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Estimating the Optimal Ratio of Standard Pallet Use for Logistics Standardization

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목 차

Key Words : Korean standard pallet, logistics costs, logistics standardization, optimal level of logistics standardization.

Abstract

This paper analyzes how levels of logistics standardization are related to logistics costs. The study surveyed ratios of standard pallet use in order to measure levels of firms' standardization in logistics management. Research focused on how firms' logistics costs were related to their levels of logistics standardization and ratios of standard pallet use. After measuring use of standard pallets and logistics costs, optimal levels of logistics standardization were estimated based on survey data. Logistics costs and standardization were more related to labor than to freight volume or export. Results indicated that firms could reduce logistics costs by raising levels of logistics standardization; optimal levels of standard pallet use out of Korean firms' total manufacturing cargo volume were estimated at 44.26% for multi-standard pallets and 57.99% for a single standard pallet (a unit load system). The study demonstrated that adopting a single standard pallet results in better cost saving logistics systems than use of multi-standard pallet types. These results may explain why firms pursue standardization in logistics systems.

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Ⅰ. Introduction

Increasing the level of logistics standardization is one way in which firms are attempting to reduce high logistics costs at the national level, which amounted to 12.7% of Korea's GDP (87 trillion Won) in 2002. Even though many policies have been created to increase efficiency in logistics systems, logistics standardization policies have not been included among national policies due to a lack of understanding about how logistics standardization could decrease costs.

Relative to increases in the volume of freight, costs have increased, owing to the heavy burden of logistics costs as a result of the inefficiency in the Korean logistics sector. In particular, institutional inertia in logistics standardization (Park and Kim, 1999) has led to increases in logistics costs. However, few studies have examined the effects of logistics standardization or the relationships between logistics standardization[1] and logistics costs.

For this reason, we analyzed relationships between logistics standardization and logistics costs. We surveyed the levels of various firms' logistics standardization, studied how logistics costs were related to levels of logistics standardization, and estimated the optimal ratio of standard pallet use. The ratio of standard pallet use is defined as the level of a firm's standardization in logistics management[2]. The empirical method used in this study employed survey data to analyze levels of firms' logistics standardization in multi-standard pallets and single ULD standard pallets. The results of this study have possible implications for optimal levels, policy

1) Analysis of the effects of standardization has mainly been performed by government agents for logistics associations (ANSI, 2000; CEC, 1990; CEN, 1999; DIN, 2000). These studies discussed how standards were related to economic growth or foreign trade. Blind (2004) discussed the positive and negative effects of using a standard.

2) Pallet standardization affects other logistics elements such as truck cargo capacity, inventory, loading and unloading, packaging and information systems, and standardizes them systematically. In the 'national logistics basic plan' implemented by the Korean Department of Construction and Transportation, the level of the logistics standard is measured using pallet standardization. In addition, an Australian study on logistics standardization used pallet standardization as the major factor when analyzing logistics policy (Sd+D, 2002). In Japan, palletstandardization is considered the most important factor for logistics standardization. (日本パレット協會, 2002, 2004; 經濟産業研究所, 2003).

directions, and the role of logistics standardization.

Ⅱ. Data and Sample

1. Survey Data

In order to investigate relationships between logistics standardization and logistics costs, we surveyed levels of standard pallet use in 710 firms and establishments[3] selected from a database; survey questionnaires were sent by mail. Only 137 firms returned the survey questionnaire; it is possible that only large firms were able to determine the cost of logistics items from the account balance[4]. The data collected indicated that firms had an average of 552 employees, an average capital of 85.5 billion Won, and average sales of 230.1 billion Won. While only large firms were able to answer the questionnaires, firms nevertheless differed in their responses.

<Table 1> Survey data and sample

	Average number of employees	Average capital	Average sales	Logistics cost per ton	Logistics cost/sales
Number of firms	130	111	120	79	101
Size	552 Persons	85.5 billion won	230.1 billion won	870 thousand won	7.17 %

Results from 79 firms indicated that firms had an average logistics cost per ton of 870 thousand Won. Results from 101 firms indicate that the average logistics cost compared to sales was 7.17%. These results indicate that only a few firms were able to measure logistics costs from their accounting specifications; i.e., few Korean firms distinguish and measure logistics costs.

3) Firms or establishments were chosen from the *Maekyung Economics* (www.mk.co.kr) newspaper database by capital and numbers of employees in 2003.

4) Few Korean firms can identify logistics costs because logistics items are not yet required by Public Account Law.

2, Levels of Logistics Standardization

1) Use of Pallets in Korea

The initial stage of logistics standardization in a firm is the standardization of pallets. Based on this fact, we surveyed the level of pallet use to examine logistics standardization in firms; we then adopted the ratio of standard pallet use as the level of a firm's standardization in logistics management. Survey results indicated that 77.5% of the total freight volume for each firm could be loaded and/or unloaded on pallets, and 63.9% of freight volume implements used for loading were based on standard pallets. Using these results, we measured the extent to which firms unitized the load of freight volume, based both on pallets and on standard pallets. Of the 77.5% of freight volume that could be palletalized or unitized for loading based on pallets, firms unitized 82.5% of freight volume for loading on pallets[5].

Of firms' total freight volume, 45.8% of the palletalized freight volume was loaded on standard pallets. These results mean that during freight volume unitized loading, on average, firms only loaded 59.1% of that freight volume on standard Korean pallets[6].

<Table 2> Ratios of palletalized freight volume

Ratio of freight volume that can be unitized for loading based on pallets	Ratio of freight volume unitized for loading by pallets	Ratio of freight volume unitized for loading based on pallets
77.5%	63.9%	45.8%

2)Ratio of Pallet Use by Size

We surveyed the extent to which firms used pallets by type or size. Table 3 lists the ratio of each pallet type. Note that only six types of pallets were surveyed from among the seven multi-standard pallets available in Korea because the 1500 × 1100 mm pallet is rarely used; however, this size was included in the 'other' pallet

5) 63.9%/77.5%=82.5%

6) 45.8%/77.5%=59.1%

category used in the survey. Survey results indicate a 63.9% ratio of multi-standard pallet use and a 33.1% ratio of non-standard pallet use. Use of the 1100 × 1100 mm pallet (the ULS or unit load system) was 32.0%, of the 1200 × 800 mm was 5.9%, of the 1200 × 1000 mm was 9.6%, etc. The actual ratio of 1100 × 1100 mm pallet use was 26.4%[7]; this includes the ratios of standard pallet use as well as 1100 × 1100 mm pallet use.

<Table 3> Ratios of loading freight volume on pallets by type

Pallet type	1100 mm × 1100 mm	1200 mm × 1000 mm	1300 mm × 1100 mm	1100 mm × 800 mm	1200 mm × 800 mm	1400 mm × 1100 mm	Other
Ratio in use	32%	10%	9%	8%	6%	2%	1%

3) Ratios of Standard Pallet Use by Freight Volume and Year

We measured the extent to which firms used standard pallets to determine levels of logistics standardization. Table 4 presents ratios of standard pallet use; for the firms surveyed, ratios of standard pallet use by total freight volume were 43.98%, 45.38%, 45.92%, and 45.84% for 2000, 2001, 2002, and 2003, respectively. These results indicate a lack of recent changes in the ratios of standard pallets used in Korea, and that firms have maintained levels of pallet standardization of about 45%.

<Table 4> Ratios of standard pallet use by total freight volume

2000	2001	2002	2003
43.98%	45.38%	45.92%	45.84%

7) The ratio of total use standard pallets in freight volume 66.9% × the ratio of the 1100 × 1100 mm pallet 32.0% =26.4%.

Ⅲ. Effects of Logistics Standardization

1. Relationships between Logistics Costs and Major Factors

This section discusses our investigation of how standardization affects logistics costs. We began with a conventional cost function $C = C(y, s)$, where y represents output or amount of products or freight volume and s represents logistics standardization variables. This formula is based on the assumption that freight volume and number of employees are major factors that affect logistics costs. If freight volume increases, firms should have relatively more costs and may try to find more efficient ways of reducing costs, such as by reducing labor costs. In this case, management should realize that introducing standardization or an automatic system is more cost effective than increasing labor input.

We began by estimating the relationship between logistics costs and some important variables that may affect these costs. In the empirical analysis, we adopted the following formula in order to investigate relationships between logistics costs and statistically cost driving variables:

$$\ln Cost_i = c_i + b_1 \ln Q_i + b_2 \ln L_i + e_i$$

where $\ln Cost_i$ represents the logarithms of the logistics cost, c is a constant, is the logarithm of the amount of products or freight volume $\ln L$, is the number of employees in terms of logarithms e, is the error term, b represents parameters, and i is the i^{th} plant or firm.

The equation indicates that logistics costs are related to the amount of product and the number of employees; logistics costs will increase if amounts of product and labor affect logistics costs negatively.

By empirically estimating the logistics cost function, we found that logistics cost had a positive relationship with the number of employees, but also with the amount of freight volume that the firm transported. The results indicated that logistics costs increased more when the number of employees increased than when the amount of product volume increased.

<Table 5> Estimated results of relationships between logistics costs and amount of products and labor

Parameter estimates

R-Square	0.3859
Adj R-Sq	0.3420
Obs. 79	
Dependent variable: LNC	

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.35085	1.83870	0.19	0.8500
LNQ	0.10179	0.10082	1.01	0.3213
LNL	1.14918	0.29800	3.86	0.0006

Next, we estimated relationships between logistics costs and exports. Logistics costs increased if firms exported products to foreign countries and had higher shipping expenditures. We defined Exp as export in terms of logarithms of money value of each firm's exports. Empirical analysis indicated that logistics costs had a lesser relationship with exports and, again, a greater relationship with the number of employees. This implies that labor has a negative effect on logistics costs, but neither exports nor freight volume have negative effects.

<Table 6> Empirical results of relationships between logistics costs and exports

Parameter estimates

R-Square 0.5620

Adj R-Sq 0.4890

Dependent Variable: LNC

Obs. 79

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	0.01561	1.83360	0.01	0.9933
LNQ	-0.05521	0.13055	-0.42	0.6774
EXP	0.19091	0.13967	1.37	0.1885
LNL	0.96715	0.33898	2.85	0.0106

2. Relationships between Logistics Costs and Logistics Standardization

1) Effects of Logistics Standardization on Logistics Costs

To examine relationships between logistics costs and logistics standardization, we estimated logistics costs and the ratio of standard pallets used as the following:

$$\ln Cost_i = c_i + b_1 \ln Q_i + b_2 + \ln L_i + b_3 T11_i + b_4 T11_i^2 + e_i$$

or

$$\ln Cost_i = c_i + b_1 \ln Q_i + b_2 + \ln L_i + b_3 S_i + b_4 S_i^2 + e_i \qquad (*)$$

where T11 is the ratio of ULS single-pallet use (1100 × 100 mm) and S is the ratio of multi-standard pallet use[8].

8) Seven types of standard pallets are used in Korea, but this ratio uses only six standard pallets.

This formula provides the effects that standard levels, freight volume, and labor had on logistics costs. If a firm faced high logistics costs when freight volume increased, then the parameter of freight volume had a statistically positive sign. Parameters of standardization in terms of the ratio of pallet use will be negative, as logistics standardization reduces costs.

Empirical results indicated that T11 and T11_2 (in our notation, $T11^2$) were statistically significant at the 10% confidence level and had negative and positive signs, respectively. Increasing the ratio of ULS single-pallet use decreased logistics costs, implying that logistics standardization may affect logistics costs negatively (Table 7). That is, an increase in the ratio of levels of logistics standardization should decrease logistics costs.

Empirical analysis of standard pallet use indicated that the parameter of S had a negative sign in the 10% confidence level, meaning that standardization in terms of multi-standard pallet use also decreased firms' logistics costs (Table 8).

<Table 7> Estimation results of relationships between logistics costs and unit load pallets

Parameter estimates

R-Square 0.4682
Adj R-Sq 0.3864
Dependent Variable: LNC
Obs. 79

Variable	Parameter Estimate	Standard Errort	Value	Pr > |t|
Intercept	1.55542	1.96358	0.79	0.4355
LNQ	0.09591	0.09747	0.98	0.3342
LNL	1.21493	0.29481	4.12	0.0003
T11	-0.09627	0.04833	-1.99	0.0570
T11_2	0.00083499	0.00043702	1.91	0.0671

<Table 8> Estimation results of relationships between logistics costs and standard pallets

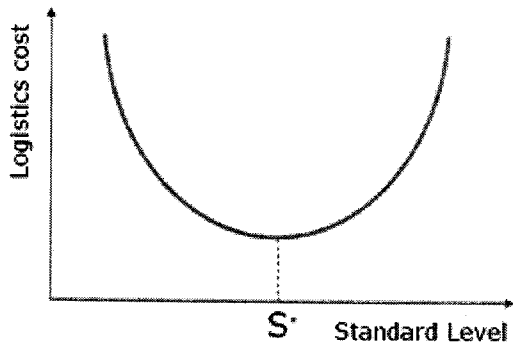
Parameter estimates

R-Square 0.5173
Adj R-Sq 0.4822
Dependent Variable: LN
Obs. 79

Variable	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	-0.06704	1.20926	-0.06	0.9560
LNL	1.28178	0.18412	6.96	<.0001
LNQ	0.08826	0.06621	1.33	0.1880
S	-0.04467	0.02248	-1.99	0.0519
S2	0.00050461	0.00022515	2.24	0.0291

2) Optimal Levels of Logistics Standardization

This section presents our investigation of how standardization affected logistics costs. We measured levels of standardization that minimized logistics costs, i.e., the level at which a firm must maintain logistics standardization to minimize logistics costs. In the base specification, signs and statistical significances of the standardization variable indicated whether they satisfied the condition of minimizing the cost function; if so, parameters of standardization (T11 or S) were negative and significant, and the second parameters of standardization (T11_2 or S2) were positively significant. If they satisfied the conditions, they created the U-shaped logistics cost function shown in Figure 1. If they satisfied the conditions, we could measure the level of standardization that minimized logistics costs, called the 'optimal level of logistics standardization in terms of cost function'.



<Figure 1> U-shaped logistics costs level

First, we estimated relationships between logistics costs and ratios of standard pallet use. Empirical results indicate that that T11 and S were negatively related and T11_2(or $T11^2$) and S_2(or S^2) were positively related to logistics costs statistically in the 5% confidence levels; results are shown in Tables 7 and 8, respectively. Results indicate that each variable had a non-linear relationship with logistics costs and satisfied the minimization conditions, so logistics costs resulted in a U-shaped function like Figure 1.

Thus, we were able to measure the level of logistics standardization required to minimize logistics costs. To measure optimal levels, we used the parameter estimates shown in Tables 7 and 8 based on equation (*).

From equation (*), we get:

$$\frac{\partial \ln C}{\partial T11(orS)} = b_3 + 2b_4 T11(orS) = 0 \quad \Rightarrow \quad T11(orS) = -\frac{b_3}{2b_4}$$

or

$$b_4(T11(orS) - \frac{b_3}{2b_4})^2 - \frac{b_3}{4b_4} .$$

Empirical results provided the ratio of ULS single-pallet use:

$$0.00083T11^2 - 0.09627T11 = 0.00083(T11 - 57.99398)^2 - 2.808324$$

or

$$T11 = -\frac{b_3}{2b_4} = 57.99398$$

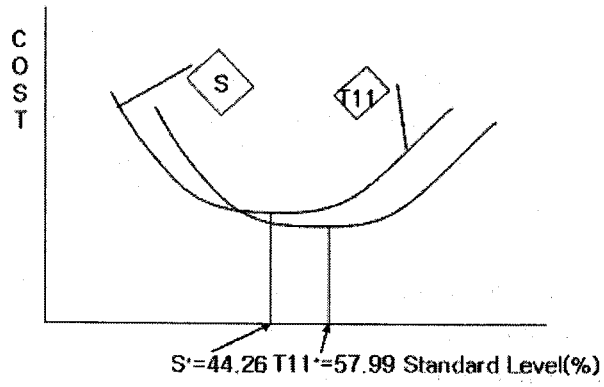
and

$$0.0005S^2 - 0.04467S = 0.0005(S - 44.2619)^2 - 0.98589$$

or

$$S = -\frac{b_3}{2b_4} = 44.2619$$

The signs and figures of these variables indicate that logistics costs decreased until ratios for multi-standard and ULS single-pallet use increased to 44.26% and 57.99%. This means that optimal ratios were $T11^*$ = 57.99% for ULS single pallets and S^* = 44.26% for multi-standard pallets, as shown in Figure 2. Figure 2 was plotted using the slope of the above equation: the S line is flatter and has a higher minimum point than the T11 line, implying that the ratio of ULS single-pallet use increases more than current levels, but that the ratio of multi-standard pallet use is relatively optimal and does not need to increase because ratios of both types of pallet used are 45.8% (Table 2) and 32.0% (Table 3), respectively. The results indicated that in order to minimize logistics costs, levels of logistics standardization were lower when firms adopted multi-type pallets as logistics standardization tools than when firms used only one type of pallet.



<Figure 2> Shape of the logistics cost function by pallet type

Ⅳ. Summary and Conclusions

This paper examined relationships between logistics standardization and logistics costs. Using survey data from Korean firms or establishments, our study demonstrated why firms must increase levels of logistics standardization; the following paragraphs summarize the evidence.

First, we found that logistics costs at the firm level may be affected less by freight volume or exports than the number of employees.

Second, logistics standardization had a negative relation to logistics costs, meaning that an increase in the level of logistics standardization can decrease logistics costs. Logistics costs can be decreased until the ratio of ULS single-standard pallet use reaches 57.99% and the ratio of multi-standard pallet use reaches 44.26%. To reduce logistics costs, the ratio of ULS single-standard pallet use can be increased to higher than present levels. However, the ratio of multi-standard pallet use is now at a relatively optimal level and thus does not need to increase. Results also indicate that in order to minimize logistics costs, logistics standardization levels were lower when firms used several types of pallets than when firms used a single type of pallet.

We conclude that firms can increase levels of logistics standardization when labor costs increase rather than when freight volume or exports increase. These results indicate that firms should raise their level of logistics standardization when there is a need to increase labor input for product logistics management, but that firms have few incentives to invest in standardization if and only if freight volume increases. Also, adaptation of a single standard pallet, the ULD (unit load system) pallet, is a better logistics standardization tool for minimizing logistics costs than multi-type standard pallets.

This study has made progressive contributions to logistics standardization research by identifying which variables affect logistics costs and to what level firms must standardize logistics to minimize logistics costs. These results may explain why firms are motivated to standardize their logistics systems.

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