THAILAND TRANSPORTATION INFRASTRUCTURE PERFORMANCE: DEVELOPMENT AND MEASUREMENT

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Introduction

Geographically, Thailand is located at the centre of the Indochina peninsula in South East Asia. With her strategic location, Thailand is emerging as a major logistics hub to South China and neighboring countries of Indochina. As more Thai businesses engage in international trade in light of the formation of Asian Economic Community (AEC), the improvements in transportation infrastructure and facilities will continue to be mandatory. Therefore, Thailand's government, along with private investors, have for several decades been investing in large civil infrastructure projects throughout Thailand, many of which are aimed at improving the efficiency of logistics operations. (Paraphantakul et al, 2012). Whilst massive investments have been made in the development and upgrading of transportation infrastructure, its performance is still questionable. To the best of our knowledge, no attempt has been made in aggregately evaluating the performance of Thailand's existing transportation infrastructure. This lack of infrastructure performance makes it difficult for Thailand's policy makers to make effective decisions on future infrastructure development projects (Thailand Infrastructure Annual Report, 2008).

This research addresses the problem of determining the efficiency of the existing transportation infrastructure in Thailand. Specifically, a set of performance indicators of Thailand's transportation infrastructure performance is proposed. Related available data are reviewed and gathered. A national composite index of transportation infrastructure performance is developed to account for the overall performance. The last part of the research is dedicated to aggregately investigating the performance of Thailand's transportation infrastructure during 2005-2010.

Literature Review

Thailand Transportation Infrastructure

Transportation infrastructure is one of the factors enhancing country's competitiveness. Thailand has been rated in the top four of infrastructure quality assessment including transportation infrastructure performance among ASEAN countries following Singapore, Malaysia and Brunei, respectively (Schwab, 2011). To account for all possible modes of transportation for both passengers and freights, the transportation infrastructure addressed in this research is decomposed into 5 categories including road, rail, air, water and transit.

Land transport is the most widely used mode of transportation in Thailand, accounting for approximately 80% of domestic transportation (Ministry of Commerce, 2011). In terms of international transportation, it tends to increase as there is demand for more linkages among ASEAN countries and China. Road infrastructure comprising motorways, national highway and all other highways, becomes the major mode for the movement of goods domestically, accounting for 80% (Ministry of Commerce, 2011). Rail infrastructure encompasses transportation by diesel engine railway on single, dual and triple rail tracks. This also includes all transport activities within the Inland Container Depot (ICD) at Ladkrabang and Bangsue Railway Junction. Air transportation infrastructure represents the infrastructure associated with six major international airports of Thailand, including Suvarnabhumi Airport (Samutprakarn), Donmuang Airport (Bangkok), Chiang Mai Airport, Chiang Rai Airport, Phuket Airport and Hatyai Airport (Songkhla). In 2011, international and domestic transportation of goods via airport accounts for 0.3% and 0.02%, respectively. It also takes up a 6% share of passenger transportation.

Waterway transportation infrastructure accounts for facilities in association with five main international ports in Thailand, including Bangkok Port, Laem Chabang Port (Chonburi Province), Mabtaput Port (Rayong Province), Sriracha Port (Chonburi Province) and Songkhla Port. In 2011, marine transport has a substantial share of 88% of international freight transportation (Ministry of Commerce, 2011). Mass transit transportation in Thailand can be classified into 3 categories, including public bus services, rail-based mass transit systems, and bus rapid transit (BRT) system. Transit transportation infrastructure covers infrastructure for public transport under the management of the Transport

Company Limited and Bangkok Mass Transit Authority, Metropolitan Rapid Transit system (MRT), Bus Rapid Transit system (BRT), Bangkok mass transit system (BTS) and Airport Link.

Transportation Infrastructure Performance Assessment

Many researchers have proposed transportation infrastructure performance measurement tools to assess the efficiency of existing infrastructure, to identify areas for improvement, and to use the obtained data to effectively communicate with relevant stakeholders. Bogetić and Fedderke (2006) conducted a comprehensive performance assessment of South Africa's infrastructure, one of which is transportation using the World Bank database. This research intends to systematically benchmark its infrastructure with other countries using objective and perception-based indicators. Since, it could identify such country's strengths and weaknesses relatively, the outcome is applicable to infrastructure development policy and its strategic direction.

Several researches focus on assessing infrastructure performance of a particular transportation mode. For instance, Humphreys et al. (2002) review current practice in the performance of airports comprising business, service and environmental aspects. The study identified the factors that have influenced the performance of airport such as traffic profile, location, and so forth. It concludes that a great understanding of an airport's context is prerequisite before conducting a performance measurement and comparing performance with other airports.

Langen et al. (2007) reviewed existing indicators and proposed a new set of indicators for measuring port performance by exploring indicators used in leading port authorities and similar infrastructure such as airports and industrial parks. It suggests that with the use of the most suitable set of indicators, performance measurement can play a critical role in enhancing the efficiency of the port.

Kunadhamraks and Hanaoka (2007) proposed fuzzy set techniques to evaluate the logistics performance of intermodal transportation in Thailand. They recorded data and structured them as hierarchy framework, based on 4 criteria, i.e. logistics cost, service quality, reliability and security. The results assert that the lack of coordination among modes limit the attractiveness of intermodal system.

Ahren and Parida (2009) studied the factors influencing the railway infrastructure performance. They developed a conceptual overall railway infrastructure effectiveness model to be applied with Swedish rail network. The model considers 3 dimensions including infrastructure availability, performance rate (total time), and quality rate (reliability and safety). The findings indicate that the proposed model can be implemented as a key performance indicator for supporting the decision making process.

Hermans et al. (2009) studied risk factors related to road safety performance, and proposed a procedure for constructing a road safety performance index. The methodological step includes selecting appropriate indicators, collecting and analyzing data, assigning a weight and aggregating indicators, testing the robustness of index, and computing the final index scores. This method provides a comprehensive tool in conducting performance measurement.

The U.S. Chamber of Commerce initiates a project to study the relationship between infrastructure performance and economic growth. The project started in 2010 to undertake the study of "Infrastructure Index: Measuring and Benchmarking Infrastructure Performance" under the Let's Rebuild America project, aiming to develop index to measure the efficiency of the U.S. infrastructure, and to determine how it affects the economy. The procedural steps for constructing the indices include defining each mode of transportation infrastructure, identifying representative samples, creating hierarchy model, selecting appropriate indicators, compile data and weighting, and lastly calculating the index. Indicators used for transportation infrastructure performance index of the United States of America are available in the study of "Measuring and Benchmarking Performance" (U.S. Chamber of Commerce, 2010).

Some Thai researchers studied the effect of infrastructure investment on economic growth. Bussarakam (2004) investigated the relationship between transportation infrastructure investment and Thailand's gross domestic product. The paper also analyzed the impact of private and public funds on 3 sectors including agriculture, industrial and service sector by using Ordinary Least Square Method. The result shows a variety of relationships, for example, public investment has no effect on industrial productivity while private does.

Jorsa (2008) studied how transportation infrastructure investment affects the growth of each economic sector (agricultural, industrial and service). It is concluded that not all the investment would go in the same direction as economic growth. For example, the investment of air transportation infrastructure will have an effect on agricultural sector growth after the investment has initiated for 3 years. However, it is found that the investment has no impact on industrial and service sector.

While the two previous research papers studied the relationship between transportation infrastructure investment and economic growth, they have yet to conduct an assessment of Thailand's transportation infrastructure performance.

Research Methodology

The methodology used in this research is based on the comprehensive seven-step process developed in the study of the U.S. Chamber of Commerce. To measure infrastructure performance, 3 criteria were set, comprising Supply (availability, proximity and coverage), Quality of Service (convenience, reliability and safety) and Utilization (capacity for future demand). These criteria are aligned with the objective of performance measurement, which mainly involves with effectiveness and reliability aspects (Bogetić & Fedderke, 2006).

Identifying Transportation Performance Indicators

In developing a set of performance indicators in the context of Thailand, there are some issues, which necessitate the adjustment of each indicator. Firstly, the measurement units used in Thailand is different from those used in the U.S. For example, in the case of Thailand, Railway Utilization is measured by 2 indicators: the number of passengers and freight volume per 100 track kilometer. Secondly, measurement in some indicators is not applicable in the context of Thailand. For example, the U.S. port congestion is measured by lock delay per tow whereas no lock is used in Thailand. As a result, unit of measurement is hereby altered to average waiting time for docking (Chavaviwat, 2012). Furthermore, the word "marine transport" is replaced by "waterway" in this study to include not only the sea and ocean transport but also inland water transport such as river. Lastly, unlike the U.S., intermodal facilities in Thailand are operated by railway authorities. That is, the ICD in Ladkrabang is under the management of the State Railway of Thailand, and therefore is included in the set of railway indicators.

After the TPI framework for Thailand is completely constructed, the next step is to collect past data for all performance indicators. The most critical issue arisen in the data collection process is the unavailability of data for some indicators in the TPI framework due to various factors e.g. no evidence of data collection exists in any associated government authorities. Consequently, some indicators that contain insufficient data were excluded.

Weighting Indicators

For index calculation, each indicator is to be weighted using a well-known multi-criteria decision analysis technique, the Analytical Hierarchy Process (AHP), based on select experts' managerial judgment and experience. The AHP was developed by Thomas L. Saaty for addressing problems that entail multiple criteria decision making. This technique has been implemented in various areas of research such as alternatives evaluation, resource allocation, planning and development, priority and ranking, forecasting, and performance benchmarking (Vaidya and Kumar, 2006). While the AHP consists of three key steps: (1) decomposition; (2) comparative judgments; and (3) synthesis of priorities (Korpela and Tuominen, 1996), only step 2 was adopted in this research to calculate indicator weights. The phase of comparative judgment is designed to determine the relative importance of each indicator through a series of pairwise comparisons.

In the process of weighting indicators, the AHP questionnaires were purposively sent out to Thailand's experts in the field of transportation and logistics to distinguish relative importance of each indicator. Particularly, the questionnaire sheet demands the experts to carry out pairwise comparisons of the indicators with respect to the level of importance based on a nine-point scale as suggested by the AHP. Data obtained from the questionnaires are then input into a matrix form to compute the weights (see Saaty (2002) for an overview of the AHP).

Research Findings

Framework of Transportation Infrastructure Performance Index (TPI)

Thailand Transportation Infrastructure Performance Index (TPI) framework developed in this research is shown in Table 1.

Mode	Criteria	Indicator Identification	Indicator	Source	Availability
Road	Supply	ID1	Road density	Department of Highways and Department of Rural Roads	2001-2010
	Quality of service	ID2	Road Travel Time Reliability		N/A (1)
		ID3	Road Safety		2001-2010
		ID4	Road Roughness		2004-2010
		ID5	Bridge Integrity	Bureau of Bridge Construction	2011 (2)
	Utilization	ID6	Road utilization	Department of Highways and Department of Rural Roads	1999-2010
Railway	Supply	ID7	Railway Density	The State Railway of Thailand	2000-2010
	Quality of service	ID8	Railway Safety		2003-2010
	Utilization	ID9	Passenger's Railway Utilization		2005-2011
		ID10	Freight's Railway Utilization		2005-2011
Airway	Supply	ID11	Proximity of airports (Access)	Airport Authority of Thailand and Department of Civil Aviation	N/A (1)
		ID12	Availability of airport services (Capacity)		2011(2)
	Quality of service	ID13	Airport Congestion		2011 (2)
		ID14	Airport Safety		N/A (4)
	Utilization	ID15	Air Transportation Utilization		2005-2010
Waterway	Supply	ID16	Waterway Density	Marine Department	2000-2010
		ID17	Proximity of Ports (Access)	Port Authority of Thailand and private operators of 15 terminals at Laem Chabang Port	N/A (1)
	Quality of service	ID18	Port Congestion		N/A (4)
Transit	Supply	ID19	Transit Density	The Transport Company Limited, Bangkok Mass Transit Authority, BTS, MRT, BRT	2004-2011
	Quality of service	ID20	Transit Safety		N/A (3-4)
	Utilization	ID21	Transit Utilization		2004-2011

Table 1: Thailand's Transportation Infrastructure Performance Index, Data source and Availability

Figure 1 demonstrates the assessed weights of the indicators as perceived by the select experts.

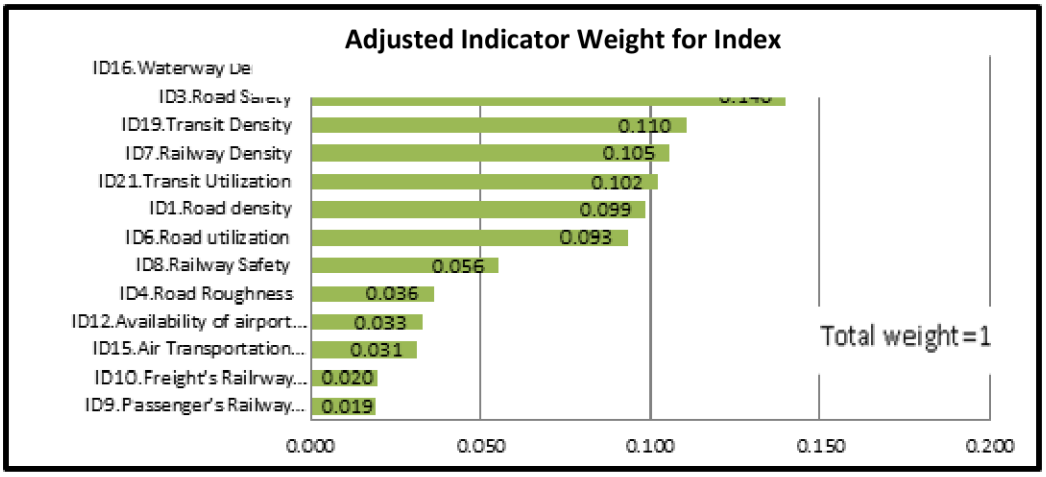

Figure 1: Indicator weights

Before calculating transportation performance index (TPI) for each year, which includes each indicator with its associated weight, all data must be normalized to transform indicators from original measures to a common scale. This step is crucial due to different scale and objective base of each indicator. For instance, higher road density indicates better performance while higher airport congestion reflects poorer quality of service. Hence, Simple Linearization Method as employed in the work of the U.S. Chamber of commerce (2010) is adopted to adjust each indicator to a scale from zero to one, where one represents the best performance. However, in this calculation, each indicator can be used only with available data including year 2005-2010.After conducting the analysis and developing Thailand Transportation Infrastructure Performance Index (TPI), the relative performance results for 2005-2010 are demonstrated in Figure 2.

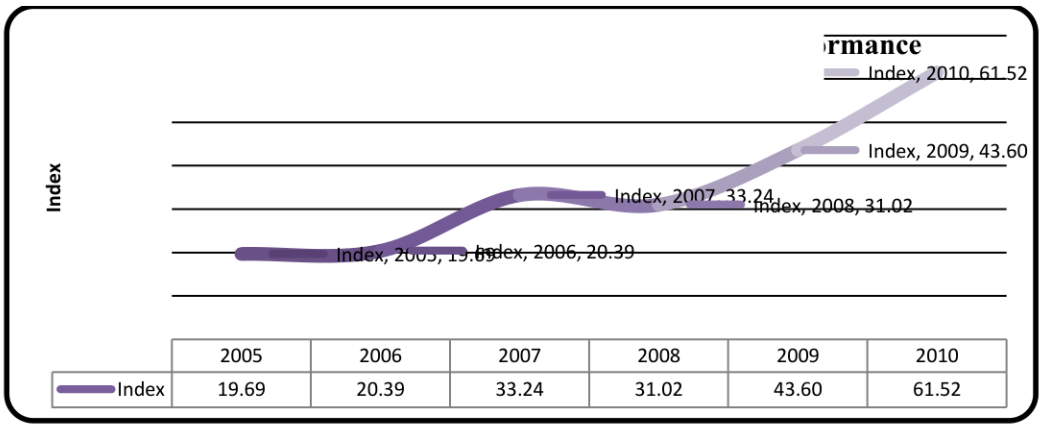

Figure 2: Thailand Transportation Infrastructure Performance Index

The result shows that TPI had been continuously increasing from 19.69 in 2005 to 61.52 in 2010. This positive growth results from the following factors:

- The government authorities had been focusing on infrastructure development in accordance w ith the country's logistics master plan under international cooperation framework, e.g. the Grea ter Mekong Subregion (Banomyong, 2008).
- The budget for investment had been increased in order to maintain, enhance, and increase th e efficiency of infrastructure. According to strategic objective of the Ministry of Transport, the b udget for developing the country's infrastructure was increased by more than 700,000 million b aht from 2006 to 2008 (Ministry of Transport, 2008).

Conclusion

One of the most crucial components affecting Thailand competitiveness and economy is transportation infrastructure performance. This research developed Transportation Infrastructure Performance Index (TPI) to assess the efficiency of Thailand's transportation infrastructure. According to the study, TPI had been continuously improving from 19.69 in 2005 to 61.52 in 2010, indicating significant performance improvement. However, some constraints encountered in the data collection stage, i.e. data unavailability, post limitations to the results of this research. Due to the incomplete data set, TPI in this research was calculated based on only 13 indicators.

As mentioned earlier, it is very significant that all relevant authorities should routinely collect all associated data, which comprise 21 indicators on transportation infrastructure performance framework, in a systematic manner in order to develop more comprehensive TPI. Moreover, realizing which type of infrastructure creates more impact on TPI could be beneficial for the improvement of overall transportation infrastructure performance. It provides the snapshot to help prioritize each infrastructure development plan. This area therefore should to be further studied and analyzed in the context of Thailand's transportation infrastructure.

In conclusion, benefits derived from this research consist of understanding of the tool to use as a measurement framework for assessing transportation infrastructure performance in the context of Thailand; recognition of the roles and responsibilities of the related agencies in collecting statistical data of each significant indicator and to compile all necessary data that has never been collected or completed. Future extensions include the development of a model that can investigate the relationship between TPI and Thailand's economy as well as emphasize its importance to Thailand's economic growth.

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