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A Simulation Model for Evaluating the Profitability of a Returnable Container System in International Logistics

국제물류환경에서 순환물류용기의 경제성 분석 시뮬레이션

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Abstract

The automotive supply chain is increasingly complex as automakers seek more profitable solutions with global out-sourcing and manufacturing strategies. In the automotive industry, using returnable plastic containers (RPCs) is very common for domestic operations, but for internationally, it has not been considered by many companies because of issues such as overall distance and difficulty of control. The results of this simulation can help to analyze the interactive and coherent behavior of packaging and supply chain systems. The data obtained from the model can be applied to make substantial decisions for choosing the most profitable packaging types, at the same time as it can lead to designing an optimum supply chain for RPCs used in international supply chains.

Key Words : international supply chains, logistics, packaging, Pooling system, RPCs

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Ⅰ. Introduction

The automotive supply chain is increasingly complex as automakers seek more profitable solutions with global out-sourcing and manufacturing strategies. In the automotive industry, using returnable plastic containers (RPCs) is very common for domestic operations, but for internationally, it has not been considered by many companies because of issues such as overall distance and difficulty of control. Because of continuous increases in awareness of environmentally-friendly supply chain practices and improvement in the efficiency of global logistics systems, using RPCs is increasingly being considered by original equipment manufacturers and their global logistics providers. Although switching from expendables to RPCs becomes a trend in some industries, there are no clear cut answers in methods of total cost estimation.

Limited resources and the lack of reliable packaging cost information make it difficult for them to make packaging management decisions (Dubiel 1996). Beyond economics, an increasing emphasis on the environmental responsibility of packaging and logistics, combined with increasing complexity of supply chains, have forced packaging managers to find more sustainable and profitable strategies. However, without comprehensive financial analyses, business decision makers have difficulties identifying the opportunities for improvement throughout their entire logistics system (Holmes 1999). Holmes also recommended to consider third party leasing of containers since neither the supplier nor receiver needs to own containers and avoids the initial capital costs to purchase containers.

A choice between reusable and expendable packaging system is one such strategic opportunity. In the vehicle manufacturing business, where car manufacturers are always looking for a more cost effective and greener supply chain, reusable shipping containers have been a popular choice for leading companies such as GM, Toyota and Volkswagen (Nunes and Bennett 2010). The global manufacturer John Deere & Co. reportedly invested an initial $20 million in containers to develop a reusable shipping container system (Kroon and Vrijens 1995). Manufacturers have adopted these reusable systems because, by applying standard and ergonomic design principles, reusable shipping containers can reduce the cost of handling, materials and packaging waste (Modern Material Handling 2006). However, there has been few published study documenting the total profitability, including logistics costs, of reusable shipping containers.

Mollenkopf et al. (2005) used a relative cost approach to compare reusable and expandable packaging in a case study with multivariate regression analysis methodology. The Reusable Packaging Association (2000) has developed a “Quick Economic Calculator” and “Environmental Calculator” to compare basic cost differences of one way corrugated packaging verses reusable plastic packaging. Such methods can help guide packaging and supply chain decision-makers, but their static cost models do not reflect the dynamic nature of the supply chain and to systemically address economic trade-offs.

Most researches regarding RPC management and cost evaluation were limited within simple logistical networks or domestic distribution, but few attempted for international logistics operation. With development of international pooling networks and information technology, international RPC operation becomes a viable option in many cases.

Hence, simulation techniques for supporting supply chain management decisions have been studied by many researchers. Kleijnen (2005) pointed out that the simulation may give researchers clear looks about the causes and effects of the supply chain performance by testing (or experimenting) inputs and model structures. Li and Duan (2009), Centeno and Perez (2009) and many others used simulation program to identify supply chain problems and to evaluate management strategies.

By all accounts, a simulation model can be used to determine financial viability of international RPC operations and can identify possible bottlenecks in the design of supply chains that must be controlled to guarantee satisfactory supply chain performance.

Ⅱ. Objectives of the study

This study is to develop a dynamic simulation model to help a company to decide between two packaging options: RPC rental or expendables (corrugated fiberboard boxes). This model is for the automotive industry focusing on three International operations between Korea and Alabama, Korea and California and Korea and China. The data obtained from the model can be applied to make substantial decisions for choosing the most profitable packaging types, at the same time as it can lead to designing an optimum supply chain for RPCs used in international supply chains.

Futhermore, the results can be used for the future study on the interactive and coherent behavior of packaging and supply chain systems.

Ⅲ. Research methods

In order to identify packaging metrics in automotive parts logistics, general surveys were used to gather initial data. A survey was conducted to identify current logistics and packaging costs on target industry and to estimate nation-wide effects on logistics by adopting national packaging standards.

The questionnaire was consisted in three parts: logistics information, product and packaging information for target product and general company information. Twenty leading Korean automotive part manufacturers were randomly selected and interviewed with packaging or logistics managers from January 2 to March 2, 2009. Observations and comprehensive interviews were performed with key employees responsible for packaging development and logistics service.

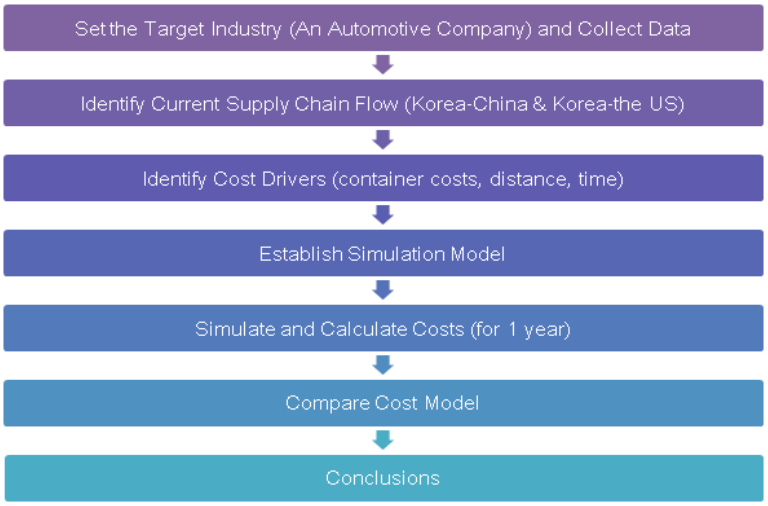
Based on the results of survey, a simulation model is developed to compare between expendable (EXP) and reusable container (RPC) costs. This simulation is only a case study for an automotive part company (A company), so the result should vary depending on a company's situation. Employee interviews, current supply chain flows and cost data provided by A company are used to construct the simulation model. Variables considered include costs of shipping containers, distance and transport time required for 1-year operation. A company does not own a RPC at all, but uses rental RPCs by a contract with a container rental company. ARENA software (Rockwell automation, Inc.) is used for the simulation model to calculate the number of RPCs and costs for three international supply chain routes of A company. Hypotheses for this simulation are as follows.

Hypotheses

- Container provider (rental company) has enough money to buy RPCs and will run for 1 year to make a decision.

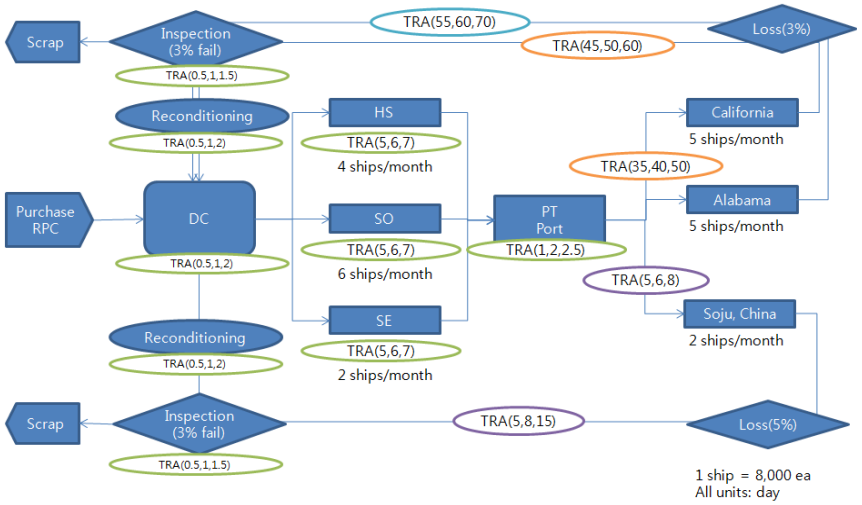
- Because a 3PL logistics company controls the oversea logistics, the 3PL does not charge for RPC returns.
- Any loss/damage will be responsible for the manufacturer. Manufacturer has to pay for full container cost to rental company.
- All costs are fixed during simulation.
- There is no profits by selling the scraps. No recycling cost is considered.

[Figure 1] shows the research flow for this study. Cost drivers are container purchasing costs, overall transport distance and total time for delivery.



[Figure 1] The research flow

[Figure 2] shows the company's logistics scheme for the simulation. All EXPs and RPCs are prepared at a distribution center, and shipped to three local manufacturing sites, HS, SO and SE. After assembling process, all containers are sent to PT port and shipped to three oversea manufacturers, California, Alabama and Soju. The model time unit is day. Triangular distribution model is used with lower limit a, upper limit b and mode c (most likely value), where $a < b$ and $a \leq c \leq b$.



[Figure 2] International RPC logistical network plan for the company "A"

<Table 1> shows container specifications and cost descriptions used in the simulation.

〈Table 1〉 Container specifications and cost descriptions

Container Size	12"×10"×7" footprint
Container load Quantities (based on 40 Ft. long)	8,000 ea (1 shipment)
Development Cost (US $)	100,000/payback period: 1 year
RPC Price (US$)	10.00 / container
EXP Price (US $)	1.00 / container
RPC Rental Price (US$)	0.20 / container / day
Inspection Cost	0.05 / container
Reconditioning Cost	0.10 / container

Ⅳ. Results

Automotive part Manufacturers can be 1st, 2nd or 3rd venders for the car makers, but considering the volume of economy and impact on total supply chain of automotive part industry,

we only consider 1st vender for the activity breakdown.

The results of interviews with automotive packaging or logistics managers show that most managers believe that packaging is one of the most important factors to determine overall logistics costs. Average time for international delivery from a vender to a oversea manufacturer was 29.75 days. The total logistics cost is about 4.51 percents of the company's annual sale, and surprisingly, the average packaging cost takes up to 48 percents of the average logistics cost. Of course, range of packaging cost varies depending on product weight and volume. For example, light and bulky products such as handles and bulbs require more packaging materials and space than heavy and dense products such as bolts and wires.

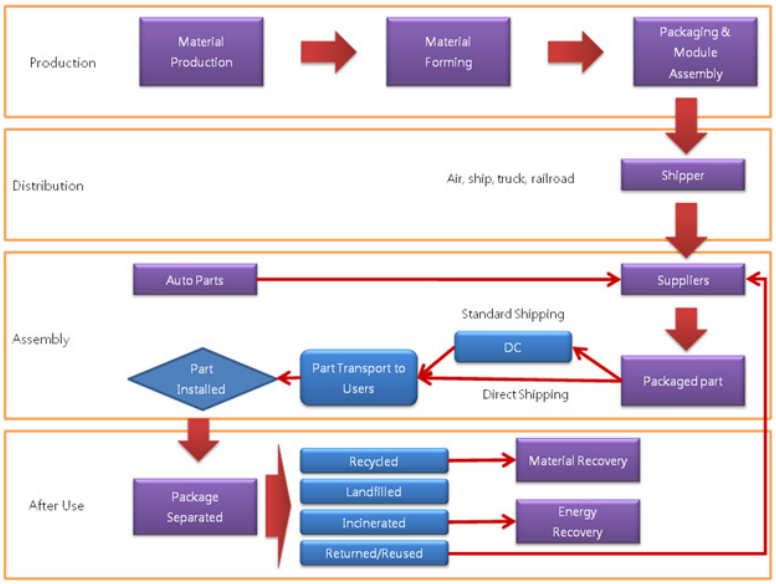
First stage of supply chain process is incoming process from sub-venders and its supply chain activities are receiving and inspection. At this stage, a raw materials and sub-parts could be packaged in totes or large reusable bulk containers. Empty totes and bulk containers are returned to the sub-venders or disposed to recycling center if unusable.

Second stage is in-house logistics process. Inspected raw products are sorted depending on frequency of usage, weight and size, stability or special needs, and transferred to the warehouse. Warehousing and storing activities could take significantly short time period if a company use lean or Just-In-Time production line.

Basically, supply chain activities of car maker are similar to vender's except after-use process. Although it is beyond this paper topic, packaging plays very important role at the after-use process stage that has various options such as reuse, recycle, recover and disposal.

As shown from the breakdown results of each logistics activity and packaging criteria, some activities and criteria were duplicated several times. It is also important to consider that the intensity of each logistics activity is not equal each other. For example, shock and vibration intensity of transportation A city to B city should be much higher than that of in-house movement in most cases, so impact level of packaging on this specific logistics activity should be greater.

Based on the observations, we could summarize the typical supply chain activities of automotive parts from the vender to car maker. [Figure 3] shows typical logistical flow of domestic automotive parts.



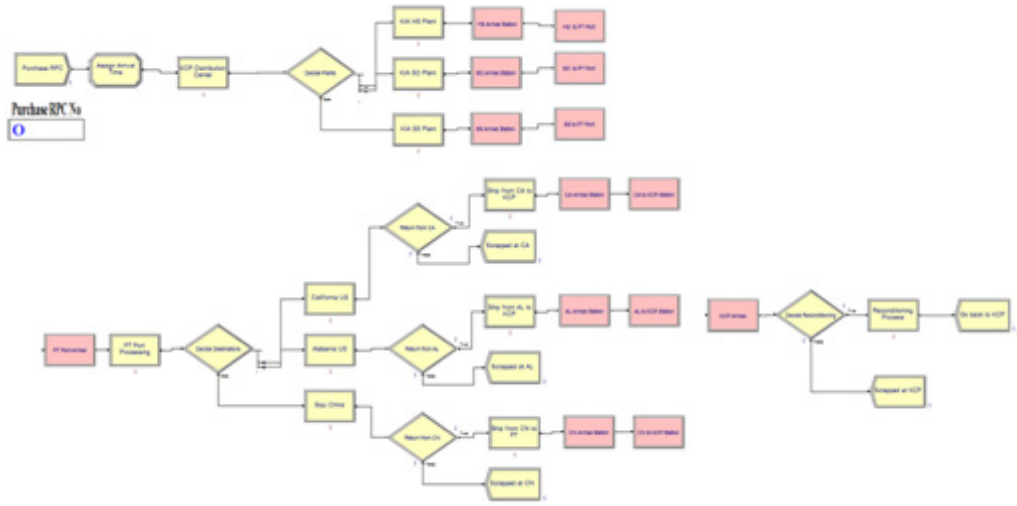
[Figure 3] Logistical flow of typical automotive parts in Korea

[Figure 4] shows the developed simulation models for returnable container (RPC) and expendable container (EXP). Considering the geographic location and supply chain characteristics, three international logistical routes for investigation are proposed for this study. The logistics process is performed by a 3PL from suppliers located in a specific geographic area (e.g. Far East), delivering goods to the manufacturing plants in a specific destination (e.g. Western America, Eastern America and China). This study considers ocean container shipping with 40 feet containers as the primary international transportation mode considering its low freight rates despite long transit time.

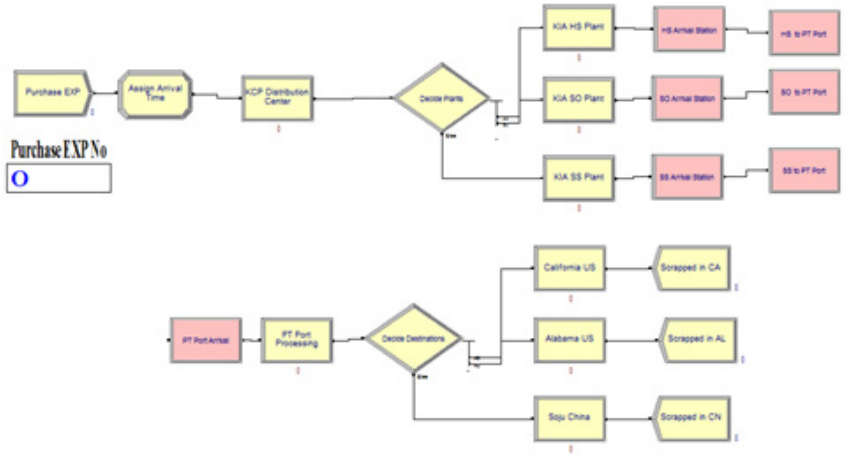
For ocean container shipping, two types of shipment methods are considered, namely full container load (FCL) and less than container load (LCL). Only FCL will be considered for this study because costs of shipping methods are not directly related to the type of shipping containers.

After unloading and custom processes, all shipments are shipped by means of road transportation and unconsolidated at the 3PL's warehouses adjacent to the manufacturing plants. All goods packed with EXPs must be repacked in order to feed to assembly lines. Used RPCs are collected by manufacturers and stored temporarily before a 3PL consolidates containers for

shipping back to suppliers (company A).



A: RPC



B: EXP

[Figure 4] Simulation models (A: RPC, B: EXP)

According to the total operation costs shown in <Table 2>, using expendable containers is more economically viable option for the company A because of the distance and return time. However, if this company uses RPC for shorter distance (in this case, between Korea and Soju, China),

RPC rental option is a much cheaper option.

Since this study compared a expendable system with a pooling system, daily rental cost to pay the rental company could be a decisive factor for container operation decision. If they could reduce the rental cost by 40 percents, switching to RPCs is more profitable option for the company A.

<Table 2> Results of RPC and EXP model simulation

Destinations	EXPs ($)	RPC rental (after 1 year)	
		$0.1/day	$0.06/day
Total	312,870	503,400	302,040
Alabama, US	116,000	248,400	149,040
California, US	131,000	223,200	133,920
Soju, China	62,000	31,800	19,080

V. Conclusions

Packaging management decisions should be based on a multi-disciplinary approach with various scientific, technical and economic analysis. From the results of simulation, using rental RPCs was the most cost efficient options for the automotive company, but the result was not significantly differ from using expendables. This is because using RPCs did not show any cost benefit for long distance supply chain such as between Korea and the US. However, for the Korea-China operation, rental costs were four times cheaper than using expendables.

Distance and return time were decisive factors for the successful international RPC operation. Pooling (or rental) system would be advantageous in short to medium distance supply chains. In conclusion, this simulation approach can help to make educated decisions for packaging total cost management and supply chain network options.

This simulation approach can be used to any industry beyond the automotive industry. This is also useful for demonstrating the importance of using a more holistic systems approach in assessing a packaging system while improving negotiations and communications with future

suppliers and customers.

Future researches should be followed since more comprehensive uses of packaging cost simulation techniques can not only help to evaluate the cost of container system alternatives, but also visualize packaging cost and its impact on supply chain.

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국문요약

국제물류환경에서 순환물류용기의 경제성 분석 시뮬레이션

김종경* · 이은재**

자동차 공급망은 자동차기업들이 글로벌화되어 아웃소싱이 일반화되고 해외생산기지를 구축함에 따라 지속적으로 복잡하게 되었다. 자동차산업에서 순환물류용기 (RPC: Returnable Plastic Container) 의 사용은 물류효율과 비용절감 측면에서 매우 일반화되어 있으나 주로 내수용으로 활용하고 있으며 국제무역용으로는 절대적인 운송거리가 길고 운영관리가 복잡해져 크게 활용되지 않고 있다. 이 연구는 시뮬레이션을 통하여 1회용기와 반복사용이 가능한 순환물류용기를 pooling system으로 적용하는 경우 기업에 미치는 경제적 영향을 비교하였다. 결론적으로 미국과 같은 장거리 국제물류에서는 순환물류용기의 사용이 어려우나 중국과 일본과 같이 비교적 단거리 국제무역에서는 pooling 시스템의 도입으로 경제적으로 타당한 것으로 나타났다. 이 연구결과는 국제공급망 환경에 따라 경제적으로 최적의 포장방법과 형태의 변화가 필요함을 밝혔다. 다만, 국제무역상 발생하는 통관상의 복잡함, 관세, 국내와 해외 물류환경의 상이로 인한 효율성 저하 등의 문제는 하기 위해서는 보다 많은 연구가 필요하다.

주제어 : 국제공급망, 물류, 포장, 풀링 시스템, 순환물류용기

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