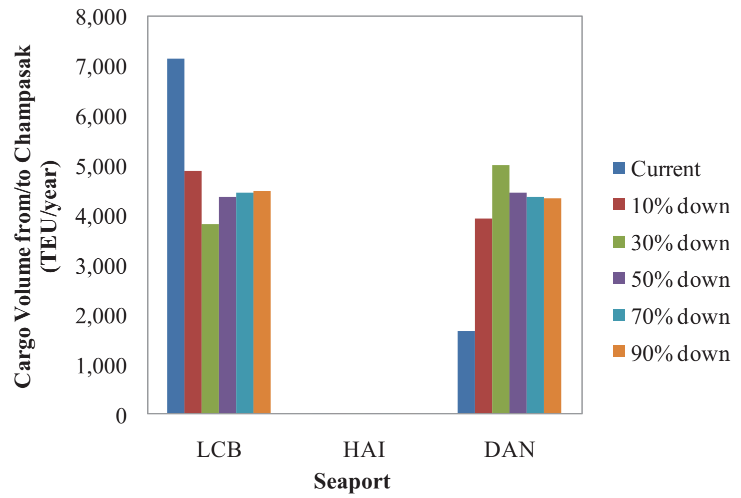


Figure 6.11 Change in Seaport Choice from/to Champassak due to Decrease in Border Reliability

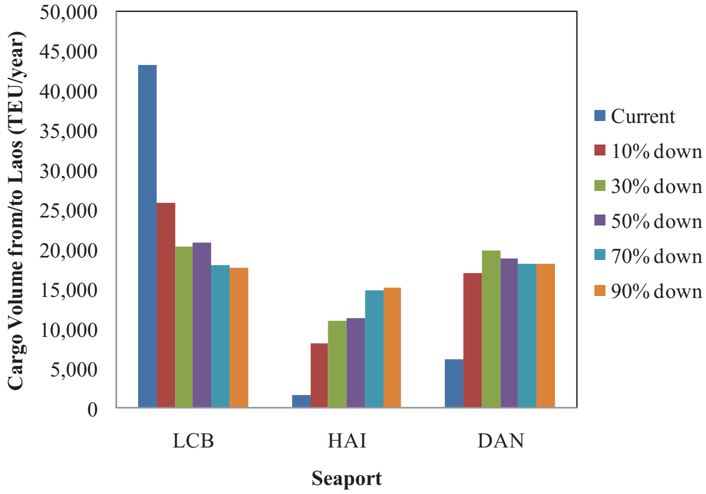


Figure 6.12 Change in Seaport Choice from/to Lao PDR due to Decrease in Border Variability

6.4.2 Improvement in Reliability of Seaport

As a second scenario analysis, change in schedule variability cost and cargo volume of each seaport is analyzed by reducing shipment time variability at seaport. The scenario is set similarly to border reliability incensement, which is changing 10% reduction till 90% reduction by 20% interval of standard deviation of shipment time variability at seaport.

The rate of schedule variability cost reduction due to increase in seaport reliability is higher than that of border reliability. This is due to the reason that shipment time variability of seaport is originally higher than that of border. In case of current situation, average schedule variability cost is 1,811 USD/TEU which occupies 29.3% of average total cost, whereas in case 90% reduction, schedule variability cost is down up to 394 USD/TEU, being 7.6% of average total shipment cost, which means 21.7% of total cost can be reduced by diminishing seaport variability. For comparison, 1,288 USD/TEU is estimated as schedule variability cost when 90% shipment time is decreased but variability is fixed. In this case, it occupies 20.8% of total shipment cost, which is much less impact on total cost reduction comparing to shipment time variability reduction. As shown in Figure 6.13, schedule variability cost of Nameo/Nam Xoi – Hai Phong seaport is high. This is due to the dominance of border variability cost in schedule variability cost. In case of increase in seaport reliability, it can be observed that two Vietnamese seaports increase their cargo volume whereas cargo volume at Laem Chabang seaport is decreasing.

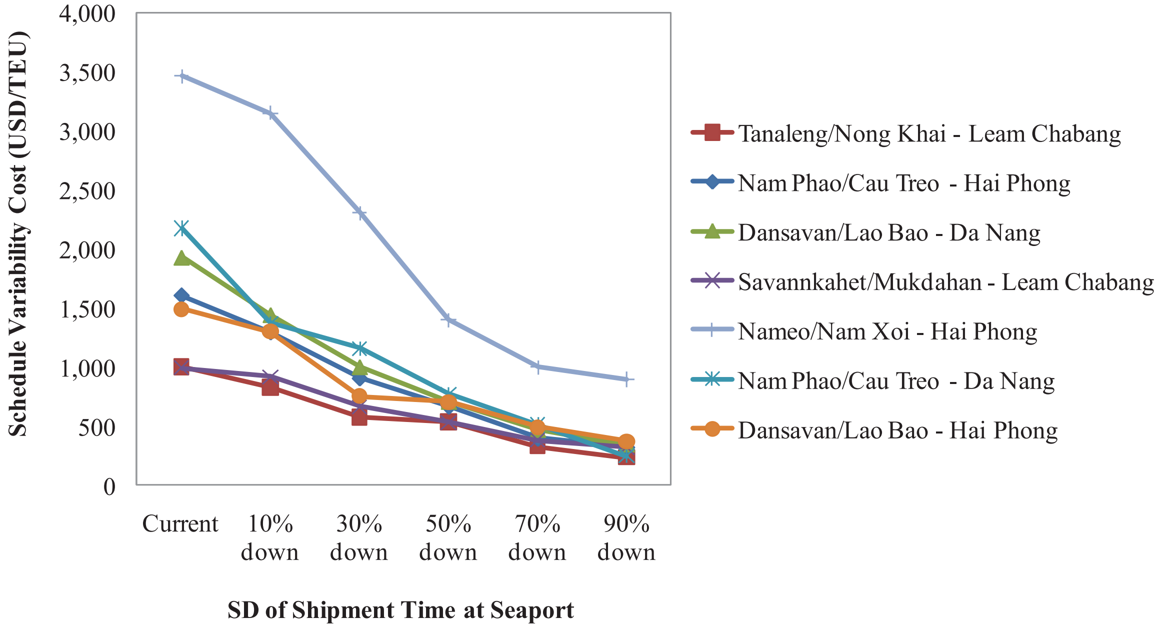


Figure 6.13 Change in Schedule Variability Cost due to Decrease in Seaport Variability

Figure 6.14 – 6.17 shows change in cargo volume at seaport from/to each city. Cargo volume in regard to from/to Luang Phabang shown in Figure 6.14 is increasing its volume at Hai Phong seaport where distance advantage owns. Nevertheless, the increase rate is duller comparing to the case of border reliability increases since Nameo/Nam Xoi border variability is still very high. Regarding to cargo volume from/to Vientiane shown in Figure 6.15, it becomes almost same volume at Laem Chabang and Da Nang seaport at more than 50% reduction in seaport variability since the resistance of both routes are to be almost same and distance is also almost no difference between two routes. As for cargo volume from/to Savannakhet and Champassak as shown in Figure 6.16 and 6.17, dominance at Da Nang seaport can be observed similarly to border reliability increase. However, seaport reliability increase case is higher rate of increase in cargo volume. The reason for this trend is that because Dansavan/Lao Bao border is originally relatively low variability, decreasing Da Nang seaport variability itself, Da Nang seaport where distance advantage owns would be dramatically increased in terms of cargo volume. In regard to cargo volume from/to Lao PDR as shown in Figure 6.18, cargo volume increase at Da Nang seaport can be observed. In the scenario analysis for border variability decreasing, three seaports were gotten almost same amount of cargo volume at 90% reduction case. However, seaport reliability increasing case shows duller increase at Hai Phong seaport. One of the reasons to explain to this is that cargo volume at Hai Phong seaport is not increased as much as border scenario analysis case from/to Luang Phabang since Nameo/Nam Xoi border is still very high variability.

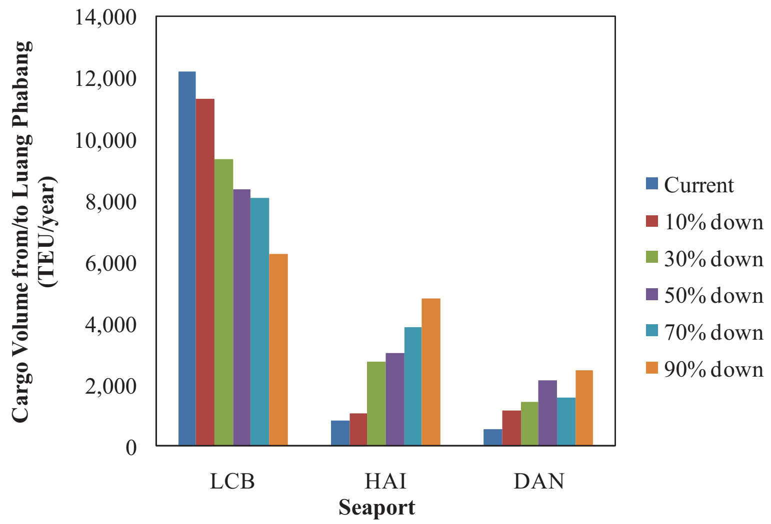


Figure 6.14 Change in Seaport Choice from/to Luang Phabang due to Decrease in Seaport Variability

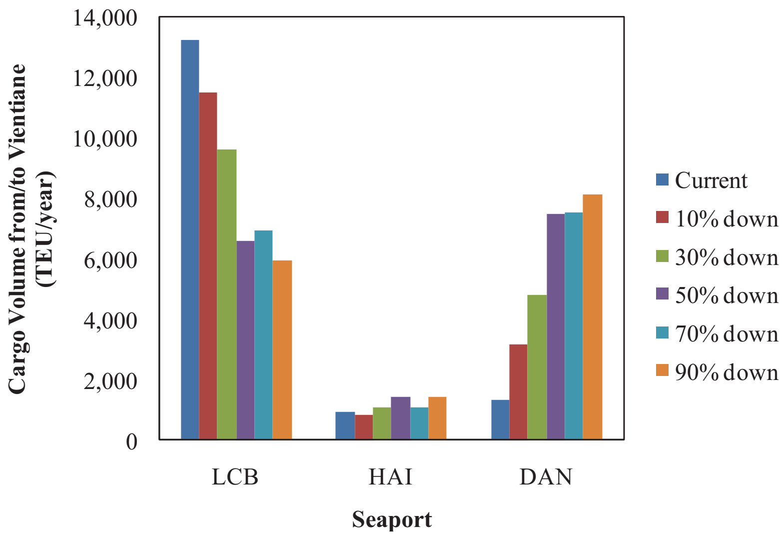


Figure 6.15 Change in Seaport Choice from/to Vientiane due to Decrease in Seaport Variability

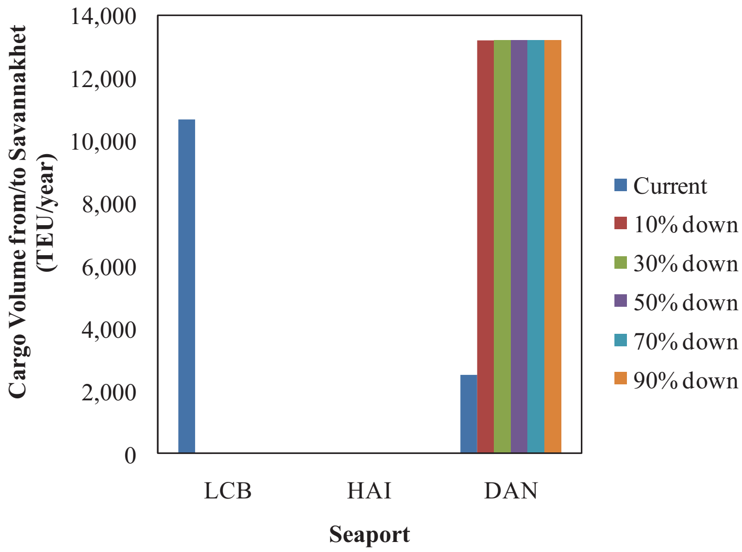


Figure 6.16 Change in Seaport Choice from/to Savannakhet due to Decrease in Seaport Variability

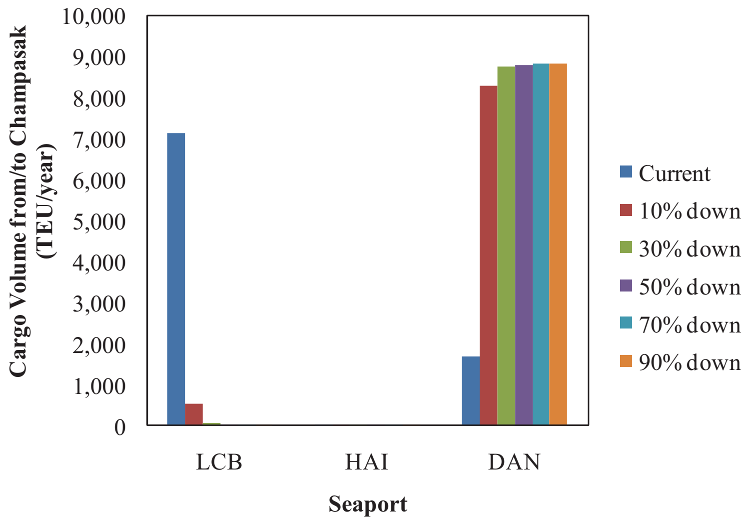


Figure 6.17 Change in Seaport Choice from/to Champassak due to Decrease in Seaport Variability

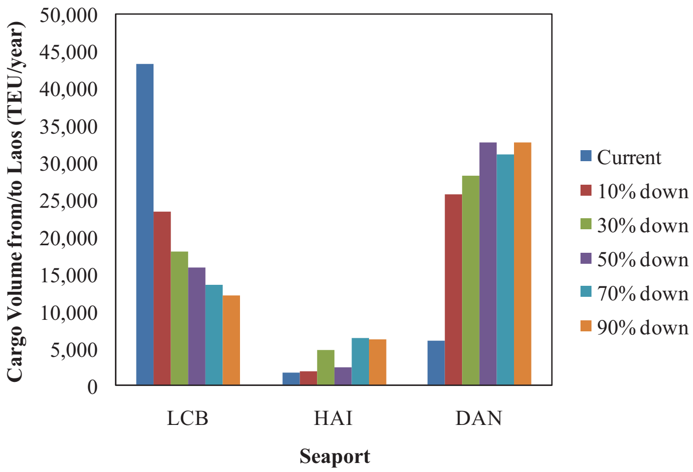


Figure 6.18 Change in Seaport Choice from/to Lao PDR due to Decrease in Seaport Variability

6.4.3 Results and Discussion

The scenario analysis has shown several insights. The most notable finding is that total cost reduction in such variable cross-border transport is higher when shipment time variability is decreased comparing to shipment time itself even though the decrease scale of shipment time itself is longer than that of shipment time variability. As seen in Figure 6.19, improving the reliability for the highest bottlenecks of each is very effective to reduce the total costs, which overwhelm the reliability improvement of all borders.

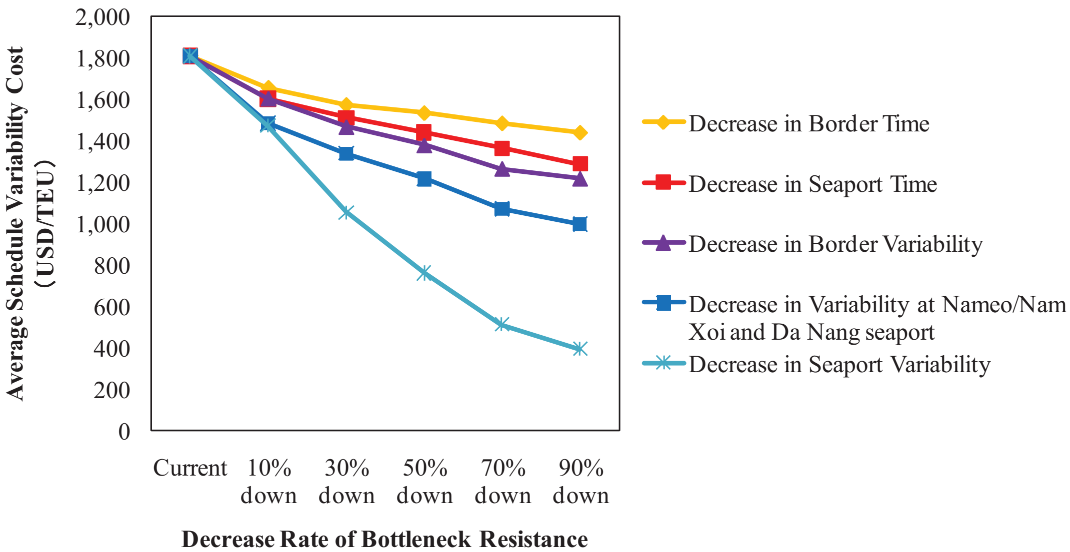


Figure 6.19 Change in Average Schedule Variability Cost for Each Scenario

On the basis of the result of scenario analysis, it is possible to propose several measures in order to contribute to economic development of Lao PDR. In the scenario analysis, it was revealed that the improvement of reliability of each bottleneck is more efficient to decrease total shipment cost rather than decrease in normal shipment time. The decrease in shipment cost would lead to decrease in price of goods. Therefore, the investment to facilitate the processing at the border and seaport is needed. Specifically, introducing Information and Communication Technology (ICT) would significantly contribute on smooth processing. Currently, almost all processing is done by paper-based document. In case of cargo inspection, X-ray scanner can significantly contribute on not only reliability improvement but also shipment time itself. This is pointed out by a lot of interviewee in all field survey location, Uzbekistan, Kazakhstan, and Lao PDR as mentioned in chapter 3. Besides, if other country's truck can enter and drive freely in other countries, transshipment at the border is omitted. However, this model cannot capture how each specific countermeasure reduces the variability even though this is important to know. For this, one needs to develop new model which explanatory variable is standard deviation of the bottleneck variability.

6.5 Chapter Conclusion

In this chapter, schedule variability cost of freight forwarder's behavior is formulated, and subsequently, scenario analysis had been conducted using developed model by changing several indicators related to shipment time at two bottlenecks, border and seaport. As for the formulation of schedule variability cost, the notable function is setting arrival buffer time is set as dynamic problem dependent on the scale of the standard deviation of the bottlenecks. To do this, the expected generalized cost is relatively estimated lower in case shipment time reliability increased. The scenario analysis brought several insights. One of them is that the impact of increase in bottleneck reliability is much more effective to facilitate the haulage or reduce total shipment cost. Thus, the result implies to policy maker in Lao PDR that shipment time should be stable in order to facilitate inland cargo flow.

CHAPTER 7

CONCLUSION

7.0 Introduction

In this dissertation, several analysis and survey have been conducted in order to fulfill four objectives in regard to the issues on freight transport of LLDCs. In chapter 3, the problems lied on this issues were clarified through the field survey in Central Asia and Lao PDR. As a result, the shipment time variability at border and seaport are to be serious problems for LLCDs. In chapter 4, we set up and examine one hypothesis, which as route is getting more variable, people needs more number of information sources for estimating expected shipment time. In this case, it can be concluded that people suffer from additional cost due to the shipment time variability. On the basis of problem finding in field survey explained in chapter 3 and some literature review in chapter 2 and suggestions from chapter 4, inland cargo flow model had been developed and analyzed several hypothetical situations so that the impact on cargo volume treated at seaport and change in the schedule variability cost is observed. Inland cargo flow model can be divided into mainly two parts, which are the valuation of shipment time variability (chapter 5) and formulation of schedule variability cost (chapter 6).

Shipment time variability has been discussed several decades mainly in international organization as serious problem for facilitation on freight transport in landlocked countries, and generates additional cost. However, there was no qualitative model to evaluate the impact of shipment time variability cost. Thus, developing inland cargo flow model which can quantitatively analyzes the impact of shipment time variability is significant contribution to this research field. Using developed model, several scenarios were analyzed. As a result of several scenario analysis, important outcome for policy making of Lao PDR were obtained, which is the reduction rate of total shipment cost is higher when shipment time variability is decreased rather than the reduction in shipment time itself. Besides, it would be possible to reverse the sharing of cargo volume at the seaport of Thailand and Vietnam depending on the reduction amount of the variability at two bottlenecks. Since main contributor to increase schedule variability cost is differed depending on the route, it is implied that the countermeasures are needed for each seaport to make shipment time stable. For example, in order to increase in cargo volume at Hai Phong seaport from/to Luang Phabang, it is better choice to increase the reliability of the border of Nameo/Nam Xoi comparing to increasing at Hai Phong seaport. In case of Da Nang seaport, seaport variability itself should be down in order to increase the share of cargo volume treated at seaport since Dansavan/Lao Bao border where is the node of the route to Da Nang seaport, variability is originally relatively low. As for valuation of shipment time variability, even though it is a part of inland cargo flow model, there was no existing practice to estimate value of shipment time variability in the region of GMS so far, thus it is valuable result for further application to other research.

7.1 Objective Based Conclusions

7.1.1 Objective 1

The first objective set for this dissertation has been to clarify the problems on freight transport of LLDCs through field surveys and literature reviews. The problems here mean not only physical issues but also institutional issues adversely contributing on LLDCs' freight transport. From the survey results, several problems were identified, for example, waiting time due to the congestion in rail transport and lack of scanning equipment that can contributes on shortening time fluctuation. These problems may ultimately result in shipment time variability. In the interview surveys in Lao PDR, 21.6% of surveyed companies are recognized that shipment time variability is important factor for seaport choice problem. In that sense, additional cost due to shipment time variability is expected.

7.1.2 Objective 2

The second objective is to identify the impact of shipment time variability on estimating expected shipment time. In the highly variable routes, it can be postulated that estimation for expected shipment time would be quite tough task. If situation is quite unstable, people needs more numbers of information sources to be confident on the prediction. On the basis of this hypothesis, one model using generalized mean concept is employed as explanatory variable is set as expected shipment time. The result is match with hypothesis set up. In all of the routes, average perception shipment time received the highest weight among the four types of shipment time. Because average perception shipment time is based on past shipping experiences, past shipment experiences clearly influence the estimation of expected shipment time. Nevertheless, recent shipment experiences do not significantly affect the estimation of expected shipment time, particularly for less variable and higher frequency routes. In particular, recent experience is not an important factor in estimating expected shipment time in low-variable routes. As shipment time becomes more variable, more number of information sources is needed. This implies that shipment time variability additionally contributes on shipment cost. This type of effect might be able to be appeared as early departure or change in route choice.

7.1.3 Objective 3

The third objective has been to develop inland cargo flow for Lao seaport choice which can be applied for other LLDCs. It is even applicable to doubly LLCs, like Uzbekistan. In this case, the convolution of lognormal distribution would be at least three, which is only one point to be modified. In Shibasaki and Watanabe (2008), shipment time variability at border is roughly considered but rigorous theoretical background was somewhat in doubt. Besides, seaport is not treated as a bottleneck in his model. The model proposed in this dissertation solved these problems. The core parts of modeling for objective 3 are; valuation of shipment time variability and formulation of schedule variability cost.

7.1.4 Objective 4

After developing inland cargo flow model which considers the cost of shipment time variability for schedule constrained freight forwarders, scenario analysis had been conducted using developed model by changing several indicators related to shipment time at two bottlenecks, border and seaport. As for the formulation of schedule variability cost, the notable function is setting arrival buffer time is set as dynamic problem dependent on the scale of the standard deviation of the bottlenecks. To do this, the expected generalized cost is relatively estimated lower in case shipment time reliability increased. The result of this dissertation implies that the stability of shipment time is more effective to reduce total shipment cost. However, one needs to remind that this model cannot capture how each specific countermeasure reduces the variability even though this is important to know. For this, one needs to develop new model which explanatory variable is standard deviation of the bottleneck variability.

7.2 Future Scope

7.2.1 Improving the Model Considering Other Factors

The inland cargo flow model has several further potential improvement points. In inland cargo flow model, transit cargo and potential demand generated due to improving LOS are not considered. For transit cargo, it is expected to be increased as border resistance diminished. Here transit cargo is mainly mentioned for between Thailand and Vietnam where cargo volume in the region is relatively high. In this case, cargo diversion from maritime transport since currently, relatively large number of cargo volume is transported by maritime transport between two capitals, Bangkok and Hanoi. As mentioned in chapter 6, the cargo share from/to Lao PDR in seaport of Thailand is extremely small, such as 0.008% of total handling volume. This trend might be similar in other LLDCs. For example in 2003 Mongolian case, even though all maritime cargo generated in Mongolia is assumed to use Tianjin seaport in China, it accounts only 1.4% of total cargo handling in Tianjin seaport (American Association of Port Authorities, 2006). However, there are some possibilities to change LOS due to the cargo from LLDCs.

The survey results in section 3.3 (more specifically, Table 3.2) implies that geographic condition might be a factor to be considered for route choice problem. In the interview survey, some of them answered the reason why Vietnamese seaport is not chosen is due to severe geographical condition of Vietnamese side. In LLDCs, it is often found such problem. Thus, the model incorporating geographical condition would be interesting.

7.2.2 Improving to an Analytical Method

Another future scope to the model proposed in this dissertation can raise the reduction in calculation process since the model includes integral calculus. Since this model would be very useful for practical problems in terms of freight transport in LLDCs, it is highly expected to reform to closed-form which includes no integral calculus for estimating expected schedule variability cost. Hence, one of the weakness points of this model is that the amount of calculation process is to be large. Calculation processes can be reduced if the integral calculus is excluded from the model.

7.2.3 Examining Lognormal Distribution in Lao Context

In this dissertation, shipment time at border and seaport are assumed as lognormal distribution based on the facts of other countries context. Actual data of shipment time at the border and seaport were not able to be obtained. Thus, Kolmogorov-Smirnov test which examines goodness-of-fit for distribution shape and Karnel density estimation which estimate the probability density function from the sample data were not conducted. However, it is needed to examine and confirm that shipment time at border and seaport is following lognormal distribution from the actual data.

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APPENDIX A

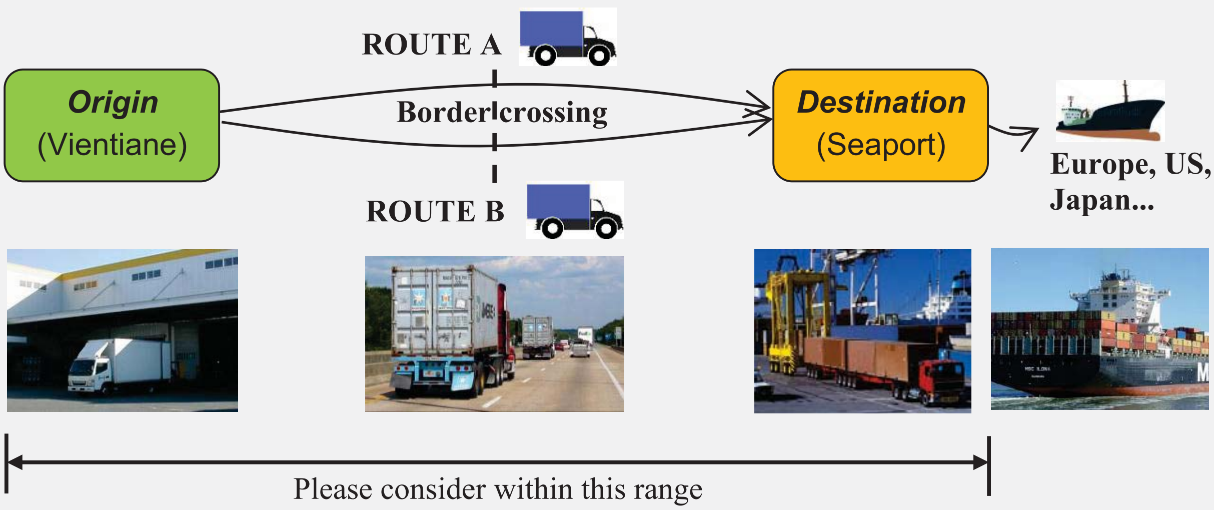
QUESTIONNAIRE FORM FOR VALUATION OF SHIPMENT TIME VARIABILITY

Choice of Shipment Route to Seaport

Now, two routes are available for same origin and destination for inland freight transport. Please choose one route which maximizes your satisfaction. Two routes are differed in terms of shipment cost, average shipment time, variability of shipment time.

Please assume a situation below;

1. You are planning to transport your goods from **Vientiane to Seaport (until loading your goods onto vessel)**
2. Transported goods to seaport will be transported to Europe after the arrival at seaport
3. Your responsibility is transporting goods until loading onto vessel
4. Two routes (ROUTE A and ROUTE B) are available to seaport
5. There are possibilities to arrive early or late due to the unexpected waiting time at border or seaport
6. Transport mode is truck
7. Please choose your preferred ROUTE.



Please choose **ROUTE A** or **ROUTE B**

ROUTE A

Average shipment time: **12 hours**
The shipment cost is **1,500USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **15 hour early**
- **13 hour early**
- **10 hour early**
- **5 hour early**
- **5 hour late**

A ☐

ROUTE B

Average shipment time: **15 hours**
The shipment cost is **1,200USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **on time**
- **15 hour early**
- **13 hour early**
- **10 hour early**
- **5 hour early**

B ✓

Example

Case 1: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	**ROUTE B**
Average shipment time: **14 hours**	Average shipment time: **19 hours**
The shipment cost is **1,700 USD/TEU**	The shipment cost is **1,400 USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **7 hours early**	- **5 hours early**
- **6 hours early**	- **4 hours early**
- **5 hours early**	- **2 hours early**
- **3 hours early**	- **on time**
- **1 hours early**	- **3 hours late**
A ☐	**B** ☐

Case 2: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	**ROUTE B**
Average shipment time: **16 hours**	Average shipment time: **24 hours**
The shipment cost is **1,900 USD/TEU**	The shipment cost is **1,300USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **4 hours early**	- **11 hours early**
- **3 hours early**	- **9 hours early**
- **2 hours early**	- **7 hours early**
- **on time**	- **3 hours early**
- **2 hours late**	- **1 hours late**
A ☐	**B** ☐

Case 3: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	**ROUTE B**
Average shipment time: **16 hours**	Average shipment time: **24 hours**
The shipment cost is **1,700 USD/TEU**	The shipment cost is **1,400 USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **7 hours early**	- **9 hours early**
- **6 hours early**	- **7 hours early**
- **5 hours early**	- **5 hours early**
- **3 hours early**	- **1 hours early**
- **1 hours early**	- **3 hours late**
A ☐	**B** ☐

Case 4: Please choose **ROUTE A** or **ROUTE B**

ROUTE A

Average shipment time: **12 hours**
The shipment cost is **1,700 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **4 hours early**
- **3 hours early**
- **2 hours early**
- **1 hours early**
- **1 hours late**

A ☐

ROUTE B

Average shipment time: **23 hours**
The shipment cost is **1,400 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **11 hours early**
- **9 hours early**
- **7 hours early**
- **4 hours early**
- **on time**

B ☐

Case 5: Please choose **ROUTE A** or **ROUTE B**

ROUTE A

Average shipment time: **12 hours**
The shipment cost is **1,900 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **2 hours early**
- **1 hours early**
- **on time**
- **1 hours late**
- **3 hours late**

A ☐

ROUTE B

Average shipment time: **23 hours**
The shipment cost is **1,300 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **7 hours early**
- **5 hours early**
- **3 hours early**
- **on time**
- **4 hours late**

B ☐

Case 6: Please choose **ROUTE A** or **ROUTE B**

ROUTE A

Average shipment time: **14 hours**
The shipment cost is **1,900 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **5 hours early**
- **4 hours early**
- **2 hours early**
- **on time**
- **2 hours late**

A ☐

ROUTE B

Average shipment time: **19 hours**
The shipment cost is **1,300 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **5 hours early**
- **4 hours early**
- **2 hours early**
- **on time**
- **2 hours late**

B ☐

Case 7: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	ROUTE B
Average shipment time: **12 hours**	Average shipment time: **23 hours**
The shipment cost is **2,100 USD/TEU**	The shipment cost is **1,200 USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **2 hours early**	- **7 hours early**
- **1 hours early**	- **5 hours early**
- **on time**	- **3 hours early**
- **1 hours late**	- **on time**
- **3 hours late**	- **4 hours late**
A ☐	**B** ☐

Case 8: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	ROUTE B
Average shipment time: **14 hours**	Average shipment time: **19 hours**
The shipment cost is **2,100 USD/TEU**	The shipment cost is **1,200 USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **6 hours early**	- **3 hours early**
- **5 hours early**	- **2 hours early**
- **3 hours early**	- **on time**
- **1 hours early**	- **2 hours late**
- **1 hours late**	- **4 hours late**
A ☐	**B** ☐

Case 9: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	ROUTE B
Average shipment time: **16 hours**	Average shipment time: **24 hours**
The shipment cost is **2,100 USD/TEU**	The shipment cost is **1,200 USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **2 hours early**	- **7 hours early**
- **1 hours early**	- **5 hours early**
- **on time**	- **3 hours early**
- **1 hours late**	- **1 hours late**
- **4 hours late**	- **5 hours late**
A ☐	**B** ☐

Case 10: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	**ROUTE B**
Average shipment time: **12 hours** The shipment cost is **2,100 USD/TEU** The shipment has an equal chance of arriving at seaport at any of the following times: - **6 hours early** - **5 hours early** - **4 hours early** - **3 hours early** - **1 hours early** **A** ☐	Average shipment time: **23 hours** The shipment cost is **1,200 USD/TEU** The shipment has an equal chance of arriving at seaport at any of the following times: - **8 hours early** - **6 hours early** - **4 hours early** - **1 hours early** - **3 hours late** **B** ☐

Case 11: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	**ROUTE B**
Average shipment time: **14 hours** The shipment cost is **1,900 USD/TEU** The shipment has an equal chance of arriving at seaport at any of the following times: - **5 hours early** - **4 hours early** - **2 hours early** - **on time** - **2 hours late** **A** ☐	Average shipment time: **19 hours** The shipment cost is **1,300 USD/TEU** The shipment has an equal chance of arriving at seaport at any of the following times: - **5 hours early** - **4 hours early** - **2 hours early** - **on time** - **2 hours late** **B** ☐

Case 12: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	**ROUTE B**
Average shipment time: **14 hours** The shipment cost is **1,700 USD/TEU** The shipment has an equal chance of arriving at seaport at any of the following times: - **3 hours early** - **2 hours early** - **on time** - **2 hours early** - **4 hours late** **A** ☐	Average shipment time: **19 hours** The shipment cost is **1,400 USD/TEU** The shipment has an equal chance of arriving at seaport at any of the following times: - **3 hours early** - **2 hours early** - **on time** - **2 hours early** - **4 hours late** **B** ☐

Case 13: Please choose **ROUTE A** or **ROUTE B**

ROUTE A

Average shipment time: **16 hours**
The shipment cost is **1,700 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **2 hours early**
- **1 hours early**
- **on time**
- **2 hours late**
- **4 hours late**

A ☐

ROUTE B

Average shipment time: **24 hours**
The shipment cost is **1,400 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **7 hours early**
- **5 hours early**
- **3 hours early**
- **1 hours late**
- **5 hours late**

B ☐

Case 14: Please choose **ROUTE A** or **ROUTE B**

ROUTE A

Average shipment time: **16 hours**
The shipment cost is **1,900 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **7 hours early**
- **6 hours early**
- **5 hours early**
- **3 hours early**
- **1 hours early**

A ☐

ROUTE B

Average shipment time: **24 hours**
The shipment cost is **1,300 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **4 hours early**
- **2 hours early**
- **on time**
- **4 hours late**
- **8 hours late**

B ☐

Case 15: Please choose **ROUTE A** or **ROUTE B**

ROUTE A

Average shipment time: **12 hours**
The shipment cost is **1,700 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **4 hours early**
- **3 hours early**
- **2 hours early**
- **1 hours early**
- **1 hours late**

A ☐

ROUTE B

Average shipment time: **23 hours**
The shipment cost is **1,400 USD/TEU**

The shipment has an equal chance of arriving at seaport at any of the following times:

- **6 hours early**
- **4 hours early**
- **2 hours early**
- **1 hours late**
- **5 hours late**

B ☐

Case 16: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	ROUTE B
Average shipment time: **16 hours**	Average shipment time: **24 hours**
The shipment cost is **2,100 USD/TEU**	The shipment cost is **1,200 USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **9 hours early**	- **6 hours early**
- **8 hours early**	- **4 hours early**
- **7 hours early**	- **2 hours early**
- **5 hours early**	- **2 hours late**
- **3 hours early**	- **6 hours late**
A ☐	**B** ☐

Case 17: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	ROUTE B
Average shipment time: **12 hours**	Average shipment time: **23 hours**
The shipment cost is **1,900 USD/TEU**	The shipment cost is **1,300USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **7 hours early**	- **4 hours early**
- **6 hours early**	- **2 hours early**
- **5 hours early**	- **on time**
- **4 hours early**	- **3 hours late**
- **2 hours early**	- **7 hours late**
A ☐	**B** ☐

Case 18: Please choose **ROUTE A** or **ROUTE B**

ROUTE A	ROUTE B
Average shipment time: **14 hours**	Average shipment time: **19 hours**
The shipment cost is **2,100 USD/TEU**	The shipment cost is **1,200 USD/TEU**
The shipment has an equal chance of arriving at seaport at any of the following times:	The shipment has an equal chance of arriving at seaport at any of the following times:
- **5 hours early**	- **10 hours early**
- **4 hours early**	- **9 hours early**
- **2 hours early**	- **7 hours early**
- **on time**	- **5 hours early**
- **2 hours late**	- **3 hours early**
A ☐	**B** ☐

APPENDIX B

SCENARIO ANALYSIS

(DECREASE IN SHIPMENT TIME AT BORDER)

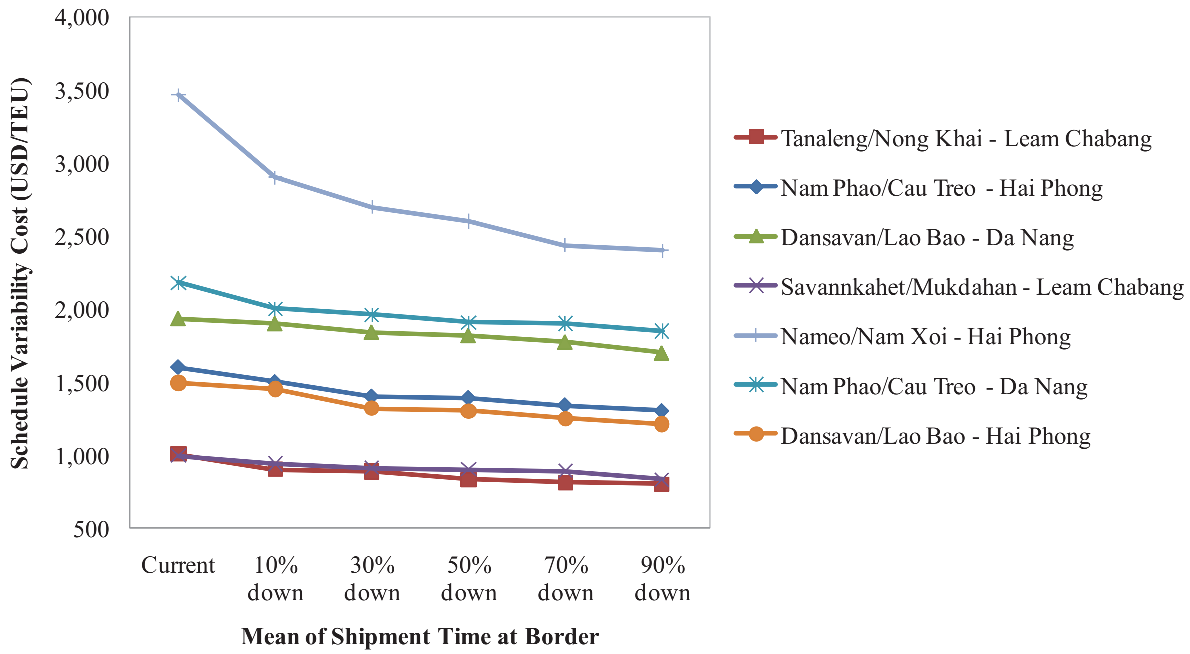


Figure B.1 Change in Schedule Variability Cost due to Decrease in Shipment Time at Border

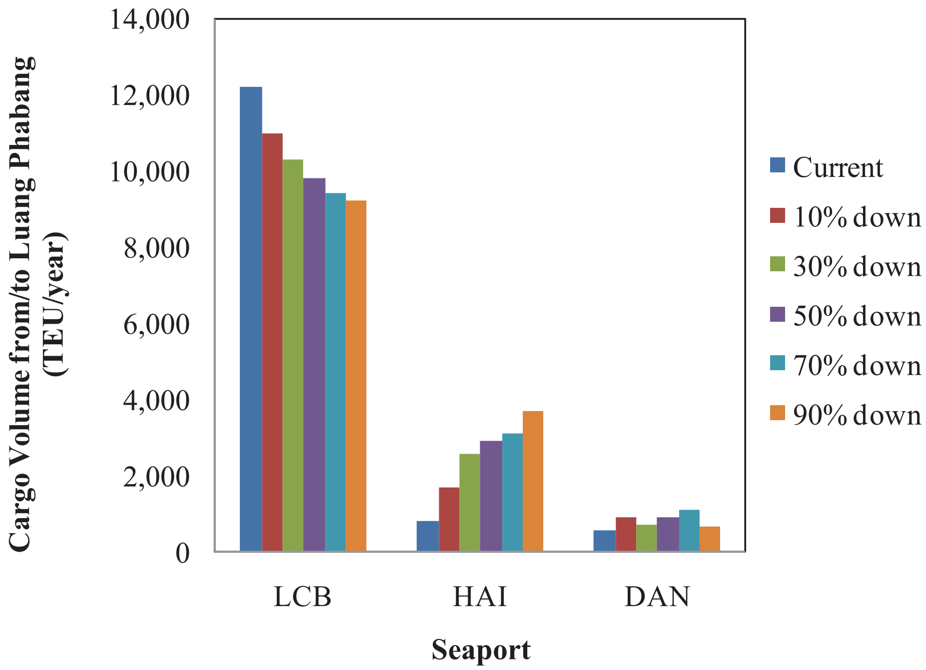


Figure B.2 Change in Seaport Choice from/to Luang Phabang due to Decrease in Shipment Time at Border

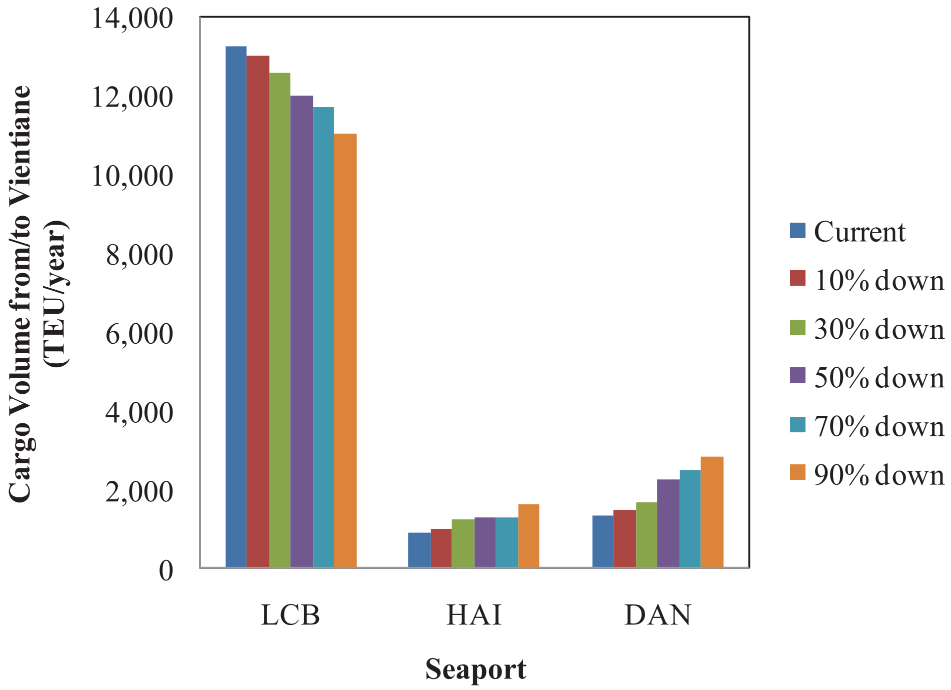


Figure B.3 Change in Seaport Choice from/to Vientiane due to Decrease in Shipment Time at Border

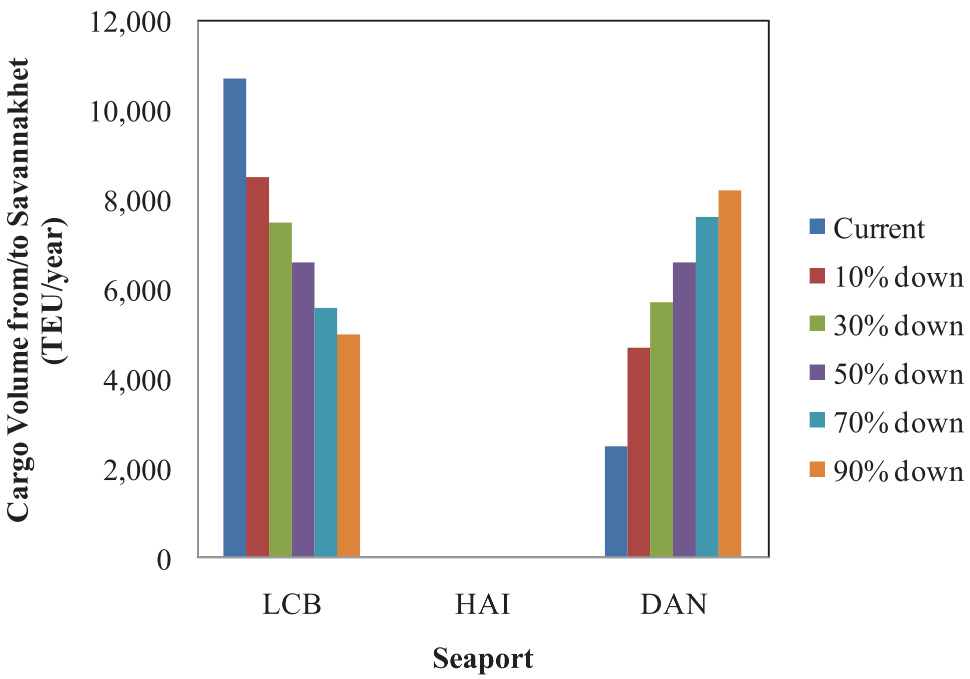


Figure B.4 Change in Seaport Choice from/to Savannakhet due to Decrease in Shipment Time at Border

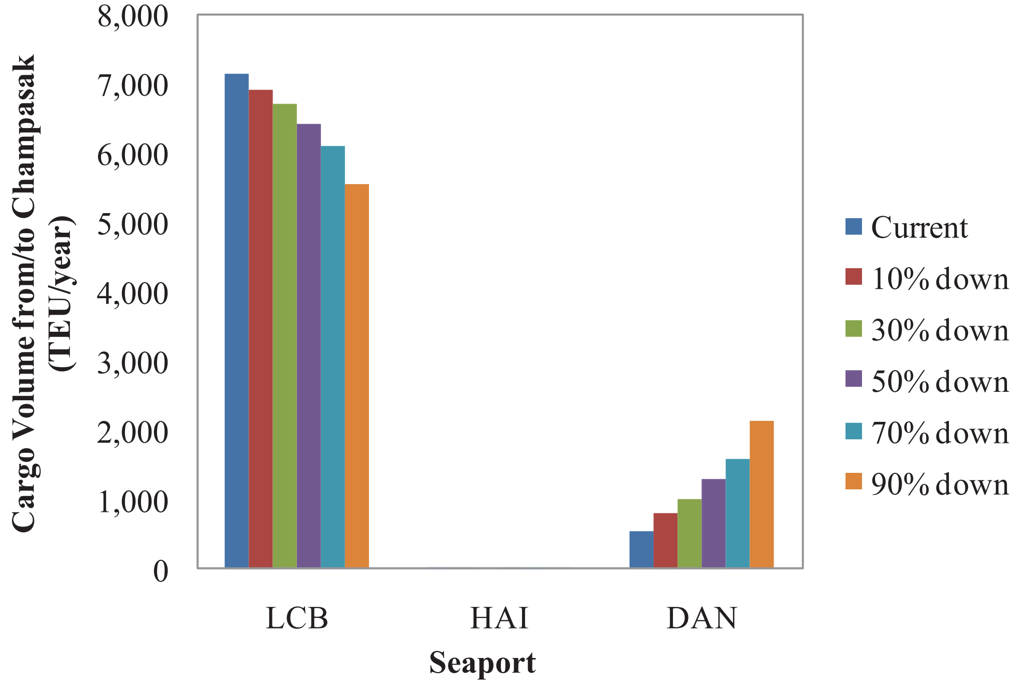


Figure B.5 Change in Seaport Choice from/to Champassak due to Decrease in Shipment Time at Border

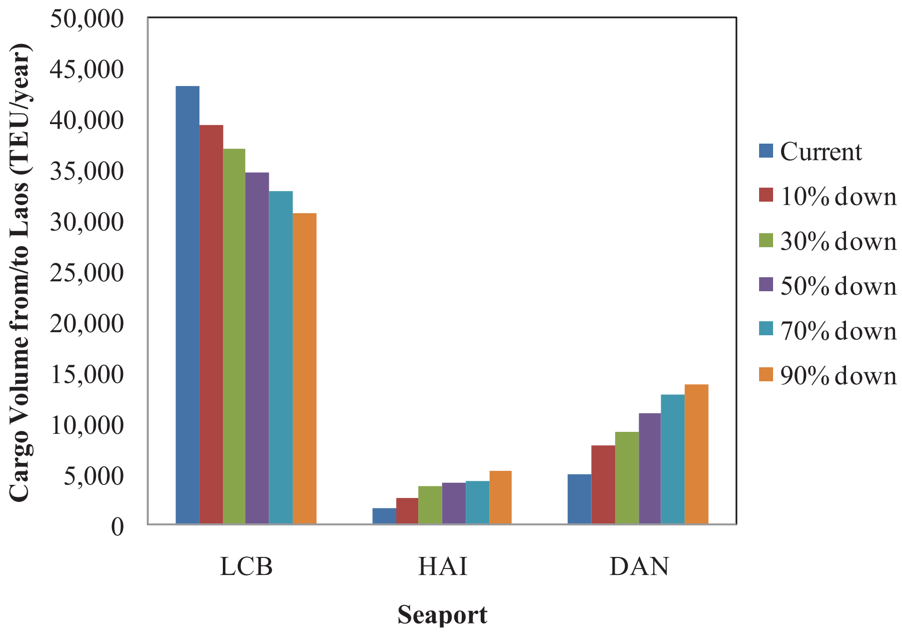


Figure B.6 Change in Seaport Choice from/to Lao PDR due to Decrease in Shipment Time at Border

APPENDIX C

SCENARIO ANALYSIS

(DECREASE IN SHIPMENT TIME AT SEAPORT)

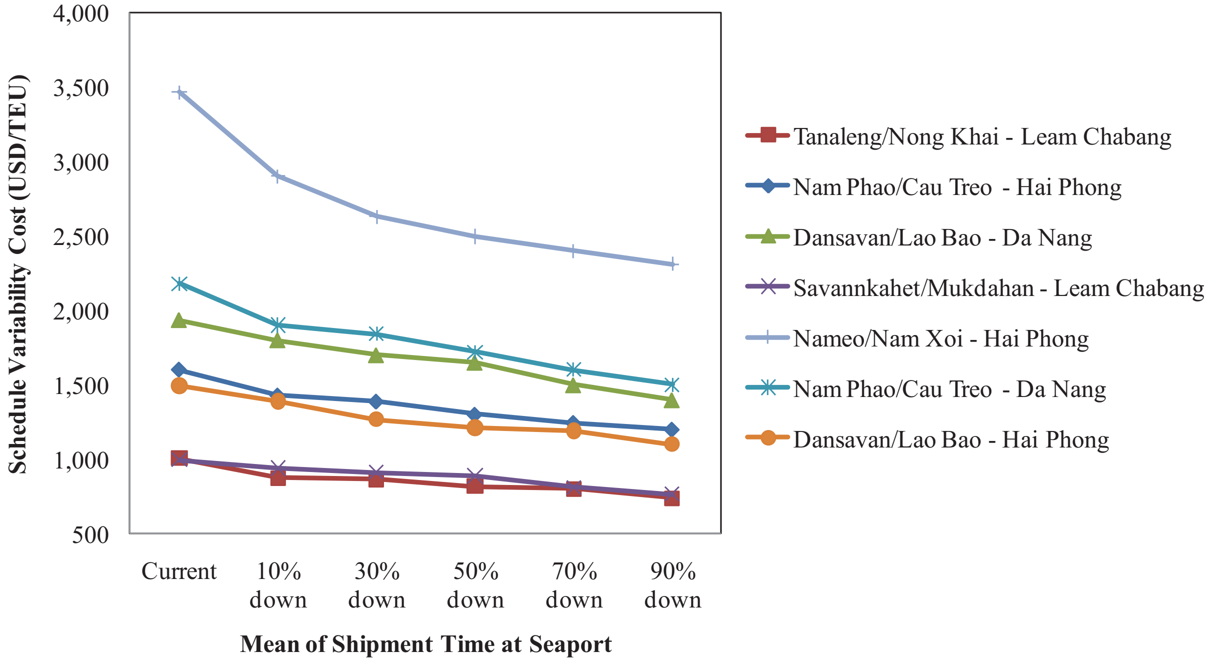


Figure C.1 Change in Schedule Variability Cost due to Decrease in Shipment Time at Seaport

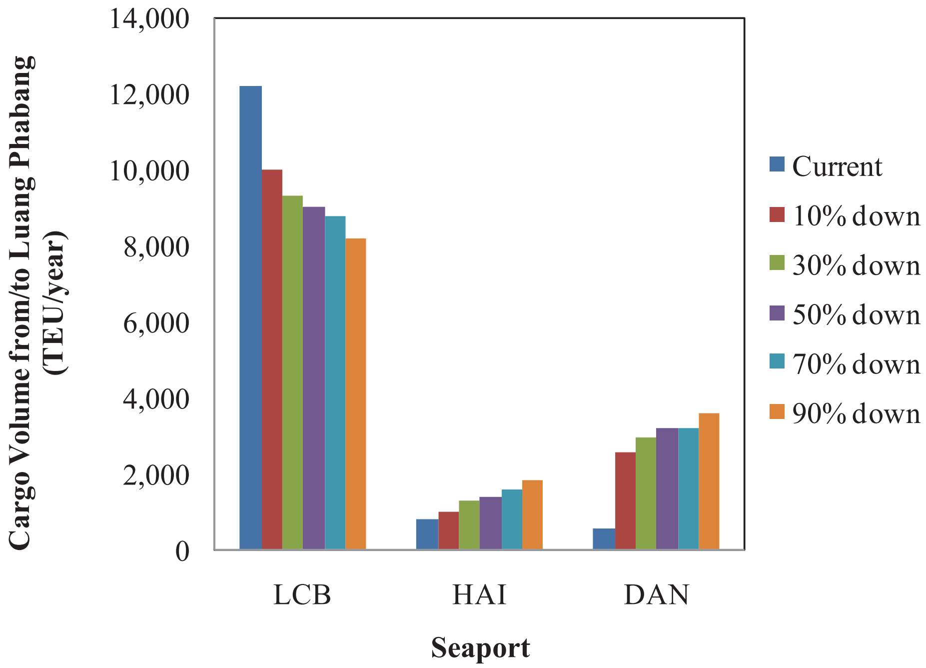


Figure C.2 Change in Seaport Choice from/to Luan Phabang due to Decrease in Shipment Time at Seaport

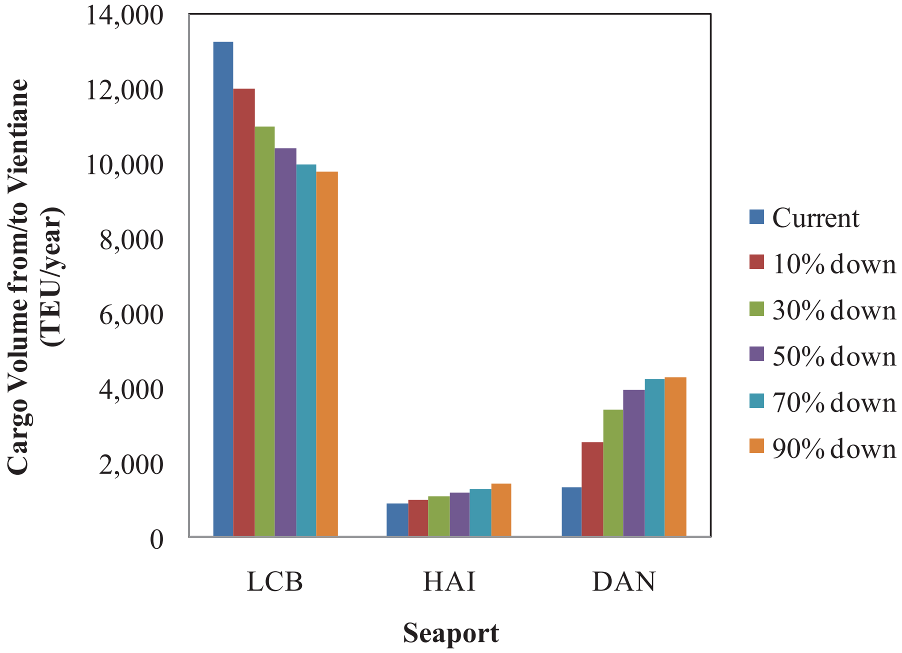


Figure C.3 Change in Seaport Choice from/to Vientiane due to Decrease in Shipment Time at Seaport

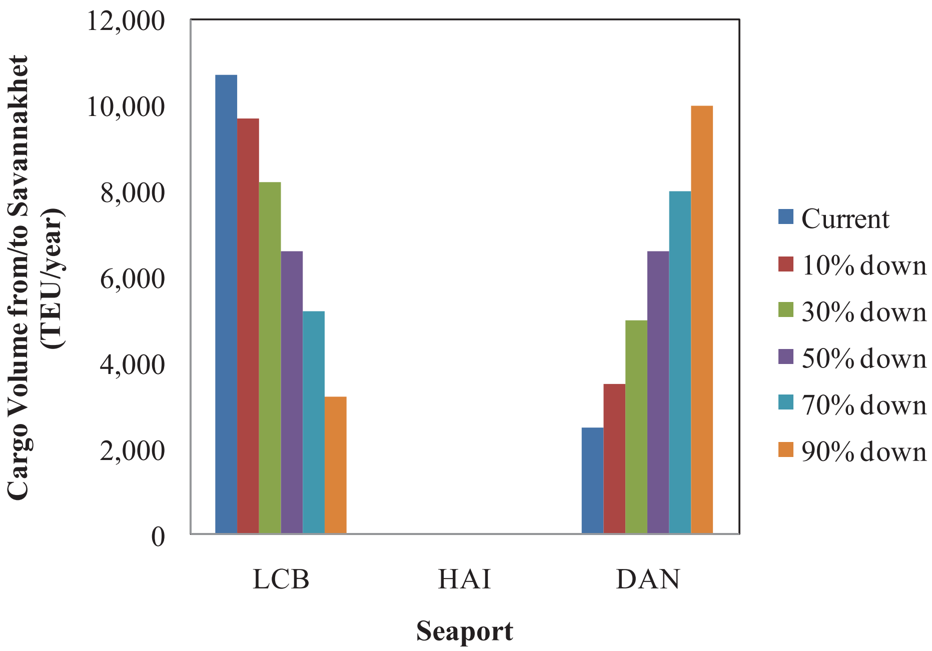


Figure C.4 Change in Seaport Choice from/to Savannakahet due to Decrease in Shipment Time at Seaport

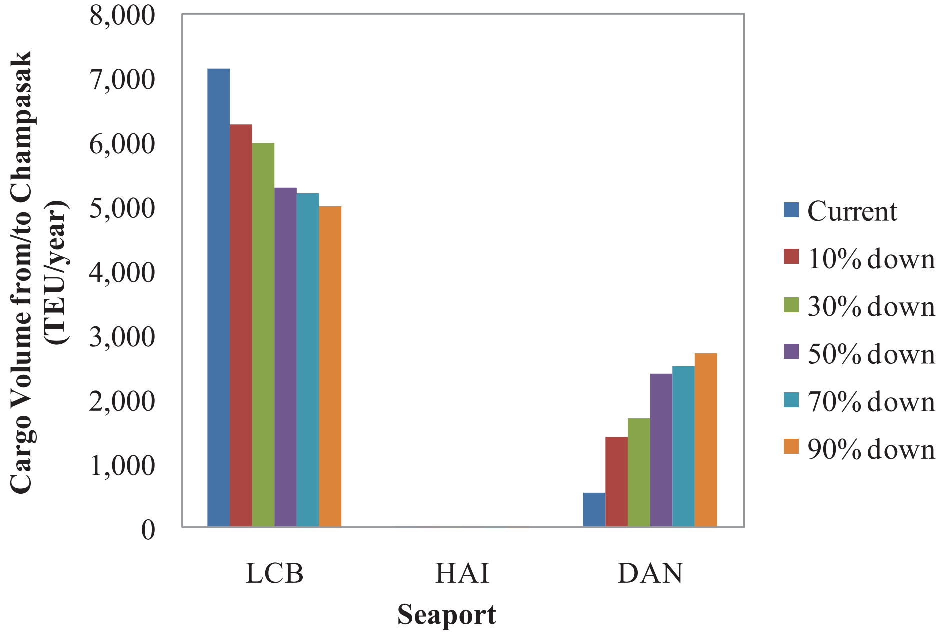


Figure C.5 Change in Seaport Choice from/to Luan Phabang due to Decrease in Shipment Time at Seaport

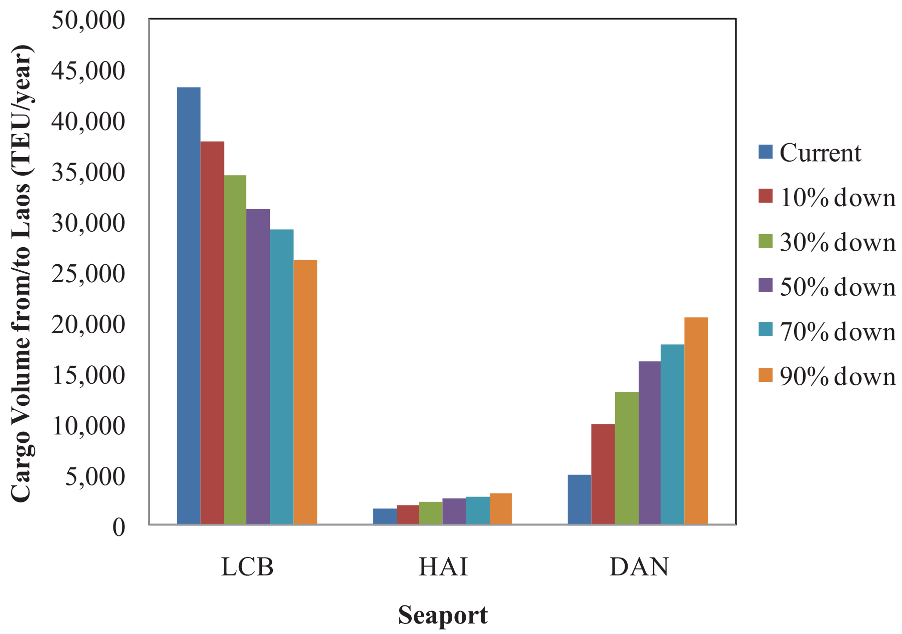


Figure C.6 Change in Seaport Choice from/to Lao PDR due to Decrease in Shipment Time at Seaport

APPENDIX D

SCENARIO ANALYSIS

(DECREASE IN SHIPMENT TIME VARIABILITY AT NAMEO/NAM XOI AND DA NANG SEAPORT)

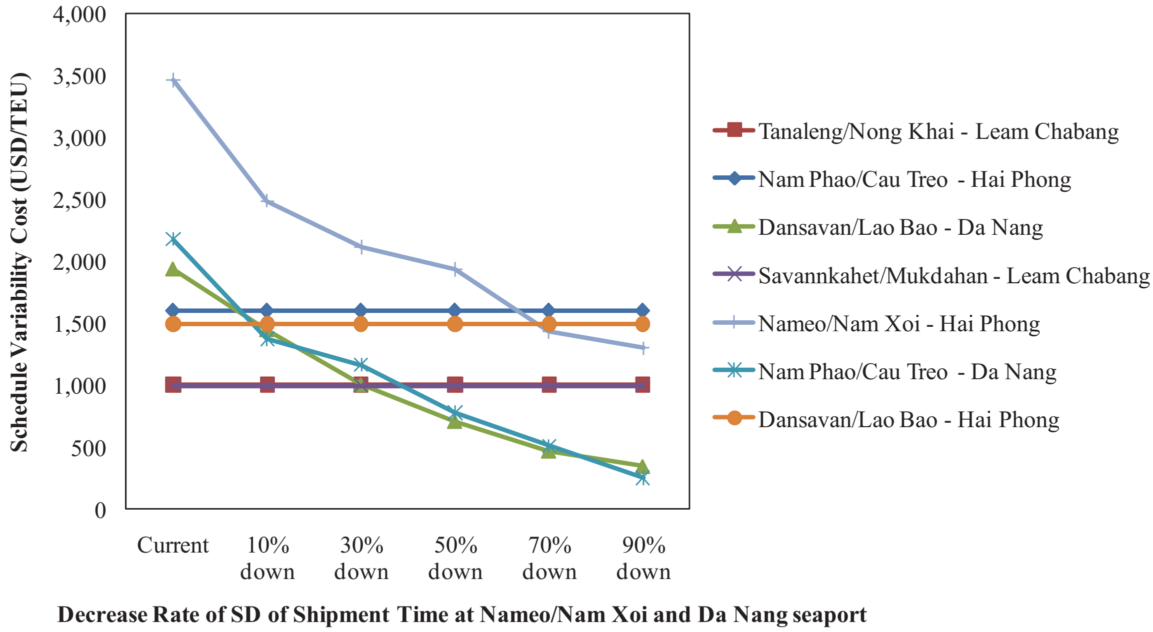


Figure D.1 Change in Schedule Variability Cost due to Decrease in Shipment Time Variability at Nameo/Nam Xoi and Da Nang Seaport

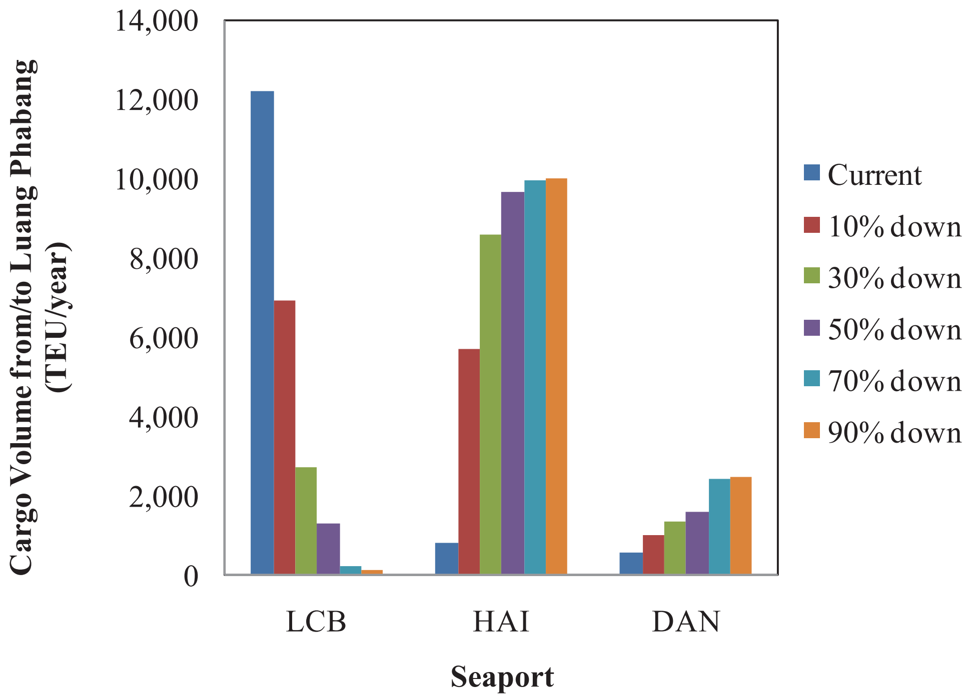


Figure D.2 Change in Seaport Choice from/to Luan Phabang due to Decrease in Shipment Time Variability at Nameo/Nam Xoi and Da Nang Seaport

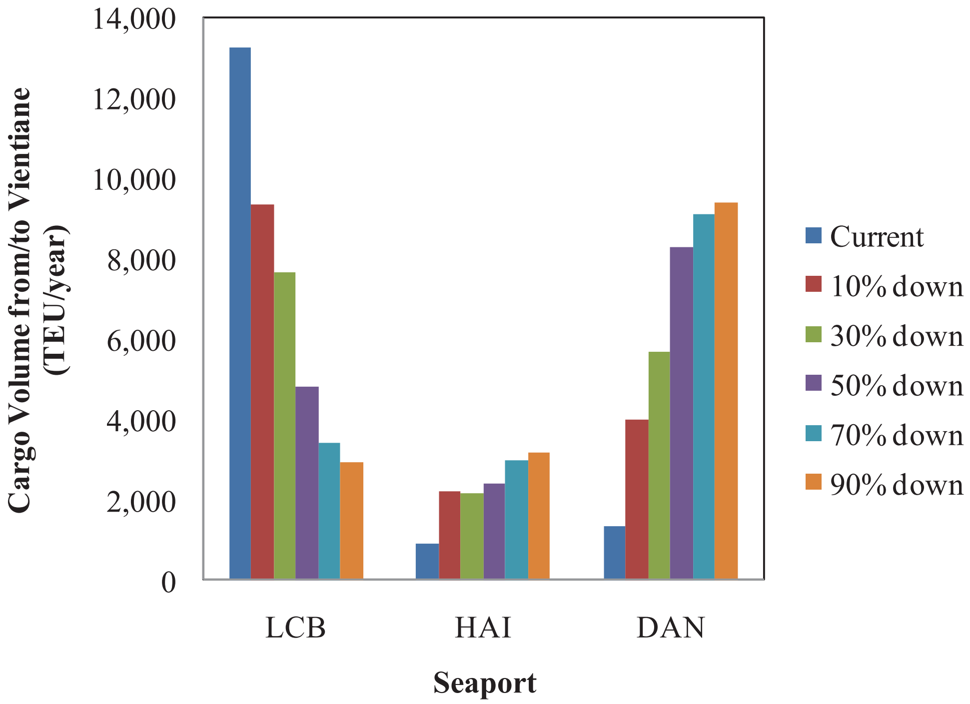


Figure D.3 Change in Seaport Choice from/to Vientiane due to Decrease in Shipment Time Variability at Nameo/Nam Xoi and Da Nang Seaport

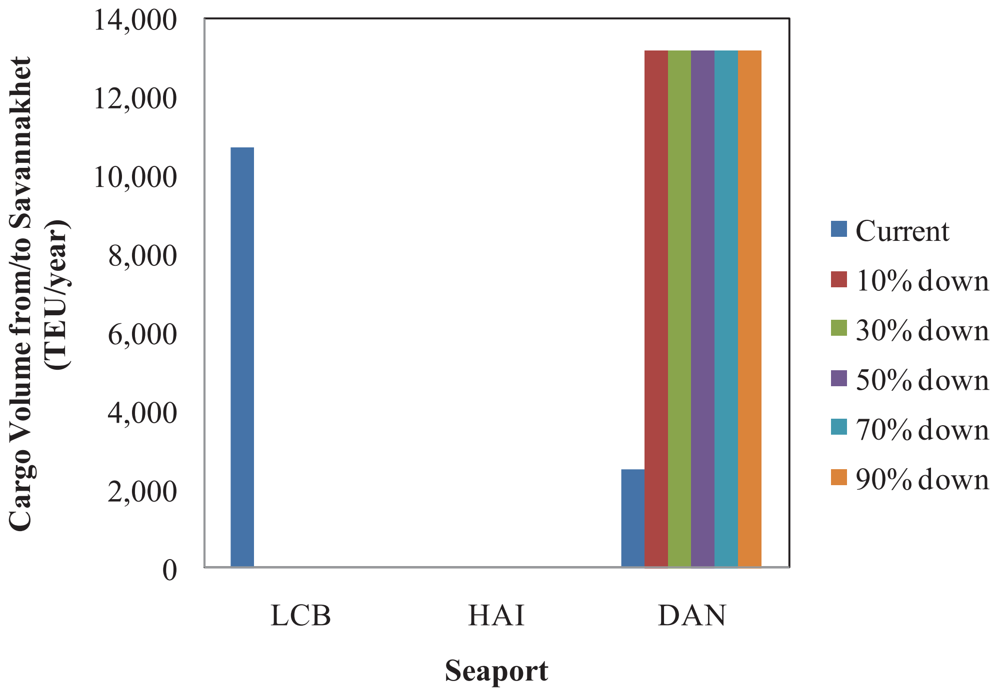


Figure D.4 Change in Seaport Choice from/to Savannakahet due to Decrease in Shipment Variability at Nameo/Nam Xoi and Da Nang Seaport

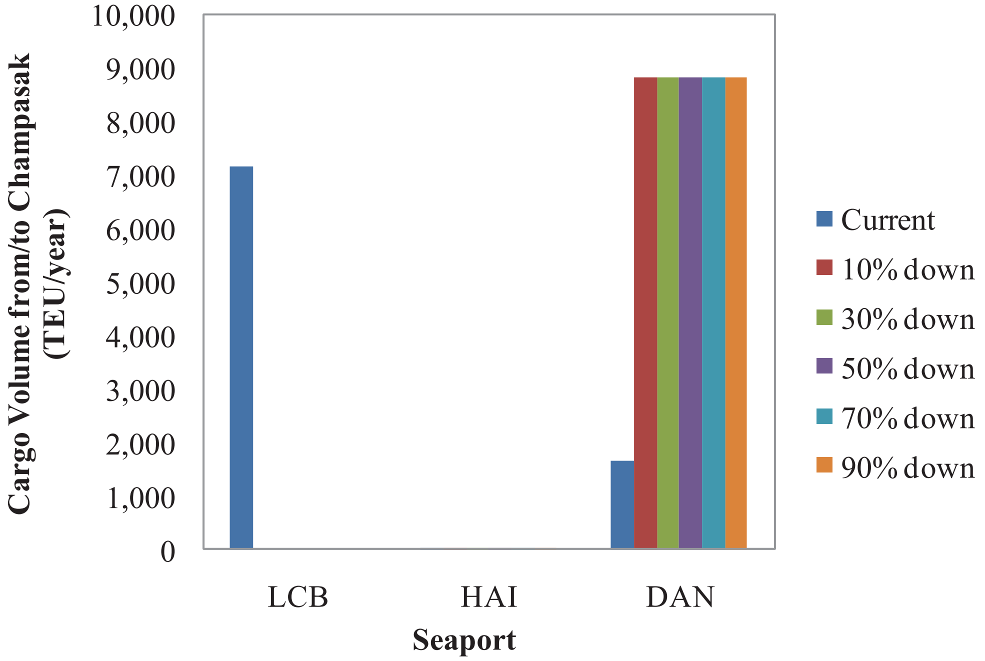


Figure D.5 Change in Seaport Choice from/to Luan Phabang due to Decrease in Shipment Variability at Nameo/Nam Xoi and Da Nang Seaport

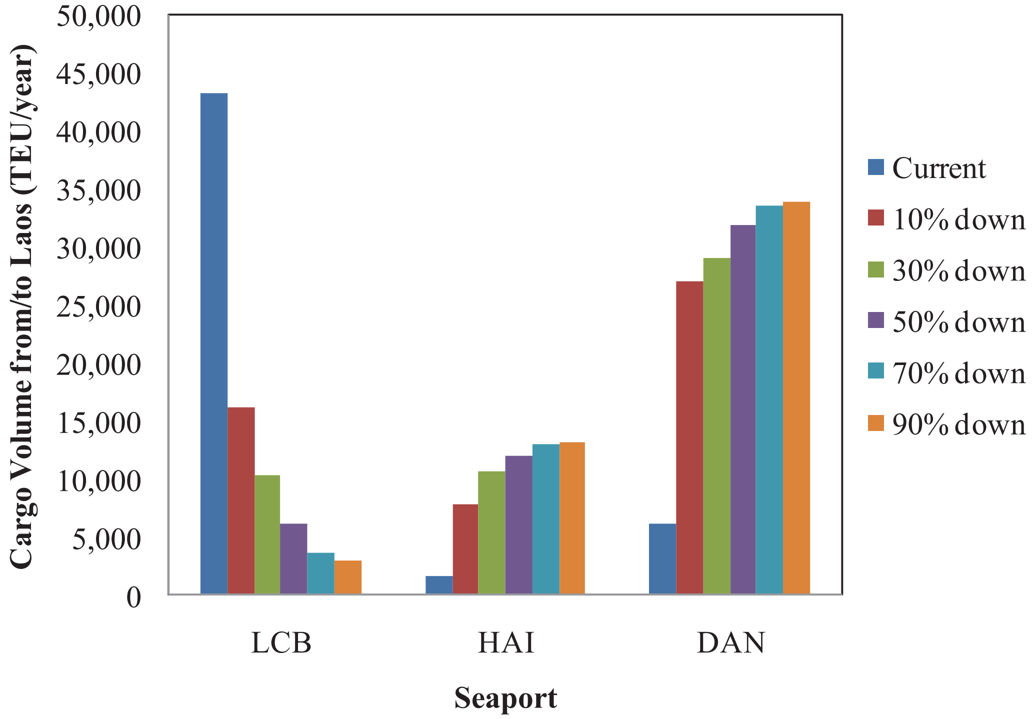


Figure D.6 Change in Seaport Choice from/to Lao PDR due to Decrease in Shipment Variability at Nameo/Nam Xoi and Da Nang Seaport