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New Concept of Container Allocation at the National Level: Case Study of Export Industry in Thailand

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Abstract

This paper presents container allocation technique of which minimizing the total opportunity loss of an export industry in Thailand. This new allocation concept applies as a strategic management tools at the national level since it is consistent to the characteristics of the container supply chain management in Thailand. The first section of this paper presents the review of facts and problems of container supply chain management. It reveals that containerization system is significant to the international trade as it holds good characteristics of sea transportation. It can transport a lot of products while minimize the damage of goods. Supply chain management of the containerization system presents and shows that there are four main players in managing the container – principal, port, container depot, and customer. After an intensive review of containerization system's problem, the most common problem that all parties have encountered is an imbalance between demand and supply of container. The well-known solution to the stated problem is relocation of containers between various places using optimization technique, which aims to minimize operation cost. Indeed, those solutions are unable solve the containerization system's problem in Thailand: lacking their own fleets: having no bargaining power in relocating container between areas as needed. In the present, many of Thai exporters face with losses of sales or profit because they cannot find enough or proper containers to transport their goods to the customer. The authors, therefore, have seen that those problems need to be strategically solved by the government. The limited number of containers must be properly allocated to the exporter with regard to the minimum losses to the economics of the country. The main contributions of this paper are two folds. First, the opportunity losses of the various export industry are indicated when lack of containers, Second, the mathematical model has been formulated using linear programming technique with several constraints, such as, demand, supply, obsolete time, operating cost, lead time etc. The authors hope that the new concept presented in this paper will provide the great contribution for other countries, which face the same problem of Thailand.

Keywords: Container Management, Opportunity Loss, Allocation Problem, Optimization, International Trade

1. Introduction

Over five thousand years ago, the sea transportation system played a vital role for international trade. A main objective was to ship more quantities of cargo in a long distance across the countries, e.g. Allen (2000). In the beginning, it was shipped by caravel speeded on seaboard of East Mediterranean Sea and Arabian Gulf. It was used to ship olive oil, textile, ceramics and carved metal-ware. Therefore, it would be desirable for a fast pace of vessels to float across the sea particularly in Europe. In the middle era, European developed a technology advance of sea transportation such as more potential vessels that spread widely to Africa in 1487.

During 1950 to 1990, this period illustrated specialized capabilities to come up with its affluently international trade. Furthermore, there were not only a large capacity of liquid and dry bulk cargo carriers but also the conventional vessel was changed into utilization system (i.e. Palletization, Package, Timber Carriers, Barge Carriers, or RO/RO). Additionally, in 1956s, Malcolm Mclean initiated a concept in developing the containerization system that made available for shipping in a specific route between New York and Puerto Rico, e.g. Chavawiwat (2007). Thereafter, the containerization system was then well-known in general cargo transportation all over the world. It, then, turned into a vital transportation direct to global trade accordingly. Due to diversification of loading utilization, it was rapidly transported to different countries around the world by intermodal transportation with least damages, e.g. Schmeltzer and Peavy (1970), Escap (1983); Hayuth (1987); George (2001).

Currently, a portion of container transportation system is higher than conventional transportation system (UNCTAD, 2010). It was due to demand and supply of limited empty container management. According to Breaker's studying in 2008, he found the worldwide demand for a container was about 15% that was higher than supply situation. For Thailand's situation, it was found that there was disequilibrium between demand and supply. Mostly, Thai agricultural products were exported to other countries and it required a number of containers to contain agricultural products especially in the harvest season with nature of agricultural product be easily perishable and short-life cycle (OAE, 2012). Due to Thailand did not have its own fleet management that made no bargaining power to container management, e.g. Mhonyai *et al.* (2011). It might affect main Thai products that can compete with other countries (TNSC, 2011). Consequently, this research aims to propose container allocation technique that is suitable to reduce opportunity loss of Thai export industries. In consideration of container availability, it contains and keeps quality products until it reaches to a customer site. This technique points reduces the opportunity loss of international trade of agricultural goods that is one of the major products made in Thailand.

2. Literature Review

From related literature review of all researches in the past to present, they have been studied in innovation, methodologies, procedures and sea transportation barriers continuously, e.g. Mhonyai *et. al.* (2010). Specifically, economic growth of countries around the world, the sea transportation by containerization system has played an important role in international trade since 1950. Nowadays, level of GDP growth in each country are totally different and imbalancing of import & export transportation. As a result, the barriers of container allocation occur in both land and sea cyclic routes, e.g. Cheung *et al.* (1998). Accordingly, container repositioning becomes a main problem which has been extensively studied until now, e.g. Wang *et al.* (1998)

Therefore, the problem of container shortage directly affects the transportation cost, e.g. Song *et al.* (2009) and competitive advantage of long-term trade in other countries, e.g. Crainic (2003). Thus, distribution planning and container recycling among ports in which are so crucial for many countries around the world, e.g. Shen *et al.* (1995) and studied the problems such as in Nigeria, e.g. Taaffe *et at.* (1963), Malaysia; Rimmer (1977), Ghana; Hilling (1977) and Hong Kong; Wang (1998).

It can be stated that Hub and Spoke model is applied to solve the problem of container shortage by specified region which compose of hub port and feed port for container allocation and container recycling in each region, e.g. Murty *et al.* (2003). Beside these models, a created Network Design, analysis technique, e.g. Meng *et al.* (2011) and Mixed Integer Programming that are commonly method to solve the different problems in suitable ways, e.g. Murty *et at.* (2003).

On the whole reviewing in details, individual researchers have briefly specified whose particulars are problem-solving, objective functions and differentiation to solve problem technique. It could be summarized of main barrier in Table I as mentioned below;

- Authors / Year
- Title
- Concerned problems

- Concerned parties, Mhonyai *et al.* (2011).
- Methodologies
- Constraints

Table 1. A Review of Related Research to the Container Allocation Problem

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
White (1972)	Dynamic transshipment networks; An algorithm and its application to the distribution of empty containers	Imbalancing container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Crainic *et al.* (1993)	Dynamic and stochastic models for the allocation of empty containers, operation research	Imbalancing container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Kron *et al.* (1995)	Returnable container and example of reverse logistics	Imbalancing container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Shen *et al.* (1995)	A decision support systems for empty container distribution planning	Imbalancing container allocation, space allocation		√	√	√	Network Design Model	Volume of containers, Uncertain demand, distance
Wang *et al.* (1998)	Container load center with a developing hinterland	Imbalancing empty container allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand
Beamon *et al.* (1998)	Optimization, simulation of the integrated production	Imbalancing empty container allocation		√	√	√	Optimization Model	Volume of containers
Bourbeau *et al.* (2000)	Branch and bound parallelization strategies applied to a depot location, container fleet management problem	Container fleet management		√	√	√	Network Design Model	Volume of containers
Konnings and Thijs (2001)	Foldable containers; a new perspective on reducing container repositioning costs	Imbalancing empty container allocation	√	√	√		Mathematical Model	Volume of containers
Choong *et al.* (2002)	Empty container management for intermodal transportation network	Imbalancing empty container allocation	√	√	√	√	Network Design Model	Volume of containers, Uncertain demand

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
Choong *et al.* (2002)	Empty container management for container on-barge transportation	Imbalancing empty container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Chassiakos *et al.* (2003)	Increasing the efficiency of empty container interchange	Empty container allocation		√	√	√	Heuristic Model	Volume of containers, Uncertain demand
Gendron *et al.* (2003)	A parallel hybrid heuristic for the multi commodity capacitated location problem with balancing requirements	Imbalancing containers allocation		√	√	√	Heuristic Model	Volume of containers, Uncertain demand
Jula *et al.* (2003)	Port dynamic empty container reuse	Imbalancing empty container allocation			√	√	Deterministic Model	Volume of containers, Uncertain demand
Water *et al.* (2003)	Inventory control and management just in time	Imbalancing empty container allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand
Moccia *et al.* (2003)	New optimization models and algorithm for management of maritime container terminals	Imbalancing empty container allocation, vehicle routing problem			√		Mathematical Model	O/D distance
Li *et al.* (2004)	Empty container management in a port with long-run average criterion	Imbalancing empty container allocation	√	√	√		Simulation Model	Volume of containers, Uncertain demand
Shintani *et al.* (2004)	The container shipping network design problem with empty container repositioning	Imbalancing empty container allocation		√	√		Integer Programming	Time schedule
Brito *et al.* (2004)	Container management strategies to deal with the east-west flows imbalance	Imbalancing empty container allocation material flow		√	√		Mathematical Model	Volume of containers, Uncertain demand
Cheang and Li (2005)	A network flow based method for the distribution of empty containers	Port congestion	√	√	√		Mathematical Model	Volume of containers

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
Veenstra (2005)	Empty container reposition the port of Rotterdam Case	Imbalancing empty container allocation, port congestion	√	√	√		Mathematical Model	Volume of containers
Davis (2008)	Off-docks, storage of empty containers in the lower mainland of British Columbia industry	Empty container repositioning	√	√	√		Mathematical Model	Volume of containers
Kelywegt *et al.* (2005)	The stochastic inventory routing problem with direct deliveries industrial school systems	Imbalancing container allocation, Trade Imbalancing			√		Stochastic Model	Volume of containers
Murty *et al.* (2005)	A decision support system for operations in a container terminal	Imbalancing container allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand
Olivo *et al.* (2005)	An operational model for empty container management maritime economics logistics	Imbalancing container allocation, container fleet size		√	√		Mathematical Model	Volume of containers, Uncertain Demand, Time schedule
Tongzon *et al.* (2005)	Port privatization, efficiency and competitiveness	Imbalancing container allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand
Chang. *et al.* (2006)	Empty container reuse in Los Angeles long beach port area	Imbalancing container allocation		√	√	√	Heuristic Model	Volume of containers
Francesco *et al.* (2006-07)	Optimal management of heterogeneous fleets of empty containers	Imbalancing container allocation		√	√	√	Deterministic Model	Volume of containers, Uncertain demand
Gendorn *et al.* (2006)	A parallel hybrid heuristic for the multi commodity capacitated location problem with balancing requirements	Imbalancing container allocation, low margin and utilization		√	√	√	Mathematical Model	Volume of containers, Uncertain demand

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
Jula *et al.* (2006)	Empty container reuse	Imbalancing container allocation, container fleet management	√	√	√	√	Simulation Model and case study	Volume of containers, Uncertain demand
La gourist *et al.* (2006)	Modeling container fleet size: a case of medium size container shipping company	Imbalancing container allocation		√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Xie *et al.* (2006)	First automatic empty container yard with no operator in China	Imbalancing empty container allocation	√	√	√		Simulation Model	Volume of containers, Uncertain demand
Crainic *et al.* (2007)	An optimization model for empty reposition under uncertain	Container allocation, trade imbalance, capacity management, time schedule	√	√	√	√	Optimization Model	Volume of containers, Uncertain demand
Koh (2007)	The present state of" Korean security deposit system on Empty container, its reform measure	Imbalancing empty container allocation	√	√	√		Mathematical Model	Volume of containers, Uncertain demand
Lam (2007)	An approximate dynamic programming approach for the empty container allocation problem	Imbalancing container allocation		√	√		Mathematical Model	Volume of containers
Li *et al.* (2007)	Allocation of empty containers between multi-ports	Imbalancing container allocation	√	√	√	√	Heuristic Algorithms	Volume of containers, Uncertain demand
Robles *et al.* (2007)	Empty container logistics fundamental international maritime transport management tools	Imbalancing empty container allocation	√	√	√		Mathematical Model	Volume of containers, Uncertain demand
Shintani *et al.* (2007)	The container shipping network design problem with empty container repositioning	Imbalancing empty containers allocation	√	√		√	Mathematical Model	Volume of containers, Uncertain demand
Theofanis *et al.* (2007)	Imbalance and container repositioning strategies	Imbalancing empty containers allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
Wang *et al.* (2007)	Research on the optimization of international empty container reposition of land-carriage	Imbalancing empty containers allocation		√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Yan *et al.* (2007)	Empty containers distribution among railway network container freight station	Imbalancing empty containers allocation	√	√	√	√	Non-Linear, programming	Volume of containers, Uncertain demand
Yeh *et al.* (2007)	Examining the efficiency of container movements	Imbalancing empty containers allocation	√	√		√	Mathematical Model	Volume of containers, Uncertain demand
Braekers *et al.* (2008)	Integrating empty container allocation with vehicle routing in intermodal transportation	Imbalancing empty containers allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand, vessel capacity
Feng *et al.* (2008)	Empty container reposition planning for intra-Asia liner shipping	Imbalancing container allocation high cost of container acquisition		√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Furio *et al.* (2008)	Mathematical model to optimize land empty container movement	Imbalancing empty containers allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand
Song and Carter (2008)	Empty container repositioning in shipping industry	Imbalancing empty containers allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand
Tolli (2008)	Reducing empty container flow by promoting Baltic and Russian's wastepaper export to China through port of Tallinn	Imbalancing empty containers allocation	√	√	√	√	Mathematical Model	Volume of containers
Wang *et al.* (2008)	The study on empty containers allocation in the container transportation	Imbalancing containers allocation	√	√	√		Mathematical Model	Volume of containers, Uncertain demand
Yazict (2008)	Empty container management	Imbalancing empty container allocation	√	√	√		Mathematical Model	Volume of containers

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
Bandeira *et al.* (2009)	A decision support systems for integrated distribution of empty and full containers	Imbalancing container allocation, vehicle routing			√		Mathematical Model	Volume of containers
Francesco *et al.* (2009)	The effect of multi-scenario policies on empty container repositioning	Imbalancing empty container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Song and Carter (2009)	Empty container repositioning in liner shipping	Imbalancing empty container allocation		√	√		Mathematical Model	Volume of containers, Uncertain demand
Song *et al.* (2009)	Impact of dynamic information on empty container repositioning in seaport with uncertainties	Imbalancing container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Theofanis *et al.* (2009)	Empty marine container logistics: facts, issues and management strategies	Imbalancing empty container allocation	√	√	√		Mathematical Model	Volume of containers, Uncertain demand
Belmecheri *et al.* (2009)	Modeling and optimization of empty container reuse	Imbalancing container allocation		√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Huth *et al.* (2009)	Integration of vehicle routing and resource allocation in a dynamic logistics network	Imbalancing container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Li *et al.* (2009)	The marine reposition of empty containers under uncertain demand and supply	Imbalancing container allocation		√	√	√	Stochastic Model	Volume of containers
Mhonyai *et al.* (2009)	A strategic business management of liner business in Thailand	Imbalancing empty container allocation		√	√	√	Resource based View/ Strategies	Volume of containers, Uncertain demand
Sun *et al.* (2009)	Study on empty container repositioning problem under sea-rail through transport	Imbalancing container allocation		√	√	√	Mathematical Model	Volume of containers

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
Wong *et al.* (2009)	Immunity based hybrid evolutionary algorithm for multi-objective optimization in global container repositioning	Imbalancing empty container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Bean *et al.* (2010)	Planning empty container relocations under certainty	Imbalancing empty container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Braekers *et al.* (2010)	Integrating empty container allocation with vehicle routing in intermodal transport	Imbalancing empty container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Bu *et al.* (2010)	Study on marine shipping capacity option contract optimization problem under empty container reposition	Imbalancing empty container allocation	√	√		√	Mathematical Model	Volume of containers, Uncertain demand
Chen and Li (2000)	A multi-commodity model and algorithm for the railway empty container allocation	Imbalancing container allocation		√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Chou *et al.* (2010)	Application of a mixed fuzzy decision making and optimization programming model to the empty container allocation	Imbalancing container allocation		√	√	√	Mathematical Model	Volume of containers
Islam *et al.* (2010)	Empty container truck movement problem in Auckland	Imbalancing container allocation, High operating cost	√	√	√		Mathematical Model	Volume of containers
Le-Griffin *et al.* (2010)	Managing empty container flows through short sea shipping and regional port system	Imbalancing empty container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Lin *et al.* (2010)	Robust optimization for empty container allocation problem under uncertainties	Trade Imbalancing, Imbalancing empty container allocation		√	√	√	Linear Programming	Volume of containers, Uncertain demand

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
Liu *et al.* (2010)	Forecast of monthly empty container throughput based on semi-parametric linear regression	Imbalancing empty container allocation	√	√	√	√	Game Theory	Volume of containers, Uncertain demand
Sun H.et al. (2010)	Optimal inventory control of empty container in inland transportation system	Imbalancing empty container allocation	√	√	√	√	Linear programming	Volume of containers, Uncertain demand
Yun *et al.* (2010)	Liner shipping service network design with empty container repositioning	-Imbalancing empty container allocation		√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Song *et. al* (2011)	Flow balancing based empty container repositioning in typical shipping service	Imbalancing container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Song *et. al* (2011)	Empty container truck movement problem at ports of Auckland proceedings of the 45th annual conference of the ORSNZ	Imbalancing container allocation	√	√	√	√	Mathematical Model	Volume of containers, Uncertain demand
Islam *et al.* (2010)	Empty containers repositioning; a state of the art overview	Imbalancing empty container allocation, demand forecast in global container management	√	√			Mathematical Model	Volume of containers, Uncertain demand
Rafael, *et al.* (2010)	The impact of foldable containers on container fleet management costs in hinterland transport	Imbalancing container allocation	√	√	√		Mathematical Model	Volume of containers
Shintani *et al.* (2010)	Research on optimization of intermodal empty reposition of Land-carriage	Imbalancing container allocation	√	√	√	√	Mathematical Model	Volume of containers
Wang *et al.* (2010)	Stochastic optimization model for container shipping of sea carriage	Imbalancing container allocation	√	√	√		Mathematical Model	Volume of containers, Uncertain

Authors / Year	Title	Problems	Concerned Parties				Methodologies	Constraints
			Principal	Port	Container Depot	Customers		
								demand
Wang *et al.* (2010)	Container management strategies to deal with the east-west flows imbalance	Imbalancing container allocation	√	√	√		Deterministic model	Volume of containers
Brito and Konning (N/A)	Container management supply optimization and forecasting model	Imbalancing container allocation	√	√	√	√	Reverse Logistic Theory	Volume of containers
Case study CS-005B		Imbalancing container allocation		√			Mathematical Model	Volume of containers

3. Opportunity Loss

The opportunity loss is vital for economics point of view, and relevant to a process of decision making for any type of activities. It is calculated from a value of trade-off in doing one activity, e.g. James (2008). Meanwhile, Chavez *et al.* (1998); Besanko (2009); Mario (2009); and Attallah (2006) stated that the cost of opportunity loss may have a direct impact on business entrepreneurs and industrial sectors from a local market to international trading. By allocating limited resources to any type of activities, it aims at utilizing those resources with the fullest utilization and highest efficiency. Therefore, it should consider how the opportunity loss has been incurred. From literature reviews of the factors affecting trading opportunity loss, it appeared that labor loss is one of the loss costs found in fundamental economics, e.g. Attallah (2006). In the mean time, agricultural and livestock sectors found that there were loss of total quantities and loss of perishable product found in these sectors (IICA, 2006; OAE, 2010).

On the other hand, if a product was not delivered to a customer on time, then it would incur penalty due to delay, e.g. Song (2008), resulting in loss of quota for the next period (NTB; FTA, 2009). Beside that, the opportunity cost may include with financial risk caused from international currency exchange (BOT, 2010). By transporting containers across the sea, e.g. Theofanis *et al.* (2007) and Bell *et al.* (2011) conducted research study and found that allocating containers more efficiently can be done by using minimize sailing time and dwelling time. This can subsequently reduce opportunity loss. Meanwhile, Chavawivat (2007) identified that labor loss is one of the opportunity losses that increase sea freight allowing a higher risk of international transport, e.g. Manu *et al.* (2008); Delaney (2002).

Table 2 is a list of the factors of opportunity loss cost summarized from three sources; in-depth interviewing, questionnaire surveying and theories. In the questionnaire surveying process, number of respondents is at 90% confident level of sample size, follow by Taro Yamane's formula (Yamane, 1973), sampling number equation.

Table 2. The summary of factors analysis in opportunity loss

Factors	Theories	Research	Interview
1. Loss of product (X_1)	(1),(4),(8)		(2)
2. Penalty cost (X_2)		(3)	(2)
3. Labor Loss (X_3)	(3), (5)		(2)
4. Loss of quota (X_4)			(2)
5. Baht Fluctuation (X_5)	(6)		(2), (10)
6. Non Tariff Barrier (X_6)	(9)		(2)
7. Freight rate (X_7)			(7)

Notes (1). Taniguchi, (1996.p.15) cost of quality, loss function

(2). Empirical interview from person in charge i.e. exporters, traders and gardeners etc.

(3). Song D.P. (2008), empty container management

(4). Fundamental economic; production cost, decision making

(5). Atallah G. (2006), cost function, opportunity costs, competition, and firm selection.

(6).Office of Agricultural Economics, Thailand

(7).Thai National Shippers' Council, http://www.tnsc.com

(8). Export Handbooks; Agri-business series; how to calculate export costs for agricultural products

(9). Information Office of International Trade; Department of export Promotion and Foreignpartners

(10). Bank of Thailand (BOT)

4. Problem Formulation

Another research aim is formulating new concept of container allocation. This concept aims to minimize an opportunity loss while satisfying a demand constraint of an export. The assumptions of these new mathematical concepts can be shown in Figure 1 or can be described as follow:

4.1. Thailand is an origin port.

4.2. The agricultural products of study are fresh fruits i.e. durian, longan, mangosteen.

4.3. The destinations are many countries such as, Hong Kong, Indonesia, Taiwan, Vietnam, United States of America etc.

4.4. The quantity of containers at the origin (Thailand) is less than the total demand of all industries.

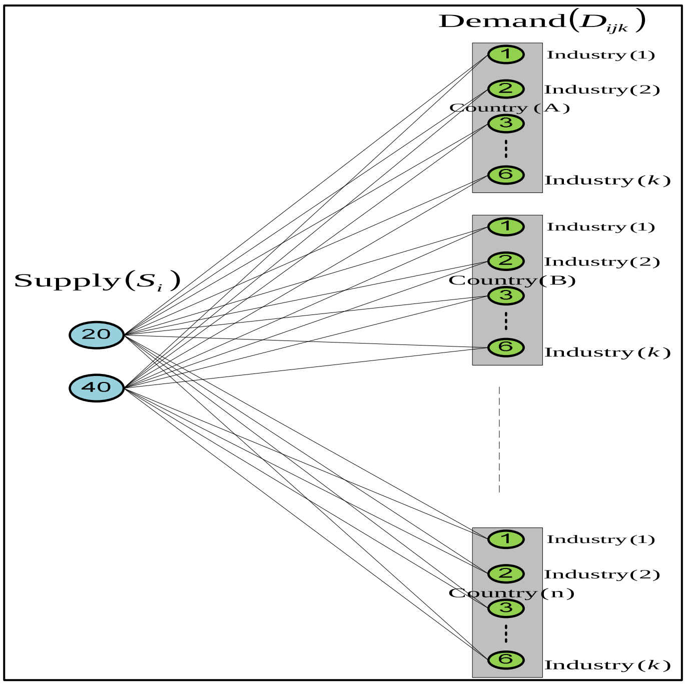

Figure 1. Flow chart of distribution process

Notation

Before introducing our mathematical model, we adopt the following notation, which is classified into two parts: parameters and decision variables.

Parameter

OL_{ijk} = An incident parameter to represent opportunity cost if the container i is not assigned to product k to destination at j

S_i = The number of empty container i supplied at Origin

D_{ijk} = Customer demands of containers i of industry k transported to destination j

Decision variables

x_{ijk} The amount of empty container i assigned to product k for delivery to destination j

L_{ijk} The amount of empty container i is not assigned to product k for delivery to destination j

From above characteristics or assumptions of the container allocation, mathematical equations can be proposed as equation (1)-(6)

Objective Function

$$Min.Z = \sum_{K=1}^{k} \sum_{j=1}^{m} \sum_{i=1}^{n} OL_{ijk} (L_{ijk}) \quad (1)$$

Constraints

$$\sum_{k=1}^{k}\sum_{j=1}^{n} x_{ijk} = S_i, \qquad \forall i \qquad (2)$$

$$x_{ijk} \le D_{ijk}, \qquad \forall i \quad \forall j \quad \forall k \qquad (3)$$

$$D_{ijk} - x_{ijk} = L_{ijk}, \qquad \forall i \quad \forall j \quad \forall k \qquad (4)$$

$$x_{ijk} \ge 0, \qquad \forall i \quad \forall j \quad \forall k \qquad (5)$$

$$L_{ijk} \ge 0, \qquad \forall i \quad \forall j \quad \forall k \qquad (6)$$

The objective function is presented in (1) aims to allocate containers to an export of various products while minimizing total opportunity loss. Equation (2) and (3) are conventional supply and demand constraints, consecutively. Equation (4) determines a lack of amount of containers to each destination while (5) and (6) give a non-negative decision variable.

5. Conclusion

At the beginning of this paper, it investigates the problem of container allocation around the world then, we scope the problem down to match the characteristics of Thai exporters. Since Thailand's main product is an agricultural product which has a short life and can be perishable. Therefore, the lack of container might make an opportunity loss to a product or industry. The loss factors presented here, they are product loss, penalty cost, labor loss, quota loss, baht fluctuation, non-tariff barrier and freight rate etc. The new concept of a mathematical model is also presented in this paper. The new idea is still paradigm, which may be beneficial to public and private sectors in Thailand.

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