Kasetsart Journal of Social Sciences 39 (2018) 320–327

Contents lists available at ScienceDirect

Kasetsart Journal of Social Sciences

journal homepage: http://www.elsevier.com/locate/kjss

Identifying factors affecting the success of rail infrastructure development projects contributing to a logistics platform: A Thailand case study

Waralee Peetawan [a, *], Kamonchanok Suthiwartnarueput [b, 1]

[a] *Logistics Management Program, Graduate School, Chulalongkorn University, Bangkok 10330, Thailand*
[b] *Faculty of Commerce and Accountancy, Chulalongkorn University, Bangkok 10330, Thailand*

ARTICLE INFO

Article history:
Received 1 April 2016
Received in revised form 19 October 2016
Accepted 7 November 2016
Available online 18 May 2018

Keywords:
fuzzy AHP,
logistics platform,
rail infrastructure development projects,
Thailand,
transportation

ABSTRACT

This research identified factors affecting the success of rail infrastructure development projects contributing to Thailand's logistics platform. Projects included in this research were double tracking the existing railways and the construction of new routes. Most projects were in the preparatory stage. The researchers extracted 24 factors from the literature review and categorized them into five dimensions. AHP and fuzzy AHP were deployed and leading success factors were identified. It was found that a rail development master plan has the highest influence on a project's success. The researchers recommend that the Thai government should establish a large-scale, long-term, integrative rail master plan for not only freight transport but also passenger services, since both cannot be solely developed. Along with the initiation of the rail master plan; stimulation should proceed in parallel on: a transit-oriented development scheme; promotion of local market development for a rail parts and assembly industry; implementation of public-private partnerships; and the institution of a new rail regulative agency.

Introduction

Thailand has encountered a continuous recession in railroad usage for several years. Before the 2000s, investment in rail infrastructure was not encouraged. Major investments during 1980–2000 were mainly infrastructure improvements and maintenance with few double tracking and triple tracking projects. The awakening of the government's concern about the country's high logistics cost per gross domestics product (GDP) with a low proportion of freight transported by rail (approximately 2% of freight transported domestically) has pushed the National Economic and Social Development Board (NESDB) to launch national logistics strategies and a master plan to bring down the cost by 2 percent by 2020. The Ministry of Transport (MOT), which has played an important part in achieving NESDB's goal, finally turned its focus on rail development after over four decades of highway development concentration.

Over the last 10 years, the MOT has initiated many rail infrastructure development projects. However, a shift in government's policies resulted in instable project direction and administration. The public also questioned the capability of State Railways of Thailand (SRT) to handle mega projects. Most importantly, impacts on the country's logistics system, cost, and performance are still in doubt. Therefore, this research aimed to identify the factors affecting the success of rail infrastructure development

* Corresponding author.
E-mail addresses: waralee_pee@utcc.ac.th (W. Peetawan), kamonchanok.s@chula.ac.th (K. Suthiwartnarueput).
Peer review under responsibility of Kasetsart University.
[1] Co-first authors.

https://doi.org/10.1016/j.kjss.2018.05.002
2452-3151/

projects contributing to Thailand's logistics platform by using the analytical hierarchy process (AHP) and to propose recommendations for rail infrastructure development projects in the future.

The contents of this research are arranged as follows. The first section is the research introduction; the second section describes the railway development background in Thailand and includes a related literature review; the third section illustrates the associated rail infrastructure development projects, AHP model, calculation assumptions and the approach for AHP and fuzzy AHP; the fourth section presents the results from calculations; the fifth section discusses the results and implications; and the last section presents conclusions and future studies.

Background and Literature Review

Background

The first railway in Thailand was built in 1891, linking Bangkok (the capital city of Thailand) to Nakhon Ratchasima (a major city in the northeast). The construction was completed in 1896 and the first train operations started immediately. During the 1900s–1940s, railroads were the most popular mode of transportation in Thailand and investment in rail infrastructure was intensified. By 1946, Thailand had 3,258 km of railroad network which connected 46 provinces. Rail infrastructure and operations were regulated by the Department of State Railway, a government agency.

After the end of World War II, the Department of State Railway was transformed to a state enterprise following a World Bank recommendation in 1951. Investment in Thailand's transportation infrastructure shifted from rail to road in accordance with the country's economic and social development plans. Most rail investment was to repair and maintain the existing infrastructure. There were some double and triple tracking railroads projects during the 1990s but no new networks were added.

During the 2000s, the government turned its attention to rail infrastructure development because of the low proportion of domestic freight transported by rail and the high logistics cost per GDP (14.2% in 2014). In 2012, the Ministry of Finance proposed a Bill Authorizing Loan for Transportation Infrastructure Investment. It was expected that the new transportation infrastructure could lower the national logistics cost per GDP by at least 2 percent.

However, due to recent change in cabinets, the direction of rail infrastructure development has been unsettled. Additionally, one of factors hindering the project's administration in the past came from SRT, which is the state enterprise that initiates and administers rail projects, maintains rail infrastructure, and operates inter-city rail passenger and freight services. A state enterprise review indicated SRT had an operating loss with a total accumulated net loss of THB 104,003 million (approximately USD 2,962 million) and consequently had a critical operating status (State Enterprise Policy Office [SEPO], 2015). The amount of domestic freight carried by rail during 2004–2015 dropped by 18 percent (Figure 1). The maintenance center of SRT reported that the proportion of locomotives available for operations was approximately 70 percent as of March 2016 (SRT, 2016a). About 80 percent of rolling stock could be used for freight transportation in 2015 (SRT, 2016b). Other operating performance parameters, including train punctuality, load factors, assets valuation, and investment management ability, were all below the targets set and evaluated by TRIS Corporation Limited under the regulation of SEPO, Ministry of Finance (SEPO, 2015). An attempt was made to restructure SRT's debt as well as to sustainably improve SRT's performance. In December 2009, the cabinet approved the new SRT organizational structure to establish three new business units: rail operations, maintenance, and assets management.

After the organizational restructure, the MOT and its think tank agency, the Office of Transport and Traffic Policy and Planning (OTP) continued to legislate for a new government agency to regulate rail transport (Ministry of Transport, 2016). The transformation should encourage SRT's operations and the rail operations' market at the same time. It is expected that the transformation should eliminate approximately three quarters of SRT's debt, especially debt from infrastructure investment since the infrastructures and associated assets will be transferred to the government. The MOT is currently drafting the act to establish the Department of Rail Transport or DRT (Ministry of Transport, 2016).

Literature Review

Common research tools used in rail operations are either optimization models for network and capacity problems or mathematical models with cost and price functions. Little research has been associated with rail infrastructure development, investment, and policy using surveys or a literature review, or a combination of both.

Semi structured interviews were used by Lehies (2012) whose research presented the implementation and

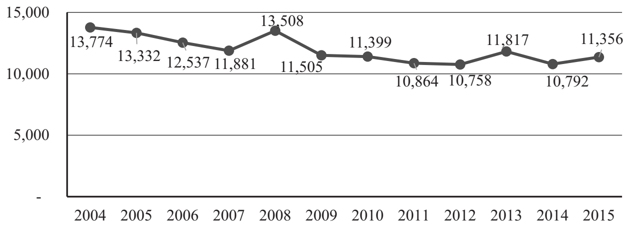

Figure 1 Volume of domestic freight carried by rail 2004–2014 (unit: thousand tonnes)

decision making process of high speed trains in France as well as key innovative mechanisms for Mediterranean TGV-line projects. Rodemann and Templar (2014) also used semi-structure interviews and case studies from a literature review to identify enablers and inhibitors associated with Eurasian intermodal rail freight under six dimensions: political, economic, social, technical, legal, and environmental.

Through a literature review, Ferreira (1997) illustrated linkage between infrastructure needs, specific benefits, and major impacts on Australian freight rail investment. Banister and Thurstain-Goodwin (2011) reviewed case studies to identify non-transport benefits incurred by rail investment. Rangarajan, Long, Tobias, and Keister (2013) also suggested the social factors associated with transportation infrastructure projects based on a literature review. Sustainability factors of Malaysian transportation infrastructure projects were explored by Amiril, Nawawi, Takim, and Ab Latif (2014).

In addition to surveys and a literature review, AHP is another technique used in assessing factors or risks associated with a transportation scheme. This approach is “a multi-criteria decision making tool that uses an Eigen value approach to pair-wise comparisons” (Vaidya & Kumar, 2006) to assess the relative importance of elements in the same level of hierarchy as well as to evaluate options at the end of the hierarchy. Elements in the same level of hierarchy affect one another but there is no connection between elements in different hierarchical levels. Sipahi and Timor (2010) listed applications of AHP, which ranged from the manufacturing and transportation industries to agriculture, environmental management, and general decision problems.

Application of fuzzy theory with AHP was introduced by Van Laarhoven and Pedrycz (1983). Fuzzy triangular numbers were used in place of priority weights in general AHP. Buckley (1985), Chang (1992, 1996), and Cheng, Yang, and Hwang (1999) proposed distinct fuzzy triangular numbers for priority weight calculations and computational steps.

Nassi and de Carvalho da Costa (2012) applied AHP to evaluate a transit fare system. Awasthi and Chauhan (2011) used the same approach together with the Dempster-Shafer theory to assess the impact of sustainable transport in medium-sized cities. Lee, Wu, Hu, and Flynn (2013) discovered the critical success factors for waterfront redevelopment using AHP and the analytical network process (ANP).

Kunadhamraks and Hanaoka (2008) evaluated the logistics performance of intermodal transportation in Thailand (in a network from the port of Laem Chabang to an inland container depot at Lat Krabang) using fuzzy AHP and fuzzy-multi-criteria analysis (fuzzy-MCA). Nguyen, Nguyen, Le-Hoai, and Dang (2015) also applied factor analysis and fuzzy AHP to quantify the complexity in transportation projects in Vietnam.

Factors, benefits, enablers, and inhibitors from the above literature can be categorized into seven dimensions as shown in Table 1, with economic; social and community, and environmental and energy being the most prevalent dimensions. The context and tools in each study do not appear to be similar from one research project to the next. Although research on infrastructure development projects has been conducted, none dealt specifically with a railway context as in this research.

Scope, Model and Methodology

Scope

This research was not restricted in its focus to projects stemming from a particular government policy but included all rail infrastructure development projects that have contributed to the country's logistics platform. After completing the construction of the 14 double tracking railway projects and nine new railway construction projects, the Thai railroad network will be 60 percent larger than the existing network, with a total railroad distance of 6,463 km.

Model

The AHP model comprised five dimensions and 24 factors as illustrated in Figure 2. Factors were drawn from the literature review. The importance of factors was quantified using a survey containing pairwise comparison questions. Participants were asked to identify the relative influence between five dimensions (criteria) and 24 factors (sub-

Table 1
Dimensions used in transportation project planning, investment, and evaluation

Dimension	Number of references where mentioned	Authors
Economic	7	Ferreira (1997), Kunadhamraks & Hanaoka (2008), Awasthi & Chauhan (2011), Banister & Thurstain-Goodwin (2011), Lee et al. (2013), Amiril et al. (2014), and Rodemann & Templar (2014)
Social/Community	7	Awasthi & Chauhan (2011), Banister & Thurstain-Goodwin (2011), Lee et al. (2013), Rangarajan et al. (2013), Amiril et al. (2014), Rodemann & Templar (2014), and Nguyen et al. (2015)
Environment/Energy	6	Ferreira (1997), Awasthi & Chauhan (2011), Banister & Thurstain-Goodwin (2011), Amiril et al. (2014), Rodemann & Templar (2014), and Nguyen et al. (2015)
Transport/Infrastructure/Operations	5	Ferreira (1997), Kunadhamraks & Hanaoka (2008), Awasthi & Chauhan (2011), Banister & Thurstain-Goodwin (2011), and Nguyen et al. (2015)
Political	2	Rodemann & Templar (2014) and Nguyen et al. (2015)
Administration	2	Amiril et al. (2014) and Nguyen et al. (2015)
Technical/Technology/Engineering	3	Amiril et al. (2014), Rodemann & Templar (2014), and Nguyen et al. (2015)

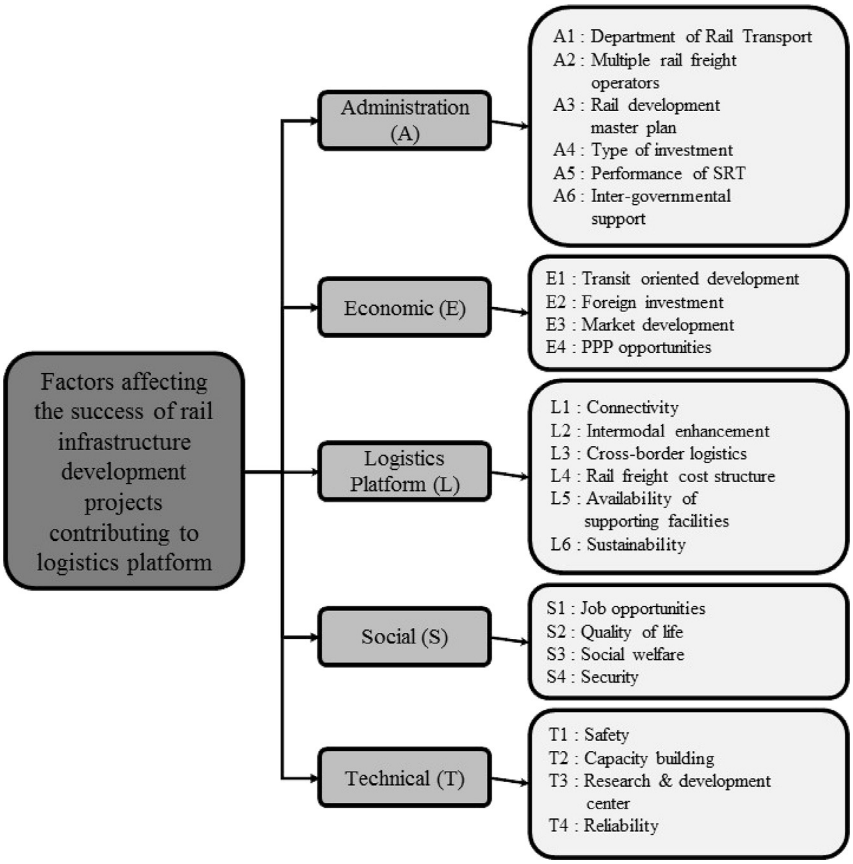

Figure 2 AHP model

criteria) by using a nine-point scale, where nine indicated extreme influence (one element will influence a given element nine times more than another does) and one indicates equal influence (all elements have equal influence on a given element). A detailed explanation of each factor follows.

Administration

Department of Rail Transport (A1): A new government agency under the MOT will initiate rail infrastructure projects and regulate all rail operations including electrified trains in Bangkok. SRT will remain its role as a rail operator.

Multiple rail freight operators (A2): Private sector is allowed to invest in and operate rail service business on SRT's network by paying an access charge.

Rail development master plan (A3): A master plan on rail development policy that focuses on the country's logistics infrastructure should be established by stakeholders. This long-term planning is supposed to shape the country's rail policy for the next 2–3 decades.

Type of investment (A4): Investment options are foreign government funding, Thai government investment, turnkey, public-private partnership (PPP), and private sector investment.

Performance of SRT (A5): The extended network will eliminate transportation bottlenecks and support SRT to increase rail freight volume, operating performance, and profits.

Inter-governmental support (A6): Support from foreign governments including cooperative planning, funding, and technical assistance.

Economic

Transit oriented development or TOD (E1): Property development on residential and business projects will attract more passengers into the rail transit system where stations can be conveniently accessed.

Foreign investment (E2): Route expansion and better infrastructure will draw foreign investment to areas with rail connectivity.

Market development (E3): Opportunities for domestic market expansion and growth in related businesses and industries such as sleepers, signaling, telecommunication, electrified systems, spare parts, and final assembly of rail cars and locomotives.

PPP opportunities (E4): Opportunities for a PPP scheme on rail infrastructure development to lessen public debt from mega investment.

Logistics Platform

Connectivity (L1): Network expansion increases domestic and international inter-city linkages.

Intermodal enhancement (L2): Opportunities to establish intermodal terminals in particular areas such as the port of Map Ta Phut, Chiang Kong, and Nakhon Phanom.

Cross-border logistics (L3): Facilities for cross-border trading that are developed and well-maintained to ensure convenience in freight movement activities.

Rail freight cost structure (L4): Changes in the rail freight cost structure as well as the rail freight rate to be more profitable for SRT and rail operators.

Availability of supporting facilities (L5): Sufficient and efficient container yards, inland container depots, and container freight stations in appropriate locations for higher freight volumes and movements.

Sustainability (L6): Higher use of rail leading to greener transportation, less CO_2 and greenhouse gas emissions, and higher energy efficiency.

Social

Job opportunities (S1): Opportunities for national and local jobs come with the construction and operation of rail infrastructure development.

Quality of life (S2): A better railroad network brings about economy of speed and town urbanization. People can live in suburban areas instead of in overcrowded cities.

Social welfare (S3): Free trains for people with low income. With the extended network, more people will gain social benefits from the free trains and class three trains.

Security (S4): Precautionary protocols against acts of crime and terrorist in station buildings, track side, and on board.

Technical

Safety (T1): Advanced rail technology installed through rail infrastructure development will yield higher operating safety and minimize derailment and associated accidents.

Capacity building (T2): Technical training and educational programs to create experts in rail planning, construction and operations.

Research and development center (T3): Encourage regional and local research and development activities as well as technology transfer so that, in the future, Thailand can reduce its reliance on technology and technical support from other countries.

Reliability (T4): Train delays and unexpected incidents can be minimized through well-planned operations and better technology.

Methodology

Data Collection

Data collection was conducted in two stages: pilot and final. The first stage involved experimental data collection to verify that all factors derived from the literature review could be included in the model. Five rail development and policy experts were asked to fill in the questionnaire as well as provide comments. All five agreed that the factors were sufficient and valid.

The final data collection took place during September–November 2015. Target participants were drawn from three different sectors: government, academia, and the private sector. Fourteen respondents in the government sector provided representation from the Ministry of Finance, the MOT (Office of the Permanent Secretary, OTP, and SRT), NESDB, National Sciences and Technology Development Agency, and the World Bank. Twelve respondents were selected from academia consisting of university lecturers and independent researchers. Eleven respondents in the private sector were drawn from commercial banks, rail project consultants, construction companies, rail manufacturers, rail equipment distributors, and rail operators. The average working experience of respondents was 15.07 years. Most respondents from the government and private sectors worked in management and at the executive level, with proportions of 55 percent and 30 percent, respectively. Furthermore, 60 percent of respondents in the government sector worked at the management level and 30 percent worked at the executive level.

AHP and Fuzzy AHP

The calculation of local and global weights for AHP followed the approach proposed by Saaty (1980). A response was declared invalid if any pairwise comparison matrix showed inconsistency. The consistency ratio (CR) was computed by dividing the consistency index (CI) by the random index (RI). CI was calculated from weights in the pairwise comparison matrix while RI was a standard number established by Saaty (1980) (Table 2). In a response, if any CR value exceeded 0.10, that response was unusable.

In this research, fuzzy AHP scales were adapted from the fuzzy scales used by Deng (1999), Tesfamariam and Sadiq (2006), and Nguyen et al. (2015) (Table 3). It should be noted that a fuzzy scale of 1 was set as (1, 1, 3) for the lower, middle, and upper scales, making the difference between the upper and middle scales equal to two. For scale 9, the fuzzy scales were set as (7, 9, 11). Fuzzy scales of both 1 and 9 were the same as the membership functions used by Deng (1999). For other fuzzy scales, the difference between the upper and middle scales (or fuzzification factor) was one, the same as used by Tesfamariam and Sadiq (2006) and Nguyen et al. (2015).

The calculation of the consistency ratio for fuzzy AHP was the same as for AHP. The defuzzification process followed the extent analysis method proposed by Chang (1992, 1996). First, compute the values of the fuzzy synthetic extent. Second, apply the degree of possibility to calculate the local weights. Third, determine the weight vector. Lastly, normalize the weight vector which yields the final local weights.

Results and Discussion

Results

Out of 37 responses, 30 responses were usable, having a consistency ratio of less than 0.10. There were 10 participants representing each sector. Table 4 shows the calculated local and global priority weights in AHP and fuzzy AHP. The local weights were calculated within the same hierarchy and yielded a total value of 1.00000 for all weights calculated in the same dimension. Global weights were the final weights used to determine the significance of

Table 2
Random Indices (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Table 3
Fuzzy AHP scales

AHP Scale	Fuzzy AHP Scale	Definition
1	(1,1,3)	Equal importance
3	(3-Δ,3,3+Δ)	Weak importance
5	(5-Δ,5,5+Δ)	Essential or strong importance
7	(7-Δ,7,7+Δ)	Demonstrated importance
9	(7,9,11)	Extreme importance
2,4,6,8 (x)	(x-Δ, x, x+Δ)	Intermediate values between two adjacent judgments
1/x	(1/(x+Δ), 1/x, 1/(x-Δ))	

Δ is a fuzzification factor and in this case equals 1

each factor, and were calculated by multiplying the local weights of a dimension by the local weight of the factor laid in that dimension. While the local weights of both AHP and fuzzy AHP showed slight differences, the similarities among the global weights of both approaches were greater.

Although both AHP and fuzzy AHP yielded similar rankings at the local weights level, the global weights of both approaches generated different results (Table 5). The following discussion is based on the results of fuzzy AHP, which suited the model better than the crisp AHP as the rail infrastructure projects are managed under uncertain circumstances.

Discussion

In the dimensional level, administration was weighted the highest among the five dimensions, followed by economic, logistics platform, social and technical, respectively. The rail development master plan (A3), TOD (E1), rail freight cost structure (L4), quality of life (S2), and safety (T1) were identified as the leading factors in each dimension.

Overall, the rail development master plan (A3) was identified as the leading success factor, from which it can be interpreted that a large-scale, long-term rail plan together with project stability is required for success of the rail construction project. However, establishing a master plan is not a simple process, as it necessitates strong collaboration among government agencies. Several countries have

Table 4
AHP and fuzzy AHP results

Dimension	AHP		Fuzzy AHP				
	Local Weight	Global Weight	Triangular Numbers			Local Weight	Global Weight
			Upper	Middle	Lower		
A	0.30554		0.56432	0.29687	0.14345	0.30549	
E	0.24500		0.50172	0.24879	0.12315	0.26842	
L	0.20817		0.43196	0.20816	0.10037	0.21520	
S	0.12832		0.31290	0.12923	0.06279	0.11669	
T	0.11297		0.29264	0.11696	0.05629	0.09419	
Factor							
A1	0.19313	0.05901	0.23384	0.05952	0.01365	0.18953	0.05790
A2	0.16952	0.05180	0.20499	0.04788	0.01091	0.18094	0.05528
A3	0.28124	0.08593	0.29765	0.08041	0.01900	0.28324	0.08653
A4	0.15608	0.04769	0.20856	0.04693	0.01008	0.16063	0.04907
A5	0.11918	0.03641	0.17107	0.03908	0.00953	0.12354	0.03774
A6	0.08085	0.02470	0.12961	0.02305	0.00508	0.06213	0.01898
E1	0.31023	0.07601	0.32392	0.07560	0.01788	0.30352	0.08147
E2	0.14277	0.03498	0.20727	0.03744	0.00820	0.14419	0.03870
E3	0.25287	0.06195	0.28946	0.06604	0.01570	0.25913	0.06955
E4	0.29414	0.07207	0.32520	0.06971	0.01462	0.29317	0.07869
L1	0.19898	0.04142	0.18457	0.04333	0.01016	0.19779	0.04256
L2	0.18482	0.03847	0.17433	0.04006	0.00960	0.18448	0.03970
L3	0.07897	0.01644	0.09363	0.01683	0.00373	0.06221	0.01339
L4	0.25630	0.05335	0.20425	0.05086	0.01211	0.26257	0.05651
L5	0.12715	0.02647	0.12636	0.02549	0.00593	0.12999	0.02797
L6	0.15379	0.03201	0.13934	0.03159	0.00787	0.16296	0.03507
S1	0.29636	0.03803	0.19069	0.03331	0.00666	0.27409	0.03198
S2	0.35998	0.04619	0.23660	0.04602	0.00997	0.37304	0.04353
S3	0.17252	0.02214	0.15304	0.02487	0.00518	0.18011	0.02102
S4	0.17113	0.02196	0.15650	0.02504	0.00540	0.17276	0.02016
T1	0.39665	0.04481	0.21826	0.04508	0.01012	0.39386	0.03710
T2	0.20439	0.02309	0.16046	0.02701	0.00571	0.20374	0.01919
T3	0.13924	0.01573	0.11580	0.01628	0.00340	0.13281	0.01251
T4	0.25972	0.02934	0.17111	0.02859	0.00622	0.26959	0.02539

Table 5
AHP and fuzzy AHP rankings

Dimension	AHP		Fuzzy AHP	
	Weight	Rank	Weight	Rank
A	0.30554	1	0.30549	1
E	0.24500	2	0.26842	2
L	0.20817	3	0.21520	3
S	0.12832	4	0.11669	4
T	0.11297	5	0.09419	5
Factor				
A1	0.05901	5	0.05790	5
A2	0.05180	7	0.05528	7
A3	0.08593	1	0.08653	1
A4	0.04769	8	0.04907	8
A5	0.03641	14	0.03774	13
A6	0.02470	19	0.01898	22
E1	0.07601	2	0.08147	2
E2	0.03498	15	0.03870	12
E3	0.06195	4	0.06955	4
E4	0.07207	3	0.07869	3
L1	0.04142	11	0.04256	10
L2	0.03847	12	0.03970	11
L3	0.01644	23	0.01339	23
L4	0.05335	6	0.05651	6
L5	0.02647	18	0.02797	17
L6	0.03201	16	0.03507	15
S1	0.03803	13	0.03198	16
S2	0.04619	9	0.04353	9
S3	0.02214	21	0.02102	19
S4	0.02196	22	0.02016	20
T1	0.04481	10	0.03710	14
T2	0.02309	20	0.01919	21
T3	0.01573	24	0.01251	24
T4	0.02934	17	0.02539	18

established their rail development master plans for both passengers and freight. The Kingdom of Saudi Arabia has issued the Saudi Railway Master Plan (SRMP), a rail passenger and freight development plan from 2010 to 2040, covering their railway network of 9,900 km. Under regulation of Saudi Railways Organization, several policies are applied in the master plan, namely public-private partnership, the sharing of responsibilities among associated rail transport sectors, multimodal transportation system, regional and global market development, and transport infrastructure.

The second ranked success factor, TOD (E1), suggests that rail freight transport has to be implemented with rail passenger transport. By providing access to rail stations and creating commercial and property development opportunities, more passengers will be drawn into rail transport systems. Interestingly, the respondents considered that passengers with freight such as parcels and a luggage service on passenger trains can stimulate rail logistics when implementing a TOD scheme.

The third ranked success factor, market development (E3), indicates the demand for rail industrial growth. Although local companies can manufacture concrete sleepers and specific rail parts, the proportion of rail-associated products that can be produced domestically is small. Research funded by the Office of Industrial Economics, Ministry of Industry and conducted by the Transport Institute of Chulalongkorn University in 2009 described possible rail product categories for local manufacturing and assembly. Therefore, strong and stable government support is needed to encourage the private sector to invest in the rail industry (Office of Industrial Economics, 2009).

PPP opportunities (E4) was ranked fourth in the success factors, pinpointing that investment in rail development projects should not only be handled by the government but also by the private sector. Although the investment options for most of the rail infrastructure development projects included in this research have been finalized, the respondents still supported PPP. Furthermore, the type of investment also influences the success of the projects. Despite the fact that SRT is familiar with the PPP procedure because it supervises the concession of the inland container depot at Lat Krabang, PPP implementation can be challenging. The unlegislated rail regulator agency leads to concern about the project initiator and host of PPP on the government side, which is still undetermined.

DRT (A1), ranked fifth for the success factors, reflects the need for stability in project governance as well as being a driver for rail operations competition. Transferring ownership of the rail infrastructure and debt from infrastructure investment to the government should not only lessen SRT's debt obligation but also stimulate better operating performance. Respondents also considered that when DRT is legislated and rail operations are no longer monopolized, SRT will have to focus its core business on rail operations to keep the organization in the market when there are multiple rail freight operators.

Conclusions and Future Studies

Conclusions

By using AHP and fuzzy AHP, the leading dimensions and success factors affecting railway projects contributing to the country's logistics platform were identified. When comparing global weights, both approaches shared similar rankings—the top nine and bottom two factors. The top five leading factors were in the administration and economic dimensions. Therefore, it can be concluded that the Thai government should establish a solid, large-scale, long-term, integrative rail transport plan governed by DRT and OTP for the success of rail infrastructure projects. The master plan should cover both passenger and freight transport schemes, since the weight of TOD confirms that passenger transport should be developed in parallel but separated from freight transport. The rail parcel service system should also be part of the master plan. Local market development for the rail industry should be encouraged by related government agencies and, if possible, included in the rail infrastructure development master plan. PPP should be consider as a prevalent investment option. Therefore, it is also critical to legislate DRT as soon as possible to regulate and initiate the rail development master plan.

Future Studies

ANP can be implemented together with AHP, as in the research of Lee et al. (2013). This approach evaluates the connection between elements in different hierarchical levels. As discussed earlier, some of the cross-dimensional factors (type of investment in the administration dimension and PPP opportunities in the economic dimension) are unquestionably related. ANP would have discovered such cross-dimensional relationships and revealed very interesting results. Furthermore, this research focused on rail infrastructure development projects only in Thailand. The research scope can be extended to rail transportation between Thailand and countries in Indochina to cover all possible international connectivity.

The Center for Neighborhood Technology in United States manages cargo-oriented development (COD) projects in the states of Illinois, Louisiana, Ohio and Tennessee. COD is based on the same principle as TOD but is applied to freight and cargo instead of passengers. The projects cover studies on the integration of freight yards, railroads, and industries in the neighborhood to increase their efficiency. Despite the differences in the operating nature, the Center for Neighborhood Technology recommends that COD should be developed with TOD in close proximity to ensure that communities can maximize land values with limited infrastructure investment and boost local job opportunity while minimizing pollution and traffic. Research on COD's application to railroads as well as the possibility of success is novel and should produce out-of-the-ordinary development for Thai and Indochinese railroad systems.

Confilct of Interest

There is no conflict of interest in this manuscript.

References

Amiril, A., Nawawi, A. H., Takim, R., & Ab Latif, S. N. F. (2014). Transportation infrastructure project sustainability factors and performance. *Procedia Social and Behavioral Sciences, 153*, 90–98.

Awasthi, A., & Chauhan, S. S. (2011). Using AHP and Dempster-Shafer theory for evaluating sustainable transport solutions. *Environmental Modelling and Software, 26*(6), 787–796.

Banister, D., & Thurstain-Goodwin, M. (2011). Quantification of the non-transport benefits resulting from rail investment. *Journal of Transport Geography, 19*(2), 212–223.

Buckley, J. J. (1985). Fuzzy hierarchical analysis. *Fuzzy Sets and Systems, 17*(3), 233–247.

Chang, D. Y. (1992). Extent analysis and synthetic decision, optimization techniques and applications. *World Scientific, 1*, 352.

Chang, D. Y. (1996). Applications of the extent analysis method on fuzzy AHP. *European Journal of Operational Research, 95*(3), 649–655.

Cheng, C. H., Yang, K. L., & Hwang, C. L. (1999). Evaluating attack helicopters by AHP based on linguistic variable weight. *European Journal of Operational Research, 96*(2), 423–435.

Deng, H. (1999). Multicriteria analysis with fuzzy pairwise comparison. *International Journal of Approximate Reasoning, 21*, 215–231.

Ferreira, L. (1997). Planning Australian freight rail operations: An overview. *Transportation Research Part A Policy and Practice, 31*(4), 335–348.

Kunadhamraks, P., & Hanaoka, S. (2008). Evaluating the logistics performance of intermodal transportation in Thailand. *Asia Pacific Journal of Marketing and Logistics, 20*(3), 323–342.

Lee, P. T.-W., Wu, J.-Z., Hu, K.-C., & Flynn, M. (2013). Applying analytic network process to rank critical success factors of waterfront redevelopment. *International Journal of Shipping and Transport Logistics, 5*(4/5), 390–411.

Leheis, S. (2012). High speed train planning in France: Lessons from the Mediterranean TGV-line. *Transport Policy, 21*, 37–44.

Ministry of Transport. (2016). *Ministry of Transport's performance report*. Retrieved from http://www.mot.go.th/file_upload/2559/report_gov/report_gov201602.pdf.

Nassi, C. D., & de Carvalho da Costa, F. C. (2012). Use of the analytic hierarchy process to evaluate transit fare system. *Research in Transportation Economics, 36*(1), 50–62.

Nguyen, A. T., Nguyen, L. D., Le-Hoai, L., & Dang, C. N. (2015). Quantifying the complexity of transportation projects using the fuzzy analytical hierarchy process. *International Journal of Project Management, 33*(6), 1364–1376.

Office of Industrial Economics, Ministry of Industry. (2009). *Development guidelines for mass rapid transit industry and related industry in Thailand* (Research Report). Bangkok, Thailand: Transport Institute, Chulalongkorn University. [in Thai]

Rangarajan, K., Long, S., Tobias, A., & Keister, M. (2013). The role of stakeholder engagement in the development of sustainable rail infrastructure systems. *Research in Transportation Business and Management, 7*, 106–113.

Rodemann, H., & Templar, S. (2014). The enablers and inhibitors of intermodal rail freight between Asia and Europe. *Journal of Rail Transport Planning and Management, 4*(3), 70–86.

Saaty, T. L. (1980). *The analytic hierarchy process*. New York, NY: McGraw-Hill.

Sipahi, S., & Timor, M. (2010). The analytic hierarchy process and analytic network process: An overview of applications. *Management Decision, 48*(5), 775–808.

State Enterprise Policy Office. (2015). *State enterprise review—state railways of Thailand*. Retrieved from http://www.sepo.go.th/tinymce/plugins/filemanager/thumbs/ser58_3/8.pdf.

State Railways of Thailand. (2016a). *Locomotive status – March 2016*. Retrieved from http://58.181.223.131/maintenance_center/loco_info/locostatus.htm. [in Thai]

State Railways of Thailand. (2016b). *Wagon status*. Retrieved from http://58.181.223.131/upload/wagon/wagon.pdf. [in Thai]

Tesfamariam, S., & Sadiq, R. (2006). Risk-based environmental decision-making using fuzzy analytic hierarchy process (F-AHP). *Stochastic Environmental Research and Risk Assessment, 21*(1), 35–50.

Vaidya, O. S., & Kumar, S. (2006). Analytic hierarchy process: An overview of applications. *European Journal of Operational Research, 169*(1), 1–29.

Van Laarhoven, P. J. M., & Pedrycz, W. (1983). A fuzzy extension of Saaty's priority theory. *Fuzzy Sets and Systems, 11*(3), 229–241.