Financial Evaluation by the Combined AHP-PROMETHEE Method: A Case Study of Integrated Logistics Service Providers in Thailand

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Abstract

In relation to core competence, cost reduction and improvement of customer satisfaction, an outsourcing has noticeably become a crucial strategy to cope with those of numerous firms. Logistics services (such as management of inventory and transport) have been emerged as one of the outsourcing activities, which a logistics service provider performs its logistics capability to fulfill operations of any firm tied up with the complex networks of supply chain. In this case, the financial performance of integrated logistics service providers located in Thailand were compared through the notion of multi-criteria decision making (MCDM). Therefore, the combined AHP-PROMETHEE method was proposed in this study. AHP was utilized to determine weights of four criteria and 15 sub-criteria based directly on financial ratios, while PROMETHEE was employed to evaluate and rank four pre-determined alternatives of integrated logistics service provider from the best to worst one on financial ability. As a consequence, an outcome shows that III is viewed as the best organization among others for manipulating on the whole finance efficiently. Ultimately, this is a benchmark for other firms to improve their financial performance, and investors can manipulate this method as a tool to carefully invest in the stock market.

Keywords: AHP, Financial Ratio, Logistics Service Provider, MCDM, PROMETHEE

Introduction

In today's business setting, where firms face fierce competition and reduced margins, increasing profits can be achieved via effective planning, design and management of the entire supply chain (Min & Zhou, 2002). In response, the manufacturing and business activities have led industries to outsource many business operations and focus more on their core competence which is the one thing that a company can do better than its competitors (Chase et al., 2006). Thus, most of them have chosen to outsource their non-core tasks such as logistics operations to logistics service providers (Venus Lun et al., 2015). Customers of logistics service providers (e.g. traders, manufacturers, and retailers) increasingly request more, better, and faster services in support of their production and marketing activities (McGinnis & Kohn, 2002). In the perspective of Lai (2004), a logistics service provider can be defined as a provider of logistics services that performs all or part of a client company's logistics functions. Generally, those logistics service providers specialize in managing a wide range of service-related logistical activities for clients, such as warehouse management, shipment consolidation, customs brokerage, transportation /distribution management and customer service (Daugherty et al., 1998; Mentzer et al., 2001). Based on Research and Markets (2019), "The global logistics service market revenue accounted for US$ 1,122.58 billion in 2018 and is expected to grow at a compound annual growth rate of 6.9% during the forecast period (2019-2027), to account to US$ 2,029.38 billion by 2027". The consequence over revenue in 2018 was that the growing emphasis towards achieving improved operational efficiencies coupled with the rise in popularity of outsourcing logistics operations and selected supply chain process for reducing the operational costs has gained significant traction across various industries/businesses and then propelling the growth for logistics service market (Research and Markets, 2019). In Thailand, the growth of logistics services has caused by an investment in the

transport infrastructure under the 12th National Economic and Social Development Plan, which aims to diminish the country's logistics costs to 12% of GDP by 2021 (Mordor Intelligence, n.d.). Additionally, that 12th Plan (2017-2021) will call not only for the transport infrastructure development in the major cities and border provinces, but also improved linkage with neighboring countries (Mordor Intelligence, n.d.). As a result, an effect of Thailand's growth rate on logistics service business is an increase of logistics service providers. As an intense competition among those of them has rapidly risen, their performance on financial view should be taken into account. This may enable those logistics service providers to compare financial capability with other competitors and lead to improve it. Also, investors could use that information to make a judgement on which one will be invested.

Therefore, the objective of this study is to evaluate the financial performance of integrated logistics service providers based in SET (Stock Exchange of Thailand). In this case, the combined MCDM means between AHP (Analytic Hierarchy Process) and PROMETHEE (Preference Ranking Organization Method for Enrichment of Evaluations) is applied with following descriptions. Once criteria and sub-criteria of financial ratio are defined, weights of them will be obtained by the procedure computation of AHP via pairwise comparisons. Subsequently, PROMETHEE is used to evaluate and rank alternatives of logistics service provider. Eventually, the rank of them in regard to financial performance from the best to worst one is appeared.

Literature Review

Multi-Criteria Decision Making (MCDM)

Presently, people/organizations have experienced lots of complicated problems in their daily lives/activities, so some aids have emerged as tools to assist in making a decision. One of the them is MCDM methods, dealing with investigation of alternatives with regard to multiple criteria and conflicting objectives (Voogd, 1983). In general, those methods are utilized to solve decision-making problems in a variety of disciplines, e.g. business, finance, logistics/supply chain, production, engineering, technology, energy, environment. To cope with them, Mosadeghi et al. (2015) reveal that MCDM ones particularly involve in a multi-stage process which is composed of defining objectives, choosing the criteria to measure the objectives, specifying alternatives, assigning weights to the criteria and applying the appropriate mathematical algorithm for ranking alternatives. With several MCDM methods, nevertheless, AHP and PROMETHEE are among the most recognized ones and were reviewed in this study. For example, the research of Luthra et al. (2016) engaged AHP to evaluate and determine relative importance of barriers with respect to the adoption of sustainable consumption and production initiatives in supply chain. In automotive industry, Petruni et al. (2019) employed AHP to assist safety managers and risk assessors in the human reliability analysis technique selection process. Mastrocinque et al. (2020) adopted an AHP-based multicriteria model for sustainable supply chain development in the renewable energy sector. With respect to PROMETHEE, Murat et al. (2015) utilized it to choose the best school related to criteria of achievement, non-attendance, social activities and projects. Due to an importance in today's global economic marketplace of food industry, Govindan et al. (2017) applied PROMETHEE to rank several suppliers in food supply chain from each decision maker's preferences. Lopes et al. (2018) exploited PROMETHEE to investigate the competitiveness of tourism destinations based in the northern region of Portugal. As e-commerce played a vital role in the hotel industry, Ostovare & Shahraki (2019) conducted PROMETHEE and its function to rank and develop the visual aid of websites.

In addition to the single MCDM approaches of AHP and PROMETHEE, the hybrid ones of them have been widely acknowledged in various fields. For instance, the study of Yu et al. (2011) proposed an evaluation model of ranking e-commerce websites in e-alliance in regard to AHP and fuzzy TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution). AHP was conducted to analyze the structure of ranking problem and determine weights of criteria, fuzzy sets were employed to present ambiguity and subjectivity with linguistic values, and finally, TOPSIS was used to obtain the final ranking. In order to select the best alternative with the aim to improve electronic supply chain management performance of Indian automobile industry in the region of Delhi, Tyagi et al. (2014) developed a MCDM model of AHP-TOPSIS. As an ERP (Enterprise Resource Planning) system played a major role for a firm, Kilic et al. (2015) proposed an integration between ANP (Analytic Network Process) and PROMETHEE to choose the most attractive ERP. ANP was utilized to determine weights of criteria, and obtained weights were used in PROMETHEE for optimal ranking of the alternative system choices. In reference to the travel industry, Butowski (2018) aimed to build an evaluation structure used for the assessment of European coastal and offshore areas for sailing tourism, so AHP-PROMETHEE method was emerged as an essential tool to evaluate the attractiveness of different destinations.

Methodology

Overall, the methodology is presented as the conceptual framework for evaluating the financial performance of integrated logistics service providers illustrated in Figure 1 along with the following details of criteria/sub-criteria and alternatives as well as the combined AHP-PROMETHEE method.

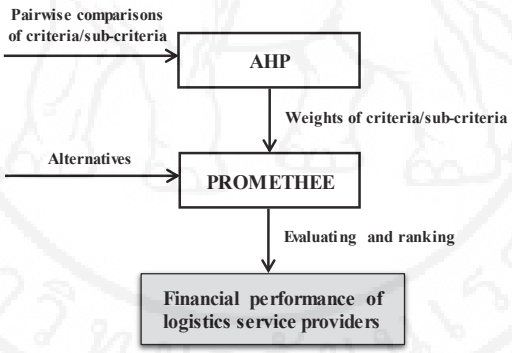

Figure 1 The Conceptual Framework of AHP-PROMETHEE Method

Criteria/Sub-criteria and Alternatives

Served as a criterion/sub-criterion in this case, a financial ratio is clearly defined an index that relates two accounting numbers and is obtained by dividing one number by the other (Van Horne & Wachowicz, 2009). Particularly, it is a useful analytical tool that can reveal the financial strength and weakness of any firm (Rezaie et al., 2014). Similarly, it is a tool for the financial analyst to evaluate a firm's financial condition and performance (Van Horne & Wachowicz, 2009). In this study, financial ratios are classified as four criteria/15 sub-criteria along with symbols held in parentheses and presented by formulas as follows (Trent, 2015; Van Horne & Wachowicz, 2009):

1. Liquidity ratios *(C1)* are used to measure a firm's ability to meet short-term obligations.
   - Current ratio *(C11)* = Current assets ÷ Current liabilities
   - Cash ratio *(C12)* = Cash ÷ Current liabilities
   - Quick ratio *(C13)* = (Current assets − Inventories) ÷ Current liabilities
2. Activity ratios *(C2)* measure how effectively the firm is using its assets.
   - Asset turnover *(C21)* = Sales ÷ Total assets
   - Current asset turnover *(C22)* = Sales ÷ Current assets
   - Inventory turnover *(C23)* = Sales ÷ Inventories
   - Inventory days outstanding *(C24)* = 365 ÷ Inventory turnover
3. Leverage ratios *(C3)* measure how the firm has financed its assets as well as the firm's ability to repay its short/long-term debt.
   - Debt to equity *(C31)* = Total liabilities ÷ Equity
   - Current debt to equity *(C32)* = Current liabilities ÷ Equity
   - Interest coverage *(C33)* = Earnings before interest and taxes ÷ Interest
4. Profitability ratios *(C4)* measure how well the firm generates its profit.
   - Net profit margin *(C41)* = Net income ÷ Sales
   - Gross margin *(C42)* = (Sales − Cost of goods sold) ÷ Sales
   - Operating margin *(C43)* = Operating income ÷ Sales
   - Return on assets *(C44)* = Net income ÷ Total assets
   - Return on equity *(C45)* = Net income ÷ Equity

Table 1 Selected Alternatives of Integrated Logistics Service Providers with their Business

Acronym	Business
B	The firm provides comprehensive logistics services e.g. berths, warehouses, cargo handling, road transport, crane rental, international freight forwarding and customs clearance.
III	The firm clearly operates as an integrated logistics service provider by providing logistics and supply chain management and also serves as a goods transporter and freight forwarder.
JWD	The firm is an integrated logistics and supply chain solutions service provider in ASEAN, e.g. warehouse management, transportation and distribution, moving by providing household & office removal and so on.
WICW	The firm serves as an international logistics service and solution provider, including import and export by sea freight and air freight, custom clearance and land transport.

In regard to alternatives of logistics service provider, they were selected from SET index. Specifically, SET index is defined as a Thai composite stock market index, principally computed from the prices of all common stocks on the main board of SET. The reason to pick them from SET is that the financial information disclosure of those listed firms is quite reliable due to compliance with SET regulations. There are totally 23 firms listed in transportation and logistics sector of SET, but four of them were picked out because of acting as fully integrated logistics service providers (The Stock Exchange of Thailand (SET), 2020). As demonstrated in Table 1, those selected alternatives are presented as acronyms along with an extensive range of their logistics services (The Securities and Exchange Commission (SEC), 2020).

The Combined AHP-PROMETHEE Method

Over the last decade, it seems that the hybrid MCDM methods have been broadly emerged in many studies. The newest trend with respect to MCDM method is to merge two or more ones to make up for shortcomings in any single particular method (Velasquez & Hester, 2013). In this study, the combined AHP-PROMETHEE method was accordingly proposed. AHP is a theory of measurement through pairwise comparisons and relies on the judgments of experts to derive priority scales (Saaty, 2008); meanwhile, PROMETHEE is an outranking method for a finite set of alternative actions to be ranked and selected among criteria, which are often conflicting (Behzadian et al., 2010). Even though PROMETHEE is regarded as simplicity, clearness and stability (Brans et al., 1986), it has a constraint on how to construct weight for each criterion suitably. Therefore, AHP is utilized in enhancing a drawback of PROMETHEE. In this case, AHP was used to generate weights of criteria based on decision makers' pairwise comparison, whereas PROMETHEE was engaged to evaluate and rank the best to worst integrated logistics service provider on financial ability.

To construct weights of criteria by AHP, the following steps are described (Rajak & Shaw, 2019; Wang & Yang, 2007; Yu et al., 2011). Primarily, the number of pairwise comparisons can be determined by the formula $(n^2 - n) \div 2$, if "n" criteria are considered in the model. Next, a decision maker gives his or her perspectives on each pair of criteria concerned with one to nine fundamental scale as tabulated in Table 2.

Table 2 One to Nine Fundamental Scale (Ishizaka & Nemery, 2013)

Definition	Value
Equal Importance	1
Moderate Importance	3
Strong Importance	5
Very Strong Importance	7
Extreme Importance	9
Intermediate Values	2, 4, 6, 8

Suppose that, a set of criteria is $C = \{C_j / j = 1, 2, 3 \dots n\}$. After the pairwise comparison among "n" criteria, a (n x n) dimension matrix A is formed in which each component, a_{ij} (i, j = 1, 2 … n), represents the weight of the criterion given by the decision maker. Equation (1) shows the matrix of pairwise comparison as follows:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}, a_{ii} = 1, a_{ji} = \frac{1}{a_{ji}}, a_{ij} \neq 0 \quad (1)$$

After the pairwise comparison, mathematical computation is used to establish the relative weights of criteria. Computation includes the calculation of normalized principle Eigenvector from the given matrix A. The relative weights are acquired by the Eigenvector (w) corresponding to the largest eigenvalue (λ_{max}) as expressed in (2).

$$Aw = \lambda_{max} w \quad (2)$$

If the rank of matrix A is 1 and λ_{max} is n, then it can be conjectured that pairwise comparisons are completely consistent. The relative weights are obtained by normalizing any of the rows or columns of A. Then, a consistency index (CI) and consistency ratio (CR) are computed by Equation (3) and (4) as follows:

$$CI = (\lambda_{max} - n) \div (n - 1) \quad (3)$$

$$CR = CI \div RI \quad (4)$$

RI is random index, depending on the number of criteria. If *CR* is lower than 10%, a result can be acceptable. Otherwise, the procedure of pairwise comparison must be repeated until the decision is more consistent.

Regarding PROMETHEE, Behzadian et al. (2010) explain the procedure of PROMETHEE I and II as follows:

Step 1: Determination of deviations on the basis of pairwise comparisons.

$$d_j(a, b) = g_j(a) - g_j(b) \quad (5)$$

Where $d_j(a, b)$ denotes the difference between the evaluations of *a* and *b* on each criterion.

Step 2: Application of the preference function.

$$P_j(a, b) = F_j[d_j(a, b)] \; j = 1, ..., k \quad (6)$$

Where $P_j(a, b)$ denotes the preference of alternative *a* with regard to alternative *b* on each criterion, as a function of $d_j(a, b)$.

Step 3: Calculation of an overall preference index.

$$\pi(a, b) = \sum_{j=1}^{k} P_j(a, b) w_j \qquad \forall a, b \in A \quad (7)$$

Where $\pi(a, b)$ of *a* over *b* (from 0 to 1) is defined as the weighted sum $P_j(a, b)$ of each criterion, and w_j is the weight associated with *j* the criterion.

Step 4: Calculation of flows (i.e. PROMETHEE I: partial ranking)

$$\phi^+(a) = \frac{1}{n-1} \sum_{x \in A} \pi(a, x) \quad (8)$$

$$\phi^-(a) = \frac{1}{n-1} \sum_{x \in A} \pi(x, a) \quad (9)$$

Where $\phi^+(a)$ and $\phi^-(a)$ denote the positive and negative flow, respectively, for each alternative.

Step 5: Calculation of net flows (i.e. PROMETHEE II: complete ranking)

$$\phi(a) = \phi^+(a) - \phi^-(a) \quad (10)$$

Where $\phi(a)$ denotes the net flow for each alternative.

Results

Demonstration of AHP

Initially, decisions on pairwise comparison of 28 pairs of criteria/sub-criteria based on the fundamental 1-9 scale of experts (working in the higher education institutions and private firms) in fields of logistics/supply chain were collected and computed through AHP online. After that, the average scales of 10 experts' respondence regarding the consistency ratio (*CR*) below 0.1 held in pairwise comparison matrix are shown in Table 3-7. Later, those mean scales are transformed into weights of criteria and sub-criteria, respectively; however, ones of

sub-criteria are adjusted in order to conform to weights' boundary of criteria as displayed in Table 8. Obviously, the greatest weight with the first rank belongs to return on equity (0.2003), but inventory days outstanding (0.0091) is the smallest one with the last rank.

Table 3 Pairwise Comparison Matrix with Average Scales for Criteria (*CR* = 0.0480)

Criterion	*C1*	*C2*	*C3*	*C4*
C1	1	3.9233	2.5946	0.3636
C2	0.2549	1	0.3686	0.2100
C3	0.3854	2.7128	1	0.2732
C4	2.7505	4.7613	3.6603	1

Table 4 Pairwise Comparison Matrix with Average Scales for Sub-criteria in a Criterion of Liquidity (*CR* = 0.0000)

Criterion	*C11*	*C12*	*C13*
C11	1	0.7792	1.4142
C12	1.2834	1	1.7617
C13	0.7071	0.5676	1

Table 5 Pairwise Comparison Matrix with Average Scales for Sub-criteria in a Criterion of Activity (*CR* = 0.0050)

Criterion	*C21*	*C22*	*C23*	*C24*
C21	1	0.6071	1.6917	2.5210
C22	1.6471	1	2.5210	2.9113
C23	0.5911	0.3967	1	1.4727
C24	0.3967	0.3435	0.6790	1

Table 6 Pairwise Comparison Matrix with Average Scales for Sub-criteria in a Criterion of Leverage (*CR* = 0.0010)

Criterion	*C31*	*C32*	*C33*
C31	1	0.6329	1.4142
C32	1.5800	1	2.4495
C33	0.7071	0.4082	1

Table 7 Pairwise Comparison Matrix with Average Scales for Sub-criteria in a Criterion of Profitability (*CR* = 0.0050)

Criterion	*C41*	*C42*	*C43*	*C44*	*C45*
C41	1	5.0000	4.0000	3.0000	0.5000
C42	0.2000	1	0.5000	0.3300	0.2000
C43	0.2500	2.0000	1	0.5000	0.2500
C44	0.3333	3.0303	2.0000	1	0.5000
C45	2.0000	5.0000	4.0000	2.0000	1

Table 8 Adjusted Average Weight and Rank of Sub-criteria

Criterion	Average Weight of Criterion	Sub-criterion	Average Weight of Sub-criterion	Adjusted Average Weight of Sub-criterion	Rank
C1	0.2700	*C11* (max)	0.3350	0.0905	5
		C12 (max)	0.4260	0.1150	3
		C13 (max)	0.2390	0.0645	7
C2	0.0730	*C21* (max)	0.2850	0.0208	13
		C22 (max)	0.4190	0.0306	11
		C23 (max)	0.1720	0.0126	14
		C24 (min)	0.1240	0.0091	15
C3	0.1420	*C31* (min)	0.3020	0.0429	10
		C32 (min)	0.4910	0.0697	6
		C33 (max)	0.2070	0.0294	12
C4	0.5150	*C41* (max)	0.2380	0.1226	2
		C42 (max)	0.0900	0.0464	9
		C43 (max)	0.1020	0.0525	8
		C44 (max)	0.1810	0.0932	4
		C45 (max)	0.3890	0.2003	1

Demonstration of PROMETHEE

In this stage, weights and min/max (minimum/maximum) preferred direction of sub-criteria in Table 8 were prepared to calculate via Visual PROMETHEE. Also, the usual preference function is applied for reacting to an optimum consequence, either the higher the better or the lower the better. After computing with financial ratios, all values of an accounting period in 2019 are demonstrated in Table 9. In this case, PROMETHEE I (partial ranking) is utilized to compute positive (Phi+) and negative (Phi-) flow and allows for incomparability between alternatives when Phi+ and Phi- give conflicting rankings (VPSolutions, 2013). As shown in Figure 2, Phi+ and Phi- are the measure of strength and weakness, representing on the left-side and right-side column, respectively. The best and worst outcome are at the top and the bottom of the column, respectively (VPSolutions, 2013). Also, 1.0 is the best value on the left-side column, but 0.0 is the best one on the right-side column. Thus, III is the leader of financial ability on Phi+, followed by JWD, WICE and B, respectively. With respect to Phi-, rank of alternatives from the best to worst financial status is III, JWD, WICE and B, respectively.

Table 9 Input Data of Alternatives' Financial Ratios

Criterion	Sub-criterion	Alternative			
		B	III	JWD	WICE
C1	*C11*	3.85	1.19	0.92	1.77
	C12	1.90	0.40	0.36	0.28
	C13	-	1.19	0.90	-
C2	*C21*	0.42	1.27	0.48	1.42
	C22	0.86	3.64	1.66	2.39
	C23	-	2,175.76	62.97	-
	C24	-	0.17	5.80	-
C3	*C31*	0.36	0.74	1.39	0.77
	C32	0.17	0.51	0.75	0.60
	C33	-4.35	12.94	4.74	10.62
C4	*C41*	-7.24%	5.82%	9.34%	1.97%
	C42	-11.31%	19.59%	32.02%	16.24%
	C43	-3.99%	6.83%	13.54%	3.21%
	C44	-3.07%	7.39%	4.51%	2.79%
	C45	-4.19%	12.86%	10.78%	4.96%

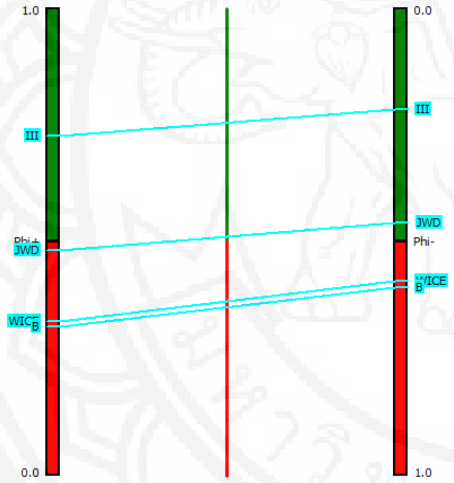

Figure 2 Diagram for Partial Ranking

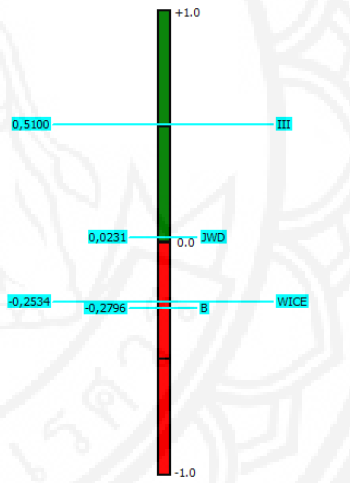

Figure 3 Diagram for Complete Ranking

Based on PROMETHEE II (Complete Ranking), it is related to only net flows and results in a complete ranking of alternatives, and the incomparable status is not existed; those alternatives can thus be ordered from the best to the worst (Ishizaka & Nemery, 2013). In Figure 3 and Table 10, the best result of the net flow (Phi) on financial capability is III. It is apparent that III and JWD (slightly above 0.0) are on the positive zone of upper column, but WICE and B are on the negative side of lower column. Hence, the evidence seems to indicate that III is the best integrated logistics service provider on financial performance, followed by JWD, WICW and B, respectively.

Table 10 Multicriteria Ph+, Ph−, Phi and Rank of Alternatives

Alternative	Phi+	Phi−	Phi	Rank
B	0.3172	0.5968	−0.2796	4
III	0.7263	0.2164	0.5100	1
JWD	0.4829	0.4598	0.0231	2
WICE	0.3303	0.5837	−0.2534	3

Conclusions and Discussions

As several firms have currently focused on core competences, their logistics operations are then outsourced by logistics service providers. To choose appropriate logistics service providers, those firms may undertake financial ratios to determine financial capability of them. In the same way, most investors can use those ratios to identify financial ability of them for investing in the stock market. In order to select the best logistics service provider on financial performance as well as rank the rest of them, MCDM methods are one of the essential tools to examine those matters. Therefore, the combined AHP-PROMETHEE method was proposed in this study. The comparison among alternatives of integrated logistics service provider in regard to different weights of financial ratios by means of PROMETHEE in bar charts is depicted in Figure 4 with following discussions. III (1st rank) exhibits strong financial competence. JWD (2nd rank) has only strength on profitability with positive contributions, while WICE (3rd rank) has only strength on activity on Phi+. Although liquidity and leverage of B (4th rank) are on positive contributions, its profitability has a dramatic fall on Phi−. Also, its activity is on Phi−.

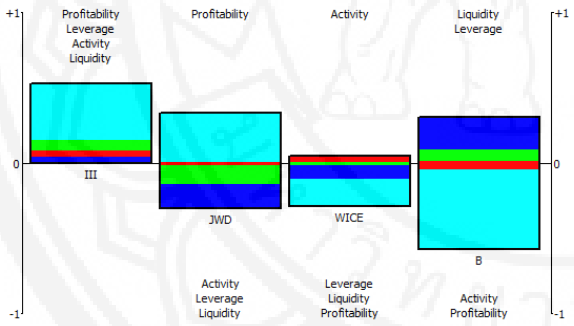

Figure 4 Bar Charts for Comparison of Alternatives

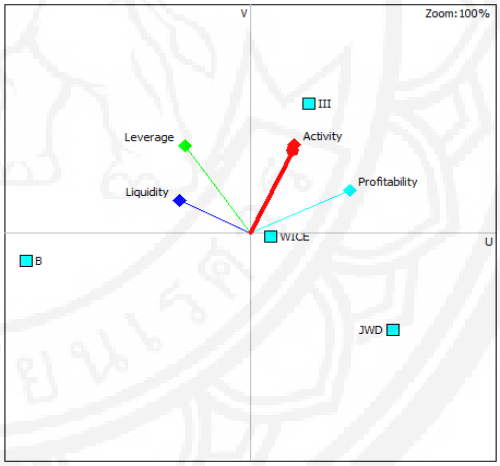

Figure 5 GAIA Plane for Comparison of Alternatives

By displaying graphical consequences in financial ratios, GAIA plane is employed to proficiently manipulate PROMETHEE. According to Figure 5, activity and profitability are close to each other. This is obvious that the higher sales cause a higher profit level. Also, liquidity and leverage are relatively close to each other, indicating that an efficient management on assets leads to carry out liabilities effectively. Also, III has excellent financial ability on activity and profitability; on the contrary, B can execute better liquidity and leverage than others.

Although the combination of MCDM methodology between AHP and PROMETHEE was applied to evaluate financial capability of integrated logistics service providers, some limitations have been in sight. For example, weights of criteria/sub-criteria may be changed if different experts are invited to give their opinions related to

pairwise comparisons of AHP. In addition, the combined AHP-PROMETHEE approach in this case should be compared with others for the same purpose. For the future study, the accounting year should be extended more than a year (e.g. three years) on purpose to observe the trend on financial performance of each logistics service provider. Also, either single or combined MCDM methods should be taken into consideration to compare with the one in this study. Those MCDM ones are, e.g. ANP, TOPSIS and so forth.

References

Behzadian, M., Kazemzadeh, R. B., Albadvi, A., & Aghdasi, M. (2010). PROMETHEE: A Comprehensive Literature Review on Methodologies and Applications. *European Journal of Operational Research, 200*(1), 198-215. https://doi.org/10.1016/j.ejor.2009.01.021

Brans, J.-P., Vincke, P., & Mareschal, B. (1986). How to Select and How to Rank Projects: The PROMETHEE Method. *European Journal of Operational Research, 24*(2), 228-238. https://doi.org/10.1016/0377-2217(86)90044-5

Butowski, L. (2018). An Integrated AHP and PROMETHEE Approach to the Evaluation of the Attractiveness of European Maritime Areas for Sailing Tourism. *Moravian Geographical Reports, 26*(2), 135-148. https://doi.org/10.2478/mgr-2018-0011

Chase, R. B., Jacobs, F. R., & Aquilano, N. J. (2006). *Operations Management for Competitive Advantage* (11th ed.). New York, USA.: McGraw-Hill/Irwin.

Daugherty, P. J., Stank, T. P., & Ellinger, A. E. (1998). Leveraging Logistics/Distribution Capabilities: The Effect of Logistics Service on Market Share. *Journal of Business Logistics, 19*(2), 35-51.

Govindan, K., Kadziński, M., & Sivakumar, R. (2017). Application of a Novel PROMETHEE-Based Method for Construction of a Group Compromise Ranking to Prioritization of Green Suppliers in Food Supply Chain. *Omega, 71*, 129-145. https://doi.org/10.1016/j.omega.2016.10.004

Ishizaka, A., & Nemery, P. (2013). *Multi-Criteria Decision Analysis: Methods and Software.* United Kingdom: John Wiley & Sons.

Kilic, H. S., Zaim, S., & Delen, D. (2015). Selecting "The Best" ERP System for SMEs Using a Combination of ANP and PROMETHEE Methods. *Expert Systems with Applications, 42*(5), 2343-2352. https://doi.org/10.1016/j.eswa.2014.10.034

Lai, K.-H. (2004). Service Capability and Performance of Logistics Service Providers. *Transportation Research Part E: Logistics and Transportation Review, 40*(5), 385-399. DOI: 10.1016/j.tre.2004.01.002

Lopes, A. P. F., Muñoz, M. M., & Alarcón-Urbistondo, P. (2018). Regional Tourism Competitiveness Using the PROMETHEE Approach. *Annals of Tourism Research, 73*, 1-13. https://doi.org/10.1016/j.annals.2018.07.003

Luthra, S., Mangla, S. K., Xu, L., & Diabat, A. (2016). Using AHP to Evaluate Barriers in Adopting Sustainable Consumption and Production Initiatives in a Supply Chain. *International Journal of Production Economics, 181*, 342-349. https://doi.org/10.1016/j.ijpe.2016.04.001

Mastrocinque, E., Ramírez, F. J., Honrubia-Escribano, A., & Pham, D. T. (2020). An AHP-Based Multi-Criteria Model for Sustainable Supply Chain Development in the Renewable Energy Sector. *Expert Systems with Applications, 150*, 113321. https://doi.org/10.1016/j.eswa.2020.113321

McGinnis, M. A., & Kohn, J. W. (2002). Logistics Strategy-Revisited. *Journal of Business Logistics, 23*(2), 1-17. https://doi.org/10.1002/j.2158-1592.2002.tb00023.x

Mentzer, J. T., Flint, D. J., & Hult, G. T. M. (2001). Logistics Service Quality as a Segment-Customized Process. *Journal of Marketing, 65*, 82-104.

Min, H., & Zhou, G. (2002). Supply Chain Modeling: Past, Present and Future. *Computers & Industrial Engineering, 43*(1-2), 231-249. https://doi.org/10.1016/S0360-8352(02)00066-9

Mordor Intelligence. (n.d.). *Thailand Freight and Logistics Market-Growth, Trends, and Forecast (2020- 2025).* Retrieved from https://www.mordorintelligence.com/industry-reports/thailand-freight-and-logistics-market

Mosadeghi, R., Warnken, J., Tomlinson, R., & Mirfenderesk, H. (2015). Comparison of Fuzzy-AHP and AHP in a Spatial Multi-Criteria Decision Making Model for Urban Land-Use Planning. *Computers, Environment and Urban Systems, 49*, 54-65. https://doi.org/10.1016/j.compenvurbsys.2014.10.001

Murat, S., Kazan, H., & Coskun, S. S. (2015). An Application for Measuring Performance Quality of Schools by Using the PROMETHEE Multi-Criteria Decision Making Method. *Procedia-Social and Behavioral Sciences, 195*, 729-738. https://doi.org/10.1016/j.sbspro.2015.06.344

Ostovare, M., & Shahraki, M. R. (2019). Evaluation of Hotel Websites Using the Multicriteria Analysis of PROMETHEE and GAIA: Evidence from the Five-Star Hotels of Mashhad. *Tourism Management Perspectives, 30*, 107-116. https://doi.org/10.1016/j.tmp.2019.02.013

Petruni, A., Giagloglou, E., Douglas, E., Geng, J., Leva, M. C., & Demichela, M. (2019). Applying Analytic Hierarchy Process (AHP) to Choose a Human Factors Technique: Choosing the Suitable Human Reliability Analysis Technique for the Automotive Industry. *Safety Science, 119*, 229-239. https://doi.org/10.1016/j.ssci.2017.05.007

Rajak, M., & Shaw, K. (2019). Evaluation and Selection of Mobile Health (mHealth) Applications Using AHP and Fuzzy TOPSIS. *Technology in Society, 59*, 101186. https://doi.org/10.1016/j.techsoc.2019.101186

Research and Markets. (2019). *Logistics Service Market to 2027-Global Analysis and Forecasts by Mode of Transportation; Logistics Providers; End-Users.* Retrieved from https://www.researchandmarkets.com/reports/4801383/logistics-service-market-to-2027-global

Rezaie, K., Ramiyani, S. S., Nazari-Shirkouhi, S., & Badizadeh, A. (2014). Evaluating Performance of Iranian Cement Firms Using an Integrated Fuzzy AHP-VIKOR Method. *Applied Mathematical Modelling, 38*(21-22), 5033-5046. https://doi.org/10.1016/j.apm.2014.04.003

Saaty, T. L. (2008). Decision Making with the Analytic Hierarchy Process. *International Journal of Services Sciences, 1*(1), 83-98.

The Securities and Exchange Commission (SEC). (2020). *Company Profile.* Retrieved from https://market.sec.or.th/public/idisc/en/CompanyProfile/Listed

The Stock Exchange of Thailand (SET). (2020). *Market Data.* Retrieved from https://marketdata.set.or.th/mkt/sectorquotation.do?sector=TRANS&language=en&country=US

Trent, R. J. (2015). *Supply Chain Financial Management: Best Practices, Tools, and Applications for Improved Performance.* Florida, United States: J. Ross Publishing.

Tyagi, M., Kumar, P., & Kumar, D. (2014). A Hybrid Approach Using AHP-TOPSIS for Analyzing e-SCM Performance. *Procedia Engineering, 97*, 2195-2203. https://doi.org/10.1016/j.proeng.2014.12.463

Van Horne, J. C., & Wachowicz, J. M., Jr. (2009). *Fundamentals of Financial Management* (13th ed.). UK: Pearson Education.

Velasquez, M., & Hester, P. T. (2013). An Analysis of Multi-Criteria Decision Making Methods. *International Journal of Operations Research, 10*(2), 56-66.

Venus Lun, Y. H., Lai, K.-H., Wong, C. W. Y., & Cheng, T. C. E. (2015). Greening Propensity and Performance Implications for Logistics Service Providers. *Transportation Research Part E: Logistics and Transportation Review, 74*, 50-62. https://doi.org/10.1016/j.tre.2014.10.002

Voogd, J. H. (1983). *Multicriteria Evaluation for Urban and Regional Planning.* London, UK: Pion.

VPSolutions. (2013). *Visual PROMETHEE 1.4 Manual.* Retrieved from http://www.promethee-gaia.net/files/VPManual.pdf

Wang, J.-J., & Yang, D.-L. (2007). Using a Hybrid Multi-Criteria Decision Aid Method for Information Systems Outsourcing. *Computers & Operations Research, 34*(12), 3691-3700. https://doi.org/10.1016/j.cor.2006.01.017

Yu, X., Guo, S., Guo, J., & Huang, X. (2011). Rank B2C E-Commerce Websites in E-Alliance Based on AHP and Fuzzy TOPSIS. *Expert Systems with Applications, 38*(4), 3550-3557. https://doi.org/10.1016/j.eswa.2010.08.143