Designing logistics systems to support multimodal transportation system's strategies under economics scenarios

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Abstract

This paper aims to design and develop logistics model particularly in determining logistics cost per unit based on Logit model development by choosing suitable economic scenarios of each paramount economic factor for adjusting logistics cost per unit and in determining the optimal logistics cost based on mathematical optimization technique for comparing logistics cost between original and model under multimodal transportation scenarios and for evaluating impact on logistics cost. The work scope focuses on rice logistics modelling in lower north of Thailand under multimodal transportation system as case study. The task of rice logistics modelling is the control and continuous development of rice commodity flow from mills in lower north's area to exporters in Bangkok and around Bangkok. This paper collects quarterly data since 1990 to present and planning period is forecast 3 months in advance. Every unit in logistic process is assumed as the government unit in order to consider logistics planning in aspect of government. Principle and reason stem from the application between Logit theory and mathematical optimization theory with real problem in case of rice logistics planning in lower north of Thailand under multimodal transportation scenarios. The results of logistics cost/unit from developing Logit model are combined with mathematical optimization model in order to minimize total logistics cost. The analysis is separated 2 cases such as comparing logistics cost under multimodal transportation scenarios and evaluating impact on logistics cost of interest rate and fuel price under economics scenarios.

It can summarize that the integration between logistics cost/unit model and mathematical optimization model makes us find the way to compare total minimum logistics cost between original and model under multimodal transportation scenarios and to evaluate the impact of interest rate, fuel price on logistics cost.

Keywords:

“Logistics modeling”; “Transportation network optimization”; “Multimodal transportation system”; “Mathematical optimization technique”; “Logit model”

1.Introduction/Background

The high logistics cost mostly has caused from the inefficiency of transportation network system and logistics network system. In addition, the lack of insight to solving logistics problem systematically is another crucial reason particularly in the integration of knowledge either logistics, supply chain management, transportation or economics etc. These problems have influenced to reducing overall logistic costs. Rice in lower north of Thailand is considered as case study in this paper. From the problem as mentioned previously, multimodal transportation modal ,Logit model and mathematical optimization technique should be considered for developing model. This research constructs Logit model for determining the suitable economic situation for adjusting logistics cost/unit corresponding to the real situation. Then mathematical optimization model (MIP) based on logistics planning under multimodal transportation scenarios is constructed for determining optimal logistics cost decision mathematically to assess impact of paramount economic factors on logistics cost including comparing total logistics cost between original and model under multimodal transportation scenarios. This research is expected significantly that this paper may be the potential benefits of implementing optimal logistic network system in the future.

2.Literature reviews

A number of researches about logistics modeling have interesting various topics and many papers in the past have attempted to review and to sum up literatures (Meixell ,2005; Santos,s.,Gouveia.; Beamon ,1998). These papers have attempted to focus on supply chain design and analysis including method of mathematical modeling. And some papers have aimed to review only some performance measures such as case of the logistics cost reduction in China (Xiaofeng,2009). After these papers have been surveyed, it have been found that logistics cost as performance measure and mixed integer programming as mathematical tool have been implemented vastly. Klingman (1988) found that MIP could solve with logistics planning in phosphate-based chemical company on large scale problem efficiently in order to minimize logistics cost. Roy(1989) and Bookbinder (1989) also found similar pattern or results. Sear, T. N. (1993) suggested about the development and application of logistics planning techniques on large scale problem in the downstream oil industry by using MIP with using dividing customers into demand zone can help to solve large scale problem but this paper showed only the concept and had no any results. J.Ashayeri (1994) have continued to develop and implement MIP in large scale problem particularly in urea fertilizer company. These works was expanded by Ana Maria Sarmiento and Rakesh

Nagi (1999). Research about mathematical logistics modeling as mentioned previously, however, is still necessary to improve and apply in the important issues especially multimodal transportation system and transport economics issues because these works is very useful for the development of logistics modeling in the future.

3.Theoretical framework

3.1 General mathematical structure of logistic network

The general mathematical structure in this paper have used linear programming and can demonstrate general form as follows.

Part I: Objective Form.

Maximize/Minimize : $C_1X_1+C_2X_2$

Part II: Constraint.

e.g. $a_{11}x_{11} + a_{12}x_{12} \geq b_1$

$a_{21}x_{21} + a_{22}x_{22} \geq b_2$

$a_{31}x_{31}+ a_{32}x_{32} \geq b_3$

Part III: Non-negative Variable.

e.g. $x_{ij} \geq 0$

3.2 Logit Model's Theory Framework

Logit model is the model for choosing situations, choices or quality/discrete dependent variables. And this model stems from the probability theory and ordinal theory. General form of Logit model can be derived as follows.

P_r (Y=1) = F($x_1,x_2,\ldots\ldots,x_n$)

= $1/(1+e^{-z})$

$=1/(1+\ell^{\beta_0+\beta_1x_1+\beta_2x_2+.....+\beta_nx_n})$ (1)

where P_r (Y=0,1) = Probability Function on Y = 0,1

x_i = Independent Variables.

Y = Dependent Variables as

If characteristics is in group 0,1 then Y = 0,1 respectively

From ln (Odd Function) = $\ln\left(\frac{P_1}{P_0}\right)$

Logit Model = $a_1x_1 +a_2x_2 +a_3x_3 + \ldots\ldots\ldots\ldots + a_nx_n$ (2)

4. Model/theoretical development and results.

The developed logistic model's design stems from the connection between logistics cost/unit model based on Logit theory and optimization model with solving real problem in case of rice logistics planning in lower north of Thailand under multimodal transportation scenarios in order to evaluate the impact of each paramount economic factors on logistic cost and to compare total logistics cost between original and model under multimodal transportation scenarios.

4.1 Logistics structure and methodology

Logistics structure depict rice commodity flow from mills in lower north of Thailand to exporters at Bangkok or around Bangkok. Quarterly data involved since 1990 to present is collected and planning period forecasts 3 months in advance. Logistics process's units are considered as government owner. Methodology in this paper consist of 3 parts such as main research methodology, development of mathematical optimization model and research methodology of logistics per/unit forecast as follows.

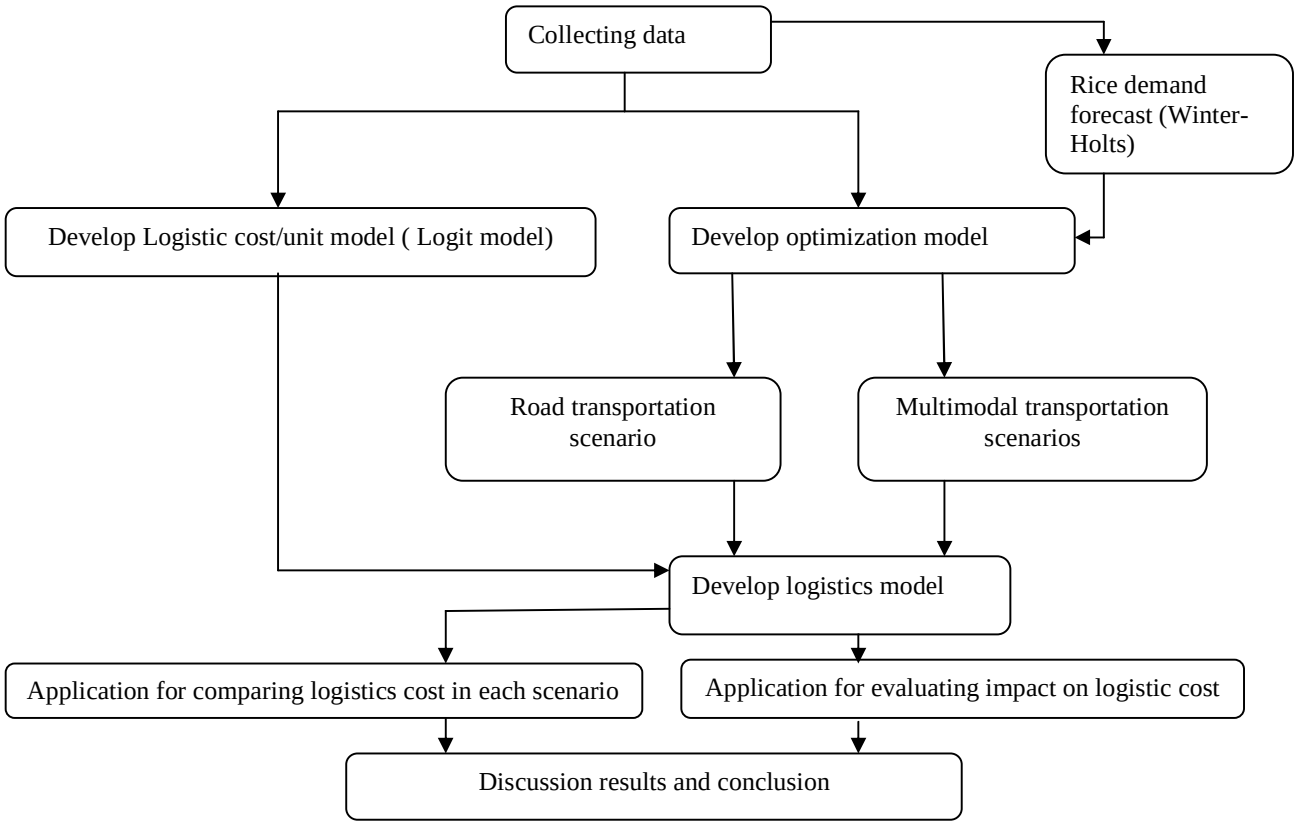

Figure 1: Main Research Methodology Chart

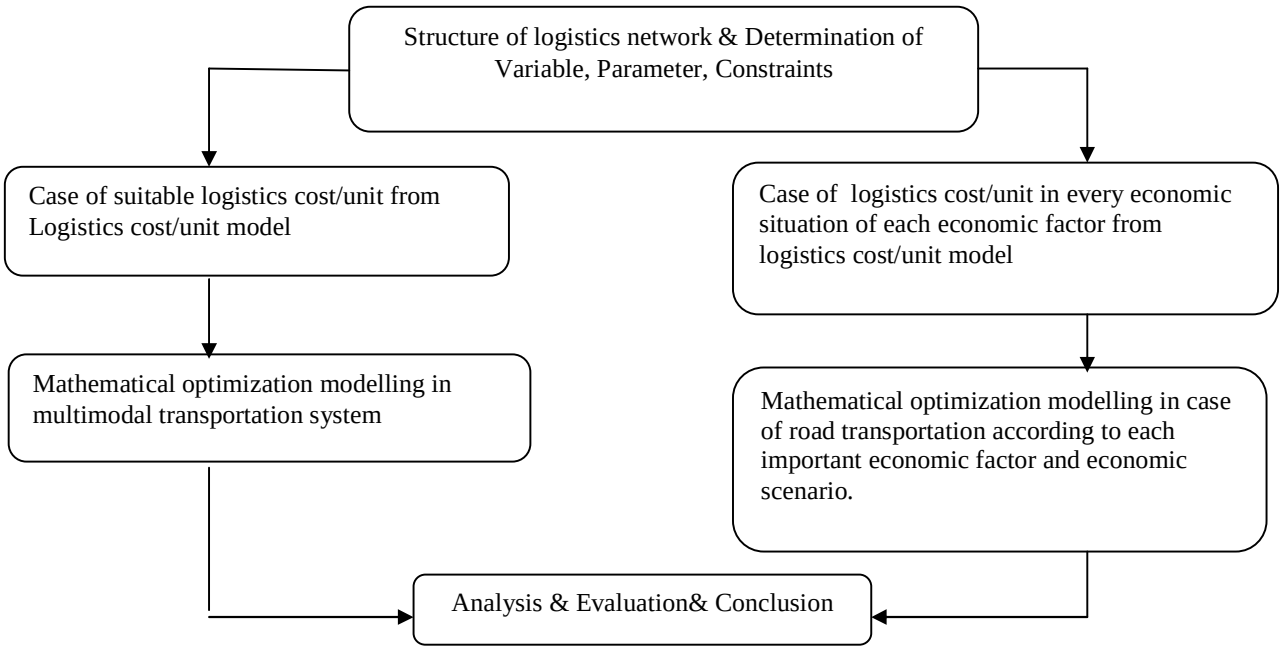

Figure 2: Development of Mathematical Optimization Model

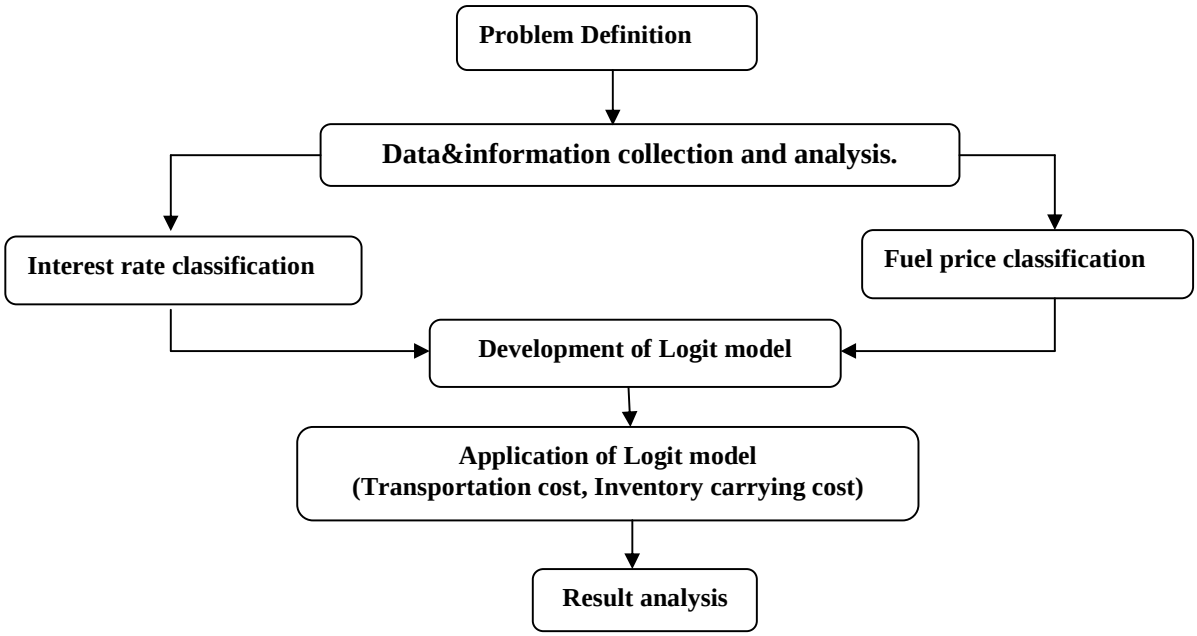

Figure 3: Research Methodology of Logistics Cost/unit Forecast

4.2 Results of model development

Innovative feature of this research focuses on the developed logistics model's design, which is the application of Logit theory and mathematical optimization theory with real problem in case of rice logistics planning in lower north of Thailand under multimodal transportation scenarios. Based on the combination of knowledge, this concept attempts to create the relationship within logistics model in order to assess the impact of substantial economic factors on logistic cost for determining the potential guideline of increasing improved logistics system's efficiency and to compare total logistics cost based on optimization technique mathematically between original and model under multimodal transportation scenarios in order to determine the optimal logistics scenario that be useful to define the potential benefit of Thailand in the future.

5.Special example corresponding to this paper and developing the conceptual design of this paper.

E. Powell Robinson, Jr. and Ronald K. Satterfield (1998) attempted to describe firm's interactions such as market share, distribution strategy and cost in design of profit maximizing. This paper utilized 2 major support models such as binary logit model for forecasting market share considering various demand-influencing parameters such as product price, distribution service and mixed integer programming for solving and determining optimal distribution network design. Logit equation in this paper was employed for solving traditional problem formulation for logistics network design in the case of assuming constant demand. The framework was applied with the real design problem facing a national distributor of industrial chemical product. The results from this paper verified the potential benefit of the integrated solution methodology and large scale capacity of this model.

This paper employed 2 major models similar to Robinson and Satterfield's paper. But this paper tried to solving traditional problem formulation for logistics network design in the case of assuming constant logistics cost per unit by logit equation and the application with actual case study of rice logistics in lower north of Thailand emphasizing on logistics design to support multimodal transportation system's strategies under economics scenarios.

6.Summary

This paper attempts to design logistics system to support multimodal transportation system's strategies under economics scenarios in the form of conceptual design. The conceptual design has aim in order to design logistics systems for comparing total logistics cost between original and model under multimodal transportation scenarios and for evaluating the impact of economics factors on logistics cost. Principle and reason are based on the application between Logit equation and mathematical optimization equation with real problem of case study. Logit equation in conceptual logistics design makes us find the way to determine the suitable logistics cost/unit corresponding to real economic situation in increasing

efficiency of logistics model. Additionally, the integration between logistics cost/unit model and mathematical optimization model makes us find the way to compare total minimum logistics cost between original and model under multimodal transportation scenarios and to evaluate the impact of interest rate, fuel price on logistics cost.

After the conceptual design is completed, the future work is the application with the real problem of rice logistics in lower north of Thailand that considered as case study. In this case study, mathematical optimization conceptual design (MIP) have to be developed, then survey and collecting data for forecasting rice demand and forecasting the optimal logistics network design under the integration between logit equation and mixed integer programming so as to answer the objectives in this paper. Finally, the test results expect that this model have ability to verify framework's large scale capacity and potential benefit of the integrated solution methodology. In addition, it's hoped that this paper may be a very useful to design and development of logistics system to support multimodal transportation system's strategies in the future.

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