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The development of a decision support system in multimodal transportation routing within Greater Mekong sub-region countries

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ABSTRACT

The objective of this research is to develop a decision support system (DSS) which can accommodate evaluation models to optimise multimodal transportation routing within Greater Mekong sub-region countries (GMS). This model is the combination of a number of models, the Analytic Hierarchy Process (AHP) which can help to bring consistency weight whose decision criteria – both quantitative and qualitative – are expressed in subjective measures according to the point of view of users. The quantitative factors are found by multimodal transport cost model and qualitative factors by using factor analysis. Then, it is followed by the Zero-One Goal Programming (ZOGP) which can integrate weights from the AHP to achieve an optimal multimodal transportation routing based upon user constraints. The analysis results, software developed, recommendations and limitations are also presented.

1. Introduction

The Thai Government places increasing emphasis on business activities amongst Greater Mekong sub-region countries (GMS, Cambodia, People's Republic of China (PRC), Lao People's Democratic Republic (Lao PDR), Myanmar, Kingdom of Thailand and Socialist Republic of Vietnam). Working within the restrictions of seasonal conditions, multimodal transportation can play a key role in increasingly intense trade competition. The National Economic and Social Development Board (NESDB) has created a plan that defines Thailand's Vision as World Class Logistics (Office of the National Economic and Social Development Board, 2007) so they can support business and trade amongst GMS countries.

Ko (2009) presents multimodal transportation as the carriage of goods by two or more modes of transport, under one contract, one document and one responsible party for the entire carriage, who might subcontract the performance of some, or all modes, of the carriage to other carriers. According to the previous research on selecting a multimodal transportation route such as Min (1991), Bookbinder et al. (1998), Banomyong and Beresford (2001) and Chang (2008) have placed emphasis on the selection of multimodal transportation routes for minimum cost or minimum time by using only quantitative criteria: without qualitative criteria; however, Banomyong and Beresford (2001) have acknowledged some risks of route but not combined this in the model. Risks of route have a serious effect on the quality of transportation, in terms of cost and punctuality of delivery, damaged freight, unexpected cost or delays. Furthermore, Chang (2008) studied the selection of multimodal transportation route by using the shortest path problems based upon time windows for an optimal route. There are some researches who have completed using several other methods, for example, Southworth and Peterson (2000) compute a multimodal transportation route with a Commodity Flow Survey in a USA route: more researches can be found in Lozano and Storchi (2001), Monzon and Rodriguez-Dapena (2006) and Ham et al. (2005).

According to the detail survey, multimodal transportation in GMS existed for some years; however, some logistics service providers (LSPs) and small and medium enterprises (SMEs) are lacking a DSS model in order to assess a satisfactory route according to their type of goods and budget within a time limitation. In general, LSPs propose some routes and detail of cost and delivery time to SMEs. Risks on route may arise unexpectedly, however, and goods, for example, are lost, damaged, or late due to road conditions in rainy seasons and document control at the borders.

Therefore, the objective of this research is to develop a decision support system (DSS) that can accommodate evaluation models and criteria including various factors to select the optimal multimodal transportation routing in transporting goods for LSPs or SMEs as decision maker (DM) between the origin and the destination within GMS countries. The quantitative and qualitative criteria are included to achieve the optimal transportation route within budget, time and risk criteria. This means that the

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users of the DSS can make the decisions according to their needs in qualitative and quantitative criteria on an optimal route based upon the lowest budget and risk, with punctual delivery for a multimodal transportation route. The DSS presented in the next sections aims to contribute to the requirements mentioned above.

This research is organised as follows. Section 2 illustrates the background of the models used in this research and some relevant literature. Section 3 describes the process of selecting a multimodal transportation route based upon newly developed models. Section 4 gives an illustrative example with a user in a transportation route between Thailand (Bangkok) and Vietnam (Hanoi). Section 5 presents some conclusions and recommendations from this research.

2. Literature review

According to the previous studies about the selection of multimodal transportation route area, there are some research gaps. For example, Banomyong and Beresford (2001) suggest cost, time and risk as factors in selecting multimodal transportation route in a Laos company but do not suggest the selection models. Min (1991) presents choices by using goal programming but does not consider quality factors. Ko (2009) presents DSS by using Fuzzy-AHP for systemic analysis. This DSS consists of cost, traffic and risk factors and selects the lowest cost, traffic and risk; however, the user cannot modify the DSS if there are limited budget, time and risk criteria. Chang (2008) also presents a way in which to select the best route for shipment by way of three important characteristics (multiple objectives; scheduled transportation modes, demanded delivery times and transportation economics of scale) but risk criteria are not included.

The purpose of the model in this research is to assist the LSPs or SMEs in making a decision for selecting a multimodal transportation route between the origin and the destination based upon budget, time and qualitative criteria. In achieving the purpose, principally there are six main models. First, a *multimodal transport cost-model* is used to find the cost and time of each route. Second, *risk analysis:* risk identification is applied by using *factor analysis* and risk assessment by using the *Delphi method*: after that the *Analytic Hierarchy Process* (*AHP*) is applied to weight users' needs for budget, time and risk. Finally, the optimal amount of transportation routing cost, routing time and risk of route: under budget, time and risk criteria from the user can be calculated by using *Zero-One Goal Programming (ZOGP)* by which the AHP's weight can be combined with the objective functions. The following literature relates to the model above.

2.1. The risk of transportation

The risk is the essential part of the choice such as where Markowitz (1952) uses mean variance framework to calculate the relationship between beliefs and choice of investment portfolio according to the "expected returns and variance of returns" rule. Choi and Chow (2008) illustrate how to quantify the payoff and the risk for each channel member in the supply chain by the corresponding expected profit and variance of profit. In this research the risk of route is from the viewpoint of qualitative factor. According to Banomyong and Beresford (2001), the routing risk is of significant uncertainty for a decision situation depending on the cost once a commitment is made. When high uncertainty is coupled with high cost, the uncertainty needs to be acknowledged. Risk means both uncertainty and the results of uncertainty. Risk analysis consists of 2 stages: risk identification and risk assessment.

The main focus of risks identification is to recognise future uncertainties. Merkle et al. (1998) present the factor analysis as a statistical technique used to identify a small number of groups or clusters that represent relationships amongst a set of interrelated variables. Factor analysis is an approach to identify a specific group of several qualitative factors for selecting a complex multimodal transportation route. Amelia and Larry (1999) test four hypotheses on the relationship of strategic purchasing to supply chain management by using factor analysis. Humphreys et al. (2004) use factor analysis for finding the impact of supplier development on buyer–supplier performance. Ghosh and Jintanapakanont (2004) mention that factor analysis technique has been used in a variety of risk management areas in recent years. For this reason, this study illustrates an application of factor analysis by extracting coordinated patterns of transportation risk identification.

According to Hallikas et al. (2002), the assessment model of risk must be simple because estimation of the probability and the effect of the risk are mainly based upon subjective estimation. Hallikas et al. (2004), suggest that the model must, therefore, be understood as a method that provides direction. The primary aim of the model is not to provide an absolute value of risk, but rather to provide support in the decision-making process. Hence, risk assessments of this research are needed by the experts in order to decide wisely and practically in the real world problems. Tsai and Su (2005) used the Delphi method to assess the political risk that affects the carriers' business. The Delphi method as developed by the Rand Corporation is amongst the most practical. Its objective is to obtain the most reliable consensus of opinion of a group of experts without direct confrontation. Theoretically, the sequence of collating, feedback and revision is repeated over several rounds until no further change is achieved. Some applications, for example, Kengpol and Tuominen (2006) used AHP, Delphi and Maximise Agreement Heuristic (MAH) methods for group decision making for the information of a logistic company. This method is appropriate for this research for brainstorming when classifying the rank of probability assessment scale and severity impact assessment scale, and for the assessment rank of probability risk and severity impact assessment scale of each route, because it can convert experiences and meaningful information from experts to become a consensus opinion that can be used in DSS as a database.

Thus, this risk scale of a route can present explicit sequence and qualitative measures for risk factor assessment. Risk scale of route can be calculated by having impact assessment scale multiplied by probability assessment scale as can be seen in Hallikas et al. (2004).

2.2. Multimodal transport cost-model

Banomyong and Beresford (2001) explained that the multimodal transport cost-model includes both transport (road, rail, inland waterway and sea) and intermodal transfer (ports, railfreight terminals, inland clearance depots) as cost components. This model has been adapted from Beresford and Dubey in 1990 and improved by Beresford in 1999. Transport costs combine intermodal transfer cost. The highlighted model affects choice of transport modes or combination of modes for given movements. The model could also assist in the logistics trade-offs, such as those between speed and costs, to be thoroughly examined in a range of circumstances. The choices of multimodal transport combinations are based upon factors other than just transportation costs, which are directly related to transit time, distance and intermodal transfer. For this reason we use a multimodal