Success Factors and Partnership Evaluation of Air–Rail Integration Development: A Case of a High-Speed Rail Project Linking Three Airports in Thailand

Waralee Rattanakijsuntorn *, Benyapa Suwannarat, Nitchamol Samittivate and Chanuwat Nithikittiwat

Abstract: As the air–rail integration continues to emerge around the globe, the successful and maintainable implementation of such schemes can be influenced by many factors within administrative, social, infrastructural, and economic aspects. With the existing airport rail link system that shifted from air–rail integration at beginning to air–rail cooperation at present, this work aims to assess the success factors of air–rail integration development in Thailand and evaluate the partnership level required to achieve a long-term and indefinite horizon of relationship based on an ongoing airport rail link project in the country. The factor assessment results from using fuzzy analytical hierarchy process (AHP) revealed different perspectives from regulators and operators, while directing the high influence of administrative, economic, and infrastructural factors. The partnership evaluation suggested the highest level of partnership; although, the operators still express doubt whether the competitive advantages incurred from the partnership and the partnership itself would be sustainable.

Keywords: air–rail integration; air–rail partnership; rail link; urban transit; Thailand

1. Introduction

For almost a century, railways have been developed as one of the public transportation systems linking cities to airports in the form of mass transit, part of the mainline trains, and airport express trains. The air and rail infrastructures were, at the beginning, designed only for people’s mobility and later expanded to support multiple transits with seamless journey features so that passengers can travel with ease and convenience.

Originally emerged as competitors, airline and train services were considered as mode substitutions. While this type of air–rail relationship still exists [1,2], airlines, airports and train operators established cooperations to ensure that there would be sufficient assistance and services to accommodate passengers’ demand, and thus inaugurated an air–rail integration. It has been illustrated that the air–rail integration is not only concerned with co-location and the proximity of train station and the airport but also the partnership features which must be presented [3]. Should the partnership features disappear, the air–rail integration will be demoted to air–rail cooperation, as in the case of Bangkok Airport Rail Link (ARL) in Thailand.

The ARL is a railway system linking the Suvarnabhumi International Airport (International Air Transport Association or IATA airport code: BKK) and the airport passenger terminal to the downtown of Bangkok, which was the first step of the connected infrastructure of transportation as an air–rail integration, equipped with baggage check-in and handling service at the City Air Terminal in Makkasan Station. Being a part of the railway construction project in the suburban mass transit system, it can accommodate approximately 14,000 to 50,000 passengers daily. All infrastructures are owned by the State Railway of Thailand (SRT) who undertook and monitored the construction works and later founded...
a subsidiary, namely SRT Electrified Train Company Limited (SRTET), to perform the train operations. The purpose of the construction was to provide the best transit service for intra-city passengers traveling from and to BKK with ease, speed, and flexibility. The air–rail integrations have proven to be beneficial whilst drawbacks can also be detected, as shown in Table 1.

Table 1. Advantages and disadvantages of air–rail integration.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Transit and travel time can be minimized, particularly for the connections between city centers and airports.</td>
<td>Requires near-perfect synchronization of air and rail schedules as well as maintenance for rail tracks to avoid time wasted from operational disruption.</td>
</tr>
<tr>
<td>Service</td>
<td>Passengers receive smooth and upgraded service from integrated ticketing, baggage handling, and coordinated scheduling.</td>
<td>Baggage handling system and other service integration can be complex and demand comprehensive planning and execution.</td>
</tr>
<tr>
<td>Environment</td>
<td>Modal shifts from air or motor carriers to rail lead to lower carbon dioxide emissions.</td>
<td>Construction of rail tracks in rough terrain could potentially result in negative environmental impacts.</td>
</tr>
<tr>
<td>Economic and Urbanization</td>
<td>Construction of a new rail line and stations as part of the air–rail integration project will bring about settlement near the train station. Road traffic congestion can be reduced as people shift to mobilize by train.</td>
<td>Massive investment in infrastructure and technology development is mandatory.</td>
</tr>
</tbody>
</table>

Despite holding voluminous advantages, the operations of ARL were later not successful in terms of mobilizing passengers from the city center to the airport. The baggage check-in service at the City Air Terminal was terminated after months of operations, followed by the suspension of the Express Line, which provides the non-stop train service on a terminus-to-terminus basis. The cancellation of the baggage check-in service was because of a lack of passenger usage volume, causing many airlines to be unwilling to provide such a service. In fact, from the beginning, there was only one service provider, which was Thai Airways. Since it was a new service to both associated organizations and users at that time, service quality, promptness, punctuality, and preparedness were heavily criticized, leading to the loss in investment of over THB 400 million [4]. The Express Line service, on the other hand, was abandoned due to maintenance issues and insufficient train sets to provide regular train services on the City Line. ARL’s only train service as of present is the City Line which serves as a commuter line for passengers travelling between the Eastern rim of Bangkok and the city center while the train operator was changed from SRTET to a consortium, Asia Era One Company Limited, in October 2021.

In this present time, the most recent project that has been commenced is the new High-Speed Rail Project, connecting three airports including BKK, Don Muang International Airport (IATA airport code: DMK), and Utapao International Airport (IATA airport code: UTP) [4,5]. The 1.435 m track gauge (standard gauge) will be constructed with the extension of two sections from Phaya Thai Station (ARL city center terminus) to DMK and from Lat Krabang Station (a preceding station to the terminus at BKK) to UTP. The completed route is shown in Figure 1, with a total track distance of 220 km. This project, in line with the Eastern Economic Corridor (EEC), is expected to stimulate economic growth in the region. The future of this project will not only improve public mobility, but it will also promote the development of the city along the route and foster the domestic economy for both major cities and minor cities. The project relies much on the existing railway route while the designated operator is the same as that of ARL, Asia Era One Company Limited.
Despite the fact that DMK and BKK are currently linked by rail transport, there are no direct train operations. Passengers require three transits or the use of four train lines (SRT red line, Mass Rapid Transit blue line, Bangkok Mass Transit System green line, and ARL) to mobilize between the two airports. Therefore, air–rail cooperation merely appears, while there is no air–rail competition, as BKK served as the primary international airport for Bangkok and DMK as the secondary hub. Both airports are about 40 km apart. As such, the convenience transfer options between both airports are shuttle bus, taxi, and private car. Although SRT offers train service on the Eastern Line to Utapao Station, the terminus is not in the vicinity of UTP, and passengers must use a motor carrier to travel to the airport. Evidently, air–rail cooperation is at a minimum level, while air–rail competition does not exist among the three airports.

With the forthcoming High-Speed Rail (HSR) Linking Three Airports Project (DMK-BKK-UTP HSR project), much is to be discussed and resolute on how air–rail integration is the essential part of operations success, as evidently, the ineffectual operations can be observed from the ARL project. This paper aims to first identify and evaluate the factors affecting the success of on-going and future air–rail integration projects in Thailand from the perspectives of transport regulators and operators. After the factors have been assessed and prioritized by using the fuzzy analytical hierarchy process, a conceptual model on partnership framework on the DMK-BKK-UTP HSR project will be developed and appraised particularly on the DMK-BKK-UTP HSR project. Lastly, the level of desired partnership for the project will be proposed and discussed.

2. Literature Review

This section includes relevant research publications on air–rail integration. Factors related to the success of the air–rail projects were discussed and research dimensions were outlined. Additionally, the reviews of the analytical hierarchy process (AHP), fuzzy theory’s application with AHP, and the partnership model were also demonstrated.

2.1. Factors Associating the Success of Air–Rail Integration

Although air–rail integration has been introduced for decades, competitions between air carriers and train operators still exist to date. The work of [2] predicted the probability of mode choice between air and rail transport in Iran and suggested that travel time, ticket price, convenience, and service level were the key influential factors. Substitution effects between high-speed rail and air transport had also been studied by [6,7]. Both works revealed that infrastructure plays key roles in mode substitution, while the latter added...
that the high-speed rail air–rail integration has significant positive influence on an air
carrier’s boarding process with the existence of an on-site high-speed rail station.

The various approaches taken, to date, to provide air–rail links with seamless journeys,
working under the premise that the relief of the constantly increasing road congestion
around airports necessitates a modal shift from road to rail transport for both intending air
travelers and airport staff, have been explored by [8]. The authors have pointed out that
there are still three crucial operational considerations that must be considered in order to
complete air–rail integration, despite the fact that all of the railway tracks and the trains
that operate on them have been provided in the paper. These include passenger information,
baggage check-in facilities, and air–rail ticketing.

The work of [9] focused on the HSR identification of a specific federal funding source
for HSR, the establishment of strong local political leadership, the involvement of private
railroads, the creation of a consensus regarding the advantages of HSR, the assurance that
state and local governments are prepared to contribute their fair share, and the creation
of cooperative relationships with the airline and local transit providers. By concentrating
on many case studies, including the United States, Japan, and Germany, it has been
summarized that if the road and aviation industries viewed HSR as an ally rather than
a rival, it would have a higher chance of succeeding. Therefore, HSR projects that create
synergistic connections with other modes of transportation are more likely to succeed.

Air–rail partnerships and agreements were studied by [10–13] on different perspec-
tives. The underlying context in air–rail integration success was primarily the high level of
cooperation and anticompetition. In addition, [14] suggested that air–rail synchronization
can be improved with seamless journey features including the rail timetable at the airport.

For the case of Thailand, [5] evaluated the advantages and disadvantages of using
public–private partnerships (PPP) in Thailand’s high-speed rail project that connects three
airports and discovered that the success of the project depends on cooperation between
the corporate and public sectors, which emphasized the factors that have a high influence
including administration, economics, infrastructure, and technical.

Dimensions associated with the success of air–rail integration can be summarized as
in Table 2.

Table 2. Dimensions related to the air–rail integration’s success. * means the dimension related to the
air—rail integration’s success appeared in the literature.

<table>
<thead>
<tr>
<th>Literature</th>
<th>Administration</th>
<th>Economics</th>
<th>Infrastructure</th>
<th>Social</th>
<th>Technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>[4]</td>
<td>*</td>
<td></td>
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<td></td>
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<td>[5]</td>
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<td>[14]</td>
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<tr>
<td>[15]</td>
<td></td>
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<td>*</td>
</tr>
</tbody>
</table>

| Total      | 10             | 9         | 8              | 6      | 1         |

As can be seen from the table that the technical dimension was mentioned only
by [5], the authors then proceeded to the factor extraction stage with four dimensions:
administration, economic, infrastructure, and social. Ten factors have been found and
classified according to relevant dimensions, as described in alphabetical order as follows.
• Accessibility refers to the location of the station together with adequate facilities that
must support all age groups and disabled people. This applies not only in terms of
quality management but also in the aspect that there are sufficient facilities to assist and advocate service users [5,7,8,10,11,13–15].

- Career opportunity refers to the fact that the increase in the number of air–rail infrastructures is expected to stimulate national and local job opportunities from construction and operations activities [4,5,8,9,12,13,15].

- Coverage refers to route expansion and new stations can attract more residents to the area surrounding railway stations. In addition, the expansion of the network will result in the rise of inter-city linkages for both domestic and international travel [5,7–12,14,15].

- Culture and lifestyle is the factor that is attributed to local culture in certain countries. The inter-city mobilities appeared in Thailand during two major events, the new year holiday and Song Kran holiday, as many Thai citizens will return to their hometown for family reunions, while there are numbers of long public holidays (up to four days) throughout the year. The extremely high travel demands during these occasions are expected to stimulate the use and the success of air–rail infrastructure [10,13].

- Price refers to the measurements of the passenger’s willingness to pay (WTP) compared to the worthiness of the transportation service or the compromised value that passenger is willing to accept in exchange for transportation service [4,5,8–13,15].

- Time refers to the service frequencies, punctuality, and the availability of trains and flights’ schedules that meet the demand of riders during weekdays and weekends as well as peak and off-peak hours [5,10,13–15].

- Safety and security refer to railroad facilities such as platforms, seating, and guardrails providing safety and security features, which are genuinely important toward the decision of using the services. Safety and security cannot be overlooked because they highly influence the usage rate in the service [5,9,13,14].

- Seamless journey refers to how the synchronized services can minimize the transfer time between modes, which has a direct effect on the time limit. The integrated air–rail ticketing and scheduling as well as baggage handling service allow passengers to transfer smoothly and conveniently from any station to another station or to the airport and vice versa [5,7,9–11,13–15].

- Service quality means that the quality of services must be consistent, efficient, and adequate in terms of service frequencies, the number of train cars in all operational periods, and sufficient and well-trained personnel are needed to provide all necessary air–rail services [4,5,8–15].

- Social welfare is the factor that usually requires strong financial support from policy makers. Achievable transportation fares that are in line with cost of living will induce more users and stimulate the demand for the air–rail integration [4,10–12,14,15].

2.2. **Analytical Hierarchy Process with Fuzzy Theory and Other Techniques**

Apart from questionnaire survey and in-depth interview, there are numerous techniques that can be used to assess factors or risks related to the air–rail integration, including the analytical hierarchy process which was developed by [16] in the 1970s. This tool is a multicriteria decision-making process that helps obtain the decision that is the best among several parameters via comparing the criteria to criteria and/or alternative to alternative, which is called a pairwise comparison [17]. The pairwise comparison can assess the relative importance of elements that are in the same level of hierarchy; an element on the other level cannot affect another on a different level of hierarchy. In addition, these comparisons are taken from the fundamental scale that reflects the strengths of preferences. The application of AHP in public transport and logistics can be found accordingly.

The AHP was applied to evaluate the best fare system to apply in a region together with using the gradient sensitivity analysis to determine the changes in one or more criteria that influence the alternatives or outcomes [18]. The factors ranged from complexity, impact on revenues, control of passengers, difficulty of implementation, long trips, forms of payment, fare price, cost of implementation, and number of trips where these factors
were linked to suitable types of fares. The results indicated that distance/zone fare, where the fares are charged differently based on the traveling distance or the number of zones covered, is the most important fare among others (service-based, market-based, time-based, and flat fare).

The factors that affect the success of the rail infrastructure development projects that have a contribution to Thailand’s logistics platform have been identified by [19]. The research was conducted by having rail experts and other related participants verify and weigh the factors that have the most impact on the success of the rail infrastructure based on their experiences. The AHP and fuzzy AHP were used to prioritize the factors and it has been found that administration weighted the highest among five dimensions, followed by economic, logistics platform, social, and technical. Additionally, the rail development master plan (the criteria of the administration dimension) was the leading success factor which indicated a large-scale and long-term rail plan along with the stability of the project, and thus it is the requirement to the success of the rail project. This shows that the importance of having strong, large-scale, long-term, and integrative planning in rail transport needs to be established by the government together with Thailand’s Department of Rail Transport (DRT) and the Office of Transport and Traffic Policy and Planning (OTP).

According to [20], strategies for the railway transportation located in the West African Economics and Monetary Union have been established by identifying the fourteen Strengths, Weaknesses, Opportunities, and Threats (SWOT) factors from questionnaire surveys on railway network authorities of different countries. The SWOT matrix combined with the AHP was used to prioritize the factors and to use them to develop strategies. The research indicated that the potential market growth is the main opportunity with large-capacity rail haulage for the long distance as its main strength.

Other AHP-related works include the evaluation of variants of the integration of urban public transport by using AHP [21]; using fuzzy AHP to analyze the complexity of transportation projects in Vietnam [22]; the application of AHP with role-playing games to determine stakeholder engagement in complex transport decision-making [23]; the evaluation of public transportation business models by using intuitionistic fuzzy AHP and sensitivity analysis [24]; the assessment and determination of freight hubs in railway stations in Slovakia [25]; and risk management related to railway transportation issues and other domains [26].

2.3. The Partnership Models

The partnership model was introduced by [27], detailing the development of supply chain partnerships aimed at cost reduction, achieving a competitive advantage, and strengthening the service level. The model and assessment methodology were further validated and implemented, resulting in the showcase of partnership facilitation from the preparation of the partnership meeting to the assessment conclusion [28]. One noticeable application of the partnership model was the adaptation of the model to the outsourcing strategic fit of Thai pharmaceutical manufacturing firms, which concluded that the good fit companies (under the strategic fit types) were more likely to form Type III partnership alliances [29].

Apart from Lambert’s partnership model, the concept of partnership also appeared in other research works such as the work of [30] on the case study of Northern Ireland’s partnership role in the local government museum service. Analytical network process (ANP) was implemented with the agile virtual enterprise partner selection [31]. The work of [32] discussed partnership components ranging from information sharing, joint decision-making, risk/reward sharing, and relationship-specific assets and used ANP to quantify the relative importance of the components. Factors influencing the alternatives of recurring partnership were reviewed and statistical analysis was performed to investigate the effect of contract terms and relative partner characteristics [33].
3. Materials and Methods

This section describes the methodology used in this research as illustrated in Figure 2. First, the related factors were identified through a literature review. The factors were categorized and drafted into an AHP model and later confirmed by a pilot study. After the model confirmation, questionnaires were distributed to experts in air and rail transport industries including high-level officers from Thailand’s government agencies and state enterprises, which are regulators, and operators. The collected numerical data from the questionnaire were input into the AHP calculation. The fuzzy AHP was implemented afterward. The consistency of results was checked, and the validated results were analyzed. Then, the partnership model’s questionnaires were developed and distributed to target respondents. The final steps were the analysis of partnership level and proposition of recommendations and conclusion.

**Figure 2.** Flowchart of research methodology.

3.1. Validation of Factors

As all factors from Section 2.1 were classified under four dimensions, administration, economic, infrastructure, and social, a pilot study was conducted to confirm the validation of model, dimensions, factors, and their relationships. Experts from the Ministry of Transport of Thailand with a minimum of 15 years of work experience related to the planning and policies of public transport have reviewed and confirmed that the factors and the model were appropriate for further study. This pilot study was carried out without collecting any personal data, backgrounds, demographics, and psychological information.
3.2. AHP

The AHP questionnaire contains a total of 14 pairwise comparisons based on nine-point ratings. All factors were thoroughly described in the questionnaire along with the detailed explanation of the final AHP model, which is displayed in Figure 3. Safety, security, and service quality were categorized under the administration dimension. The economic dimension comprises price and time. The infrastructure dimension includes accessibility, coverage, and seamless journey. Lastly, career opportunities, social welfare, and culture and lifestyle were classified into the social dimension.

![Figure 3. The proposed AHP model.](image)

The collected data were recorded in the prepared calculation matrices constructed by using Formula (1).

\[
A = \begin{bmatrix}
    a_{11} & \cdots & a_{1j} \\
    \vdots & \ddots & \vdots \\
    a_{i1} & \cdots & a_{ij}
\end{bmatrix}
\]  

(1)

where

- \(A\)—the AHP pairwise comparison matrix
- \(a_{ij}\)—the comparison weights where \(i = 1, 2, \ldots, n\) and \(j = 1, 2, \ldots, m\)
- \(n\)—the number of components in a matrix

The new calculation matrices which contain the normalized pairwise comparison weights, \(\tilde{a}_{ij}\), can be computed according to Formula (2)

\[
\tilde{a}_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}
\]  

(2)
The priority weights were computed as the arithmetic mean or row average of $\tilde{a}_{ij}$. The priority weights, which can also be called the final outputs, from all dimensions and factors were treated as local weights while the multiplication of the weight of a factor to the weight of the respective dimension was treated as a global weight. The results were validated for their consistency by using the consistency index or $CI$ and random index or $RI$ (as shown in Table 3) to compute the consistency ratio ($CR$) as in Formula (3) below.

$$CR = \frac{CI}{RI}$$ (3)

Table 3. Random index.

<table>
<thead>
<tr>
<th>n</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>RI</td>
<td>0.00</td>
<td>0.00</td>
<td>0.52</td>
<td>0.89</td>
<td>1.11</td>
<td>1.25</td>
<td>1.35</td>
<td>1.40</td>
<td>1.45</td>
<td>1.49</td>
</tr>
</tbody>
</table>

According to [34], the $CR$ values not exceeding 0.1000 are considered consistent and the results are usable.

3.3. Fuzzy AHP

The collected results based on AHP questionnaires were adapted with fuzzy theory. The authors used the fuzzy numbers as they appeared in [35], which are displayed in Table 4. It can be noted that the triangular number of the fuzzy AHP scale for the upper value in the AHP rating where the relative importance equals to 1 varied from 1 to 3. This depends on how vague and fuzzy the researchers would prefer the results to be when both criteria are equally important. In addition, the lower and the upper values in the AHP rating where the relative importance equals to 9 also differ from one research to another, as can be seen in the work of [19,36].

Table 4. Fuzzy triangular numbers.

<table>
<thead>
<tr>
<th>AHP Rating</th>
<th>Fuzzy AHP Scale</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(1, 1, 1)</td>
<td>Equal importance</td>
</tr>
<tr>
<td>3</td>
<td>(3 − $\Delta$, 3, 3 + $\Delta$)</td>
<td>Weak importance</td>
</tr>
<tr>
<td>5</td>
<td>(5 − $\Delta$, 5 + $\Delta$)</td>
<td>Essential or strong importance</td>
</tr>
<tr>
<td>7</td>
<td>(7 − $\Delta$, 7, 7 + $\Delta$)</td>
<td>Demonstrated importance</td>
</tr>
<tr>
<td>9</td>
<td>(8, 9, 9)</td>
<td>Extreme importance</td>
</tr>
<tr>
<td>2, 4, 6, 8 (x)</td>
<td>(x − $\Delta$, x + $\Delta$)</td>
<td>Intermediate values between two adjacent judgments</td>
</tr>
<tr>
<td>1/x</td>
<td>(1/(x + $\Delta$), 1/x, 1/(x − $\Delta$))</td>
<td></td>
</tr>
</tbody>
</table>

* $\Delta$ is a fuzzification factor and in this case equals 1.

The defuzzification steps were adapted from the method proposed by [37], starting from the computation of the fuzzy AHP pairwise comparison matrix based on the fuzzy triangular numbers in Table 4, followed by the calculation of priority vectors, the application of degree of possibility to compute fuzzy local weight, and lastly the normalization of the weight vector. The final outputs (local weights and global weights) can be interpreted in a similar way to the AHP final outputs.

3.4. Lambert’s Partnership Model

In this work, the authors select Lambert’s partnership model to evaluate the decision to establish partnership among stakeholders and propose the partnership level required for air–rail integration in the DMK-BKK-UTP HSR project. The partnership model was adapted from the model proposed by [28], which can be seen in Figure 4.
Figure 4. The proposed partnership model.

Originally, the partnership model aims to determine the “decision to create or adjust partnership” and the desired level of partnership ranged from a short-term and transactional basis to an indefinite horizon and period of collaborative activities between organizations. The decision model is based on the assessment of drivers and facilitators. The drivers evaluated the “compelling reasons to partner” while the facilitators are generally external and surrounding factors that would assist the progression of partnership. Both drivers’ and facilitators’ assessments lead the organizations to decide whether to establish a new partnership or revise the existing one. Had the decision been made, the organizations would require the proposition of joint activities, tasks, and processes that would develop and maintain the partnership and reach the desired outcome. In this research, the decision element was designed to create the air–rail partnership while the expected outcome was the well-established and practical air–rail seamless journey.

The partnership assessment is composed of the evaluation of drivers and facilitators, adapted from [27]. The drivers’ appraisal covers asset/cost efficiency, customer service, marketing advantage, and profit stability/growth. The facilitators’ assessment includes the consideration of corporate compatibility, management philosophy and technique, mutuality, and symmetry. Questions concerning drivers were customized for the air–rail integration scheme (see Appendix A) where eight out of ten factors identified in Section 2.1 were mapped as drivers’ components in the partnership model, as displayed in Table 5.

Table 5. AHP factors as the partnership model’s drivers.

<table>
<thead>
<tr>
<th>Drivers in the Partnership Model</th>
<th>Related Factors from the Literature Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset/Cost Efficiency</td>
<td>Accessibility (I1); Coverage (I2)</td>
</tr>
<tr>
<td>Customer Service</td>
<td>Safety and Security (A1); Service Quality (A2); Time (E2); Seamless Journey (I3)</td>
</tr>
<tr>
<td>Marketing Advantage</td>
<td>Service Quality (A2); Seamless Journey (I3)</td>
</tr>
<tr>
<td>Profit Stability/Growth</td>
<td>Price (E1); Time (E2); Culture and Lifestyle (S3)</td>
</tr>
</tbody>
</table>

After, the authors derived the final outputs quantified by AHP and fuzzy AHP. The Lambert’s partnership model questionnaire was developed and distributed. The scores are summarized based on either driver or facilitator perspectives. For both driver and facilitator assessment, the scores in each question were between 1 and 5, which are based on probability as presented in Table 6.
Table 6. Probability converted to score.

<table>
<thead>
<tr>
<th>Probability</th>
<th>0%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

The respondents were asked to evaluate the probability that certain situation will occur, for example, the probability that the seamless air–rail integration would lead to stakeholders’ ability to significantly reduce cost or utilize asset (infrastructure) efficiency. Furthermore, if the respondent’s answer resulted in score between 3 and 5, and the driver in the question would lead to stakeholders’ sustainable competitive advantage, an extra score (1) can be earned for each question. However, this extra score applies to only driver assessment. On the other hand, the facilitator assessment includes five yes-and-no extra questions concerning willingness to partner, physical proximity, partnership experience, shared competitor, and shared high-value end users. Each yes answer results in an extra score of 1. The assessment results in the individual classification of partnership level, as shown in Figure 5.

Figure 5. The propensity to partner matrix.

Arm’s length refers to the situation when two organizations conducted business on a long-term basis but did not show any form of joint commitment or operations between the firms. Under the partnership model, arm’s length was not considered as one of the partnership types. The work of [28] classified partnerships as Type I, Type II, and Type III. Type I is the most fundamental type of partnership where two organizations consider each other as partners. However, cooperative and collaborative activities are limited and focused on a short-term basis. The organizations categorized under Type II partnerships tend to have a long-term co-sharing and co-planning horizon where multiple divisions and functions are involved with the partnership. The Type III partnership, which is the highest level of partnership, depicts the two organizations with endless partnership status and incorporates an intensive level of operational integration.

From Figure 4, it can be seen that scores from both driver and facilitator assessments are required so that the partnership level in the propensity to partner matrix can be determined. The only situation when the arm’s length relationship emerges is when both driver and facilitator scores are between 8 and 11. Meanwhile, if either party’s score is between 8 and 11 while another is between 12 and 15, the relationship should be classified as a Type I partnership. Hence, the higher the assessment scores, the higher the partnership level could be identified.

4. Results and Discussion

4.1. AHP and Fuzzy AHP

The AHP questionnaires were distributed to government agencies and state enterprises owning the infrastructures and regulating air and rail transport, airport operators, railway operators, and airlines. The target respondents are the mid-level managers to executive personnel (or other positions equivalent to the indicated managerial positions). The minimum requirement of work experience for the respondent was 10 years. Information other than the respondent’s affiliation, job level, and work experience were not recorded. Hence, personal data, backgrounds, demographics, and psychological information of respondents were not collected.
The data collection (including the revision and request for further comment period) was held during March and November 2023. Out of 30 questionnaires, 24 were retrieved. Three responses were excluded from the final analysis due to significant inconsistencies and the revision of pairwise comparisons could not be made. Therefore, the total number of usable responses was 21—12 being regulators and 9 being operators. As discussed by [38], AHP does not require a large sample size as it aims to provide an analysis of decision-making results regardless of the identity or behavior of the decision makers. In addition, a study by [39] suggested the standard observations to be between 19 and 400, with a margin of error at five percent. Hence, the number of respondents of 21 in this work would be considered sufficient. The average consistency ratios of the two groups are shown in Table 7. The average work experience of 21 respondents is 16.9 years.

Table 7. Respondents’ consistency ratios.

<table>
<thead>
<tr>
<th>Levels</th>
<th>Consistency Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regulators</td>
</tr>
<tr>
<td>All Dimensions</td>
<td>0.0469</td>
</tr>
<tr>
<td>Factors under administration</td>
<td>0.0000</td>
</tr>
<tr>
<td>Factors under economics</td>
<td>0.0000</td>
</tr>
<tr>
<td>Factors under infrastructure</td>
<td>0.0214</td>
</tr>
<tr>
<td>Factors under social</td>
<td>0.0362</td>
</tr>
</tbody>
</table>

The administration and economics dimensions contain two factors, resulting in one pairwise comparison and automatically a 0.0000 value of CR. As the overall average CR values in all dimensions, factors under infrastructure, and factors under social do not exceed 0.1000, the quantitative outputs of the questionnaire were usable for further analysis. Table 8 presents the local weights from the AHP and fuzzy AHP approaches, classified by two groups of respondents: regulators and operators.

Table 8. Local and global weights by approach and respondent groups.

<table>
<thead>
<tr>
<th>Dimension and Factors</th>
<th>AHP</th>
<th>Fuzzy AHP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Regulators</td>
<td>Operators</td>
</tr>
<tr>
<td></td>
<td>Local</td>
<td>Global</td>
</tr>
<tr>
<td>Administration</td>
<td>0.2454</td>
<td>0.2068</td>
</tr>
<tr>
<td>Economics</td>
<td>0.2907</td>
<td>0.3352</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>0.3467</td>
<td>0.3343</td>
</tr>
<tr>
<td>Social</td>
<td>0.1171</td>
<td>0.1237</td>
</tr>
<tr>
<td>Safety and Security</td>
<td>0.5667</td>
<td>0.1391</td>
</tr>
<tr>
<td>Service Quality</td>
<td>0.4333</td>
<td>0.1063</td>
</tr>
<tr>
<td>Price (E1)</td>
<td>0.4806</td>
<td>0.1397</td>
</tr>
<tr>
<td>Time (E2)</td>
<td>0.5194</td>
<td>0.1510</td>
</tr>
<tr>
<td>Accessibility (I1)</td>
<td>0.3661</td>
<td>0.1269</td>
</tr>
<tr>
<td>Coverage (I2)</td>
<td>0.4019</td>
<td>0.1393</td>
</tr>
<tr>
<td>Seamless Journey</td>
<td>0.2320</td>
<td>0.0805</td>
</tr>
<tr>
<td>Career Opportunities</td>
<td>0.2205</td>
<td>0.0258</td>
</tr>
<tr>
<td>Social Welfare</td>
<td>0.3754</td>
<td>0.0440</td>
</tr>
<tr>
<td>Culture and Lifestyle</td>
<td>0.4042</td>
<td>0.0473</td>
</tr>
</tbody>
</table>

The global weights are computed by multiplying the local weight of a factor with the local weight of its respective dimension. Therefore, the calculation of a dimension’s global weight is not applicable. It can be seen that both regulators and operators considered infrastructure and economics to be one of the most important dimensions that lead to...
air–rail integration success. At factor levels, price, times, and safety and security were among the most important factors affecting the success of air–rail integration.

Evidently, the defuzzification process has signified the weights of the highly prioritized dimensions, resulting in greater local weights in the fuzzy AHP approach for the infrastructure, economic, and administration dimensions, while the social dimension’s weight has been diminished. Similarly, local weights of some factors such as safety and security (A1) and accessibility (I1) were extensively amplified under fuzzy AHP while the local weights of time (E2) and seamless journey (I3) shrunk. Consequently, global weights of both approaches were dissimilar. Figure 6 illustrates the fuzzy AHP global weights classified by the groups of respondents.

![Figure 6. Fuzzy AHP global weights classified by respondent group.](image)

The group visualization shows that regulators and operators viewed the relative importance of each factor differently. While operators’ main priorities were price (E1), safety and security (A1), seamless journey (I3), and time (E2), the regulators placed their attention on safety and security (A1), accessibility (I1), price (E1), and coverage (I2). However, both groups agreed that the social factors including career opportunities (S1), social welfare (S2), and cultural and lifestyle (S3) were of the least concern. Selected factors under the economic and infrastructure dimensions will be further discussed.

Price (E1) was ranked as the overall top priority factor that would lead to air–rail integration success. While this factor appears to be the most significant factor for the operators, the regulators had a different perspective. As price was not defined as a transportation fare but the compromised value that passenger is willing to accept in exchange for transportation service, the operators commented that the price should be more approachable for potential users and train riders which in return require a large number of subsidies so that the fares in the air–rail integration project are attractive enough to generate the desirable and sustainable growth rate of transportation demand. However, regulators viewed price
as a responsibility of operators as the project would be commenced under a certain form of a
public–private partnership, in which subsidies may not take place at all.

While operators focused largely on seamless journeys (I3), it was not considered as one
of the top priorities by the regulators. According to the respondents’ further comments, the
lack of fundamental seamless journey features, infrastructure accessibility, and willingness
to participate by air carriers are attributed to the failure of air–rail integration in the past
projects. This would potentially impact the success of the future air–rail integration project
as the planning and implementation of a seamless journey’s features are necessary elements
in the connectivity of air–rail trips.

4.2. Application with the Partnership Model: Perspectives of the Operators

The target respondents of partnership assessment are mid-level managers to executive
personnel of airport operators, train operators, and air carriers that operate domestically
and internationally in Thailand. The authors focused only the operators’ cases because,
based on the AHP data collection, the transportation regulators are willing to encourage
the seamless journey and air–rail integration to succeed, while the operators expressed
doubt as to whether the integration would be a flourishing one. By using the partnership
assessment model, it would potentially suggest the decision to partner to the stakeholders
and the level of partnership required for the success of air–rail integration. There were
five returned responses out of nine distributed questionnaires. Respondents’ personal
data, backgrounds, demographics, and psychological information were not collected. The
average scores in each perspective are shown in Table 9.

Table 9. Driver and facilitator assessment scores.

<table>
<thead>
<tr>
<th>Assessment Perspective</th>
<th>Average Scores</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers</td>
<td></td>
<td>14.6</td>
</tr>
<tr>
<td>Asset/Cost Efficiency</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Customer Service</td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td>Marketing Advantage</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Profit Stability/Growth</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>Facilitator</td>
<td></td>
<td>16.6</td>
</tr>
<tr>
<td>Corporate compatibility</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Management philosophy and technique</td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Mutuality</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Symmetry</td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Shared competitor(s)</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Physical proximity</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>Willingness to partner</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Partnership experience and past success</td>
<td>0.6</td>
<td></td>
</tr>
<tr>
<td>Shared high-value end user</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

The average score for all drivers and the first four facilitator perspectives are based on
a full mark of 5.0, with the exclusion of the extra points from the sustainable competitive
advantage evaluation in the driver section. It can be noted that all respondents had a
consensus on two aspects: the key stakeholders are in close physical proximity to each
other and the stakeholders share high-value end users. The partnership level can be
identified by using the propensity to partner matrix from Figure 4 by using the total
scores—14.6 from drivers and 16.6 from facilitators. The final classifications resulted in the
Type III partnership.

Although two out of five responses revealed the desired partnership level to be Type II,
by using average driver and facilitator scores, the required partnership level for air–rail
integration success is Type III, indicating the demand for extremely close collaboration in
all aspects between train operators, airport operators, and air carriers with strong support
from government agencies. However, based on the collected data, it can be noted that most
respondents do not believe that the asset and cost efficiency, customer service, marketing
advantage, and growth and stability in profit would bring a sustainable competitive advantage to stakeholders despite favoring each driver at more than 50% likelihood. This suggests the lack of confidence from the operators’ perspectives that the partnership and collaboration between stakeholders would be sustainable while competitive advantages, if they exist, may not last.

The Type III partnership directs that the air–rail integration should include a high level of partnership components, including the systematic joint planning among stakeholders on a continuous basis and at multiple levels from operational to executive. Joint operating controls and the scope of activities ranging from coordinated flights and train schedules; one-stop online reservation; single itinerary (or integrated ticket); code-sharing; baggage check-in, drop-off, and transfer service at major train stations; delay and/or cancellation assistance; to extended end-to-end service are mandatory. Effective communication across the stakeholders’ organization is also essential at all levels while integrated electronic communication platforms used by all parties are recommended. As one of the cores of partnership is sharing both risk and rewards, the integrated frequent flyer and rider program (or mileage collection program) and special discount can be implemented as one of the air–rail partnership offerings. The contract style and form of financial investment are some of the key components for the success air–rail integration, as the DMK-BKK-UTP HSR project which is worth approximately USD 6270.44 billion was set to commence under the PPP agreement. The PPP contractual style refers to the net cost which the concessionaire (railways operator) must invest into the infrastructure works and operational works while the government would provide subsidies only when the fares and ancillary revenues are less than the cost incurred by the concessionaire. By further investigating the PPP form, it can be observed that the net cost style does not support the risk-sharing component as the concessionaire assumes all ridership risks while having to share extra profit with the government [5]. This means that the airport operators and the airlines do not take part in the financial investment. However, both parties can still provide technological and people investment through joint product and service research and development regularly and the shared personnel in each party’s executive board of directors. Above all, regulators and policy makers must play crucial roles in driving the joint operating controls and risk/reward sharing to succeed by the provision of necessary support and stimulation which may include subsidiaries during the early years of operations when the mobility and the usage of air–rail infrastructure are insufficient. The lack of a high level of regulators’ and policy makers’ support would prominently lead to the repeated history of failed collaboration.

5. Conclusions

The DMK-BKK-UTP HSR project is expected to bring not only extended connectivity between the two major international airports of Thailand (DMK and BKK) but also provide linkage to the tertiary international airport (UTP) through railway infrastructure which would potentially lead to the progression of EEC, urban development along the rail line, and the country’s target as an aviation maintenance hub. As the project continued, the occurrence of unsuccessful air–rail integration in the past was brought into question and the study of the success factors influencing the air–rail integration was commenced. Ten factors were identified and classified under four dimensions. The fuzzy AHP outcomes revealed that price is the most influential factor, followed by safety and security, time, accessibility, coverage, service quality, and seamless journey, while all social factors are at the bottom of the list. The partnership model was brought in to determine whether the partnership is required and at which level. The results from the perspective of operators directed that the partnership is necessary for the project’s success and Type III partnership is recommended. However, the contract style and form of financial investment are the components that would hinder the partnership to reach the desired level. The nature of PPP net cost is to have the concessionaire assume all risks associated with ridership and revenue while the government would provide minimal financial support. Furthermore, infrastructure
investments are the burden of the concessionaire. The form of PPP also leads to minimum role of the government in the project and limits the government from providing financial support. The imbalance in risk/reward sharing, financial investment, and stakeholders’ role in the project, especially from the government side, may hamper the level of air–rail partnership. Although the major stakeholders in this project are train operators, airport operators, and air carriers, strong support by regulators and policy makers should be incorporated.

As the operators are those who express doubt about the project’s success, incentives to participate and build mutual trust and commitment to the air–rail integration are recommended. One of the examples which was proposed by [13] is an environmental tax leverage that can be offered to participants in the air–rail partnership. Furthermore, it has been found that the Coronavirus disease’s new normal era resulted in positive effects of factors such as energy and environment towards rail transportation in the future [40]. Environmental tax leverage seems to be one of the promising incentives as well as inductions for sustainable transportation schemes for the country.

There are several limitations in this work and one of them is the small number of responses for the partnership model assessment, which is limited to the operators. The assessment of the regulators would be beneficial to further draft the required partnership components in more specific detail to be used as guidance to navigate the air–rail integration project to success. Another limitation is the structure of the AHP model which prioritizes only the factors within the same dimension. The factors classified in different dimensions, such as seamless journey and service quality, could have relative importance that should be compared and quantified by using other techniques such as ANP. Third, the technical dimension was not included in the AHP model, which means that some factors such as engineering requirements, maintenance and operational reliability, and transit-oriented development consideration are omitted from the study. Lastly, the context of the results is limited to a case in Thailand. Nevertheless, the findings may be fundamental to extend both the model and scope of study for future studies.

Author Contributions: Conceptualization, W.R.; methodology, B.S., N.S. and C.N.; software, B.S., N.S. and C.N.; validation, W.R., B.S., N.S. and C.N.; formal analysis, W.R., B.S., N.S. and C.N.; data curation, B.S., N.S. and C.N.; writing—original draft preparation, B.S., N.S. and C.N.; writing—review and editing, W.R.; visualization, B.S., N.S. and C.N.; supervision, W.R.; project administration, W.R.; funding acquisition, W.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research received funding from the International Academy of Aviation Industry, King Mongkut’s Institute of Technology Ladkrabang. Funding number: 2564-02-18-001.

Data Availability Statement: No data set is reported.

Acknowledgments: This work was part of the project under the memorandum of understanding between King Mongkut’s Institute of Technology Ladkrabang and Thailand’s Ministry of Transport.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Assessment of Drivers

1. Assets and Cost Efficiency

What is the probability that the seamless air-rail integration will result in stakeholders’ significant cost reductions and/or efficient utilization of infrastructure assets? This includes the following features:

- Cost reductions in infrastructure’s administration, operations, and maintenance.
- Efficiency of train network and airport network administration which cover and connect the domestic and international transport, along with the proper infrastructure maintenance to be always ready for operations.
- Efficiency use of assets such as rolling stocks, ramps, walkways, or skywalks connecting air and rail infrastructure.

If the probability of the above statement is greater than 50%, will the efficiency of assets and cost management result in sustainable competitive advantage of the stakeholder?  
YES  NO

2. Customer Service

What is the probability that the seamless air-rail integration will result in stakeholders’ significant elevation of passenger service level? This includes the following features:

- Comprehensive service that supports the seamless journey within the air and rail infrastructure such as shared online ticketing platform, integrated ticketing, code-sharing for flights and trains, baggage check-in and handling between both modes, flight check-in services at train stations.
- There are reliable procedures to track, monitor, and control overall safety and security of train services and modal shift.
- There are reliable and trustworthy evaluation procedures for train and intermodal passenger services.

If the probability of the above statement is greater than 50%, will the elevation of passenger service level result in sustainable competitive advantage of the stakeholder?  
YES  NO

3. Marketing Advantages

What is the probability that the seamless air-rail integration will result in stakeholders’ significantly higher marketing advantage? This includes the following features:

- Service providers offer technology that supports time management including an application that can track both train and flight in real time, notification alert when a flight or train is delayed or cancelled.
- Train fares are approachable and attractive so that ridership can be increased and would result in a modal shift from other forms of transport (both public and private).
- Special discounts can be offered to passengers using both modes of transport through integrated tickets.
- Frequent flyer and rider program managed by airlines and train operators.
- Offering innovative services to support the seamless journey within the air and rail infrastructure.

If the probability of the above statement is greater than 50%, will the higher marketing advantage result in sustainable competitive advantage of the stakeholder?  
YES  NO

4. Profit Stability and Growth

What is the probability that the seamless air-rail integration will result in stakeholders’ significant growth of profit and/or reduction of profit’s variation? This includes the following features:

- Modal shift by Thai citizen from other forms of transport to seamless air and rail transport, particularly during major holidays and long weekends.
- Sufficient service frequency for train operations and flight availability throughout the year.
- Ability to generate revenues and profit from ancillary business such as business emerging from transit-oriented development.
If the probability of the above statement is greater than 50%, will the stability and growth in profit result in sustainable competitive advantage of the stakeholder?

YES

NO

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