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A Study on the Effect of Packaging Design Considering SCM Aspects on Logistics Efficiency (Focusing on the case of domestic A company)

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Abstract This study conducted a case study and a questionnaire analysis in parallel. In the case study, a study was conducted on domestic manufacturer A by analyzing pallet loading efficiency of RRP(Retail Ready Packaging) products and pallet loading efficiency of MWC(Membership Wholesale Club) delivered products. As a result of the pallet loading efficiency simulation of 50 RRP products of Manufacturer A, it was 80.0% based on the T-11 type pallet and 84.3% based on the T-12 type pallet. It was found It refers that the route of producing the product from the manufacturer A and delivering it to the MWC A in the form of RRP resulted in the decrease of the pallet loading efficiency through the change of the loading pattern and the adjustment of the number of loads. As a result of analyzing the questionnaire about whether the overall efficiency of the supply chain will be improved if the operation of the packaging system considering the SCM(Supply Chain Management) aspect is $\chi^2 = 178.500$, there was a statistically significant difference at the significance level of 0.000. Manufacturers and logistics companies answered “yes” the most, but distributors answered “is average” the most, confirming that the packaging can be constructed with the highest operational efficiency. Therefore, as a result of confirming the impact of packaging design considering the SCM aspect on logistics efficiency, it indicates the importance of closer collaboration between manufacturers and distributors.

Keywords *Packaging Design, SCM, RRP, MWC, Logistics efficiency*

Introduction

Packaging is a fundamental element of all kinds of goods supply chains and affects the sales of companies, so supply chain managers recognize the importance of packaging.[1] However, it is important to look at the relationship from the point of view of supply chain management, not from the point of view of package management.[2] As defined by the definition of logistics and SCM, a series of cargo flows from suppliers to end consumers, such as production, packaging, loading, transportation, loading and unloading, storage, shipping, and logistics information management, in the process of procurement of raw materials, include are related to suppliers, manufacturers, distributors, This is because various actors such as retailer and consumer are involved.[3] Due to the strong interaction between packaging and supply chain activities, several packaging systems influence the performance criteria of the supply chain. Packaging is a key element of the supply chain, which not only protects products from physical damage, but also transport, unload cargo, store warehousing, Affects all logistics activities, such as waste disposal and information management.[4] Kumar et al.[5] conducted a survey of several US hospitals and argued that more efficient and cost-effective supply chains could be achieved through improved logistics packaging design and collaboration with packaging suppliers. Jung et al.[6] should consider and reflect the new product as a specification that can improve the consistency with the pallet, which is considered as the most important logistics transportation method in the field of distribution in the study on the effect of Product Line Pricing on loading efficiency and logistics cost. Jung and Han[7] conducted a survey and analysis on the pallet loading patterns of MWC. Jung[8] emphasizes the necessity of commonly applicable product standard for improving pallet loading efficiency, and it supports 69 types of KS T 1002 (1,100 × 1,100 mm) and 40 types of KS T 1002 (1,200 × 1,000 mm). Insisted that these 21 kinds of common standards should be integrated.[9-10] In addition, Jung and Yun[11] indicates that the manufacturer's product packaging system considers pallets (T-11 type and T-12 type) displayed at each supplier in the case of MWC. The use of common standards is essential.[12] Therefore, packaging personnel should ensure that the packaging system meets other essential requirements while still meeting the primary goal of product protection[13]. Packaging is recognized as hav-

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ing a significant impact on the supply chain and in logistics systems and activities such as distribution, storage and handling, and many packaging dependent costs within the supply chain are being overlooked.[14] The efficiency of logistics in the supply chain is greatly influenced by packaging, design, unitization, and communication. Improved logistics packaging design and improved collaboration with packaging suppliers can lead to more efficient and cost-effective supply chains, but the lack of a major driver for such change is problematic. The purpose of this study is to conduct an empirical analysis on the relationship between packaging design and logistics efficiency in previous studies. The main research contents are as follows; Analysis of pallet loading efficiency between general packaging and RRP(Retail Ready Packaging) products, analysis of pallet loading efficiency between general distributor delivery and MWC(Membership Wholesale Club) products, manufacturers, distributors, The analysis was conducted by analyzing differences in recognition among logistics companies. If this study induces interest in packaging collaboration in supply chain and packaging design considering supply chain, it can bring value to academics and practically.

Study Procedure and Methods

First and second research contents of this study is case study and, on the such basis, the case study of PRP loading efficiency of RRP products and Pallet loading efficiency analysis of MWC-delivered products were conducted and its study subject is domestic manufacturer A. The pallet loading efficiency simulation tool used in this case study used the TOPS (Total Optimization Packaging Software, USA) program. The maximum allowable dimension is set to 0.0 mm so that the pallet does not come out of the pallet. The study was conducted as a reference. In other words, the simulation was performed by setting the loading height per pallet up to 2,350 mm including the pallet's own height (150 mm), the study was conducted and the results were derived. That is, the loading height per pallet was set up to 2,350 mm including the pallet's own height (150 mm), and the study was conducted based on the specifications of RRP products to identify the relationship between RRP products and loading efficiency. And the results were obtained. The third part of this study was an analysis of the perceived differences between manufacturers, distributors and logistics companies in terms of packaging design and logistics efficiency, and the questionnaire was based on the subject of this study. Will efficiency be improved?" The survey group was divided into manufacturers, distributors, and logistics companies, so that they were not biased toward specific companies. One-way batch variance analysis was performed to compare averages according to industry types, and Scheffe's Post test was performed. The verification items were then chi-squared and SPSS 21.0 statistical program was used for questionnaire analysis.

Results and discussion

1. Pallet Loading Efficiency Analysis of RRP (Retail Ready Packaging) Products

In this case study, pallet loading efficiency simulation was conducted on 50 items of RRP products manufactured by Manufacturer A from January 2 to February 10, 2020 as shown in Table 1. Except for the product code and product name, the box size, loading per loading layer, loading capacity per pallet, loading per pallet, volume (M3), loading efficiency (%), and product loading height per pallet were analyzed. For reference, the loading efficiency of T-11 type pallets as well as the T-12 type pallets were calculated and compared.

The loading efficiency analysis of T-11 type pallet was 80.0% for 50 items in Table 1, which is 3.5% higher than the loading efficiency of 76.5%, which is the analysis result of 41 items from Jung Sung-tae et al. (2012a). However, 80.0% of the pallet loading efficiency of RRP products is 17.4% compared to the average of 97.4% of the average floor loading efficiency for 69 standard T-11 pallets, which are defined in KS T 1002 (1,100 × 1,100 mm). The percentage was lower, and the minimum was 88.7% (standard 6), 8.8% lower. If you look at the original KS T 1002 (Transport package sizes by modular coordination) of the 2010-0494 publication, you can find not only 69 standards based on T-11 pallets, but also 40 types of transport packages based on T-12 pallets. It can be confirmed that also listed. As a result of analysis of loading efficiency based on T-12 pallet for 50 items in Table 1, it was 84.3%, and 15.2% was lower than 99.5% of KS T 1002 (1,200 × 1,000 mm) plane loading efficiency. T-12 pallet loading efficiency was 84.3%, 4.3% higher than average loading efficiency of T-11 pallets. The average loading efficiency of the 69 KS T 1002 (1,100 × 1,100 mm) standards was 97.4% and the average loading efficiency of the 40 KS T 1002 (1,200 × 1,000 mm) standards was 17.4% and 15.2%, respectively. These results can be inferred from the fact that the manufacturer's packaging system considering logistics efficiency was not implemented when planning new RRP products. RRP's characteristics suggest that the result is a reflection of the retailer's pursuit of operational efficiency rather than a package design that considers the entire supply chain.

2. Analysis of pallet loading efficiency of MWC (Membership Wholesale Club)

The production route from manufacturer A to the general customer is composed of a very simple process. In particular, since the product is produced at the factory and the pallet loading height (2,200 ~ 2,350 mm) worked on the palletizer is transported to the destination, the consistent transportation system is applied. On the other hand, the manufacturer's A

Table 1. Estimation of Loading Efficiency Based on RRP Product Specification of Manufacturer A

No	Size	Box/	Layer	Box/	T-11 Eff.(%)		Pro.	M^3		T-12 Eff.(%)	
	(L×W×H, mm)	Layer	/Pallet	pallet	Area	Cub.	Height	11	12	Area	Cub.
1	645×440×290	4	7	28	93.8	86.6	2180	2.6	2.6	70.9	65.5
2	598×340×423	4	5	20	67.2	64.6	2265	2.7	2.7	84.7	81.4
3	461×548×359	4	6	24	83.5	81.8	2304	2.8	2.8	84.2	82.4
4	315×180×110	18	20	360	84.3	84.3	2350	2.8	2.8	94.5	94.5
5	315×210×110	16	20	320	87.5	87.5	2350	2.8	2.8	88.2	88.2
6	685×540×175	2	12	24	61.1	58.4	2250	2.7	2.7	61.6	58.8
7	685×530×190	2	11	22	60	57	2240	2.7	2.7	60.5	57.5
8	860×460×170	2	12	24	65.4	60.9	2190	2.6	2.6	65.9	61.1
9	565×270×465	5	4	20	63	53.3	2010	2.4	2.4	76.3	64.5
10	315×210×105	16	20	320	87.5	83.5	2250	2.7	2.7	88.2	84.2
11	380×220×215	12	10	120	82.9	81	2300	2.8	2.8	90.6	88.5
12	480×334×364	6	6	36	79.5	78.9	2334	2.8	2.8	80.2	79.6
13	480×329×347	6	6	36	78.3	74.1	2232	2.7	2.7	92.1	87.2
14	490×423×526	4	4	16	68.5	65.5	2254	2.7	2.7	69.1	66.1
15	440×260×218	8	10	80	75.6	74.9	2330	2.8	2.8	85.8	85
16	450×260×218	8	10	80	77.4	76.7	2330	2.8	2.8	87.7	87
17	490×320×225	6	9	54	77.8	71.6	2175	2.6	2.6	91.5	84.2
18	545×460×170	4	12	48	82.9	76.8	2190	2.6	2.6	83.6	77.5
19	215×170×205	31	10	310	93.6	87.3	2200	2.7	2.6	97.5	90.8
20	215×175×210	31	10	310	96.4	92	2250	2.7	2.7	94.1	89.8
21	240×210×220	21	10	210	87.5	87.5	2350	2.8	2.8	84	84
22	210×175×205	31	10	310	94.2	87.7	2200	2.7	2.6	91.9	85.6
23	380×280×205	9	10	90	79.1	73.7	2200	2.7	2.6	88.7	82.6
24	560×360×305	4	7	28	66.6	64.7	2285	2.8	2.7	84	81.5
25	300×175×300	21	7	147	91.1	87	2250	2.7	2.7	96.2	91.9
26	425×180×160	14	13	182	88.5	83.7	2230	2.7	2.7	89.2	84.4
27	395×291×210	9	10	90	85.5	81.6	2250	2.7	2.7	95.8	91.4
28	415×305×233	8	9	72	83.7	79.8	2247	2.7	2.7	84.4	80.4
29	430×243×270	8	8	64	69.1	67.8	2310	2.8	2.8	87.1	85.5
30	450×255×305	8	7	56	75.9	73.6	2285	2.8	2.7	86.1	83.5
31	475×190×165	12	13	156	89.5	87.3	2295	2.8	2.8	90.3	88
32	420×550×395	4	5	20	76.4	68.6	2125	2.6	2.5	77	69.1
33	440×320×215	8	10	80	93.1	91	2300	2.8	2.8	93.9	91.7
34	440×256×207	8	10	80	74.5	70.1	2220	2.7	2.7	84.5	79.5
35	450×240×215	8	10	80	71.4	69.8	2300	2.8	2.8	90	88
36	470×300×215	8	10	80	93.2	91.1	2300	2.8	2.8	94	91.9
37	490×310×220	6	10	60	75.3	75.3	2350	2.8	2.8	88.6	88.6
38	440×440×215	4	10	40	64	62.5	2300	2.8	2.8	64.5	63.1
39	240×235×170	16	12	192	74.6	69.2	2190	2.6	2.6	94	87.2
40	260×225×185	16	11	176	77.4	71.6	2185	2.6	2.6	92.6	85.7
41	270×230×185	16	11	176	82.1	76	2185	2.6	2.6	93.2	86.2
42	530×335×440	6	5	30	88	88	2350	2.8	2.8	74	74
43	570×430×345	4	6	24	81	74	2160	2.6	2.7	81.7	76.9
44	500×430×360	4	6	24	71.1	69.8	2310	2.8	2.8	71.7	70.4
45	290×250×320	16	6	96	95.9	83.7	2070	2.5	2.5	96.7	84.4
46	408×350×260	6	8	48	70.8	66.9	2230	2.7	2.7	71.4	67.5
47	438×366×292	6	7	42	79.5	73.9	2194	2.7	2.6	80.2	74.5
48	476×366×314	6	7	42	86.4	86.3	2348	2.8	2.8	87.1	87
49	506×366×274	6	8	48	91.8	91.5	2342	2.8	2.8	77.2	76.9
50	430×360×345	6	6	36	76.8	72.2	2220	2.7	2.7	77.4	72.8
Average					80.0	76.5	2251.3	2.7	2.7	84.3	80.6

company produces products and delivers them to MWC (Membership Wholesale Club) A in the form of RRP. In the case of Manufacturer A, we compared the loading pattern when it is distributed as a general product and the loading pattern for MWC delivery as shown in Table 2. We analyzed 26 items of RRP products for MWC delivery, which were continuously sold from July 2019 to January 2020. Box size (length, width, height) excluding product code and product name, product weight and product volume (M^3), number of boxes per layer (B/L), number of stacks per pallet (L/P), number of boxes per pallet (B/P), pallet area-based loading efficiency (%), pallet loading including pallets, loading height, loading pattern.

Table 2 As a result of analysis, the overall height of pallet loading including pallet's own height was calculated to be less than 2,350 mm, with the height of rack of automated warehouse of manufacturer A considered. In the case of MWC delivery, the total pallet height was calculated to be less than 1,500mm, with the rack height located in the store considered. The quantity of boxes (B/L) per loading floor was reduced by 1 box from 12 boxes to 11 boxes for MWC delivery. The number of stacks per pallet (L/P) decreased from 10 gears to 6 gears for MWC delivery, The number of boxes per pallet (B /P) dropped 63 boxes from 138 boxes to 75 boxes for MWC delivery. Pallet area-based loading efficiency also dropped 11% from 87% to 76% for MWC delivery, Overall, pallet area-based loading efficiency was found to be deteriorating during MWC delivery. The number of loading stages (L/P) and the loading height of pallets were lowered for all 26 items, It is analyzed that the results reflect the calculation criteria of the pallet height less than 2,350 mm and less than 1,500 mm. The number of boxes per pallet (B / P) has been reduced from 125 boxes to 68 boxes on average, Pallet area-based loading efficiency (%) decreased 8.2% from 86.8% to 78.6% on aver-

Table 2. Pallet loading information of the Manufacture's A

No.	Box size (mm)			General Loading Information						Loading Information for MWC					
	A	B	C	B/L	L/P	B/P	Eff.	L.H.	Loading	B/L	L/P	B/P	Eff.	L.H.	Loading
	(L)	(W)	(H)				(%)	(mm)	Pattern				(%)	(mm)	Pattern
1	215	260	215	20	10	200	92.4	2,300	Block	20	6	120	92.4	1,440	Block
2	315	180	110	18	20	360	84.4	2,350	Block	18	12	216	84.4	1,470	Block
3	315	210	110	16	20	320	87.5	2,350	Pinwheel	15	12	180	82	1,470	Block
4	225	175	205	28	10	280	91.1	2,200	Brick	24	6	144	78.1	1,380	Block
5	305	265	385	13	5	65	86.8	2,075	Brick	12	3	36	80.2	1,305	Block
6	410	225	340	12	6	72	91.5	2,190	Pinwheel	8	3	24	61	1,170	Block
7	410	210	225	12	9	108	85.4	2,175	Pinwheel	10	6	60	71.2	1,500	Block
8	310	250	350	13	6	78	83.3	2,250	Brick	12	3	36	76.9	1,200	Block
9	315	135	115	27	19	513	94.9	2,335	Brick	24	11	264	84.4	1,415	Block
10	350	165	110	18	20	360	85.9	2,350	Block	18	12	216	85.9	1,470	Block
11	315	175	105	18	20	360	82	2,250	Block	18	12	216	82	1,410	Block
12	540	325	475	6	4	24	87	2,050	Block	6	2	12	87	1,100	Block
13	505	265	245	8	8	64	88.5	2,110	Pinwheel	8	5	40	88.5	1,375	Block
14	445	285	210	8	10	80	83.9	2,250	Pinwheel	6	6	36	62.9	1,410	Block
15	560	440	210	4	10	40	81.5	2,250	Pinwheel	3	6	18	61.1	1,410	Brick
16	570	410	310	4	7	28	77.3	2,320	Pinwheel	3	4	12	57.9	1,390	Brick
17	550	440	210	4	10	40	80	2,250	Pinwheel	4	6	24	80	1,410	Block
18	285	440	410	8	5	40	82.9	2,200	Pinwheel	6	3	18	62.2	1,380	Block
19	600	460	206	4	10	40	91.2	2,210	Pinwheel	2	6	12	45.6	1,386	Block
20	570	260	236	8	9	72	98	2,274	Pinwheel	6	5	30	73.5	1,330	Brick
21	366	260	236	12	9	108	94.4	2,274	Pinwheel	12	5	60	94.4	1,330	Block
22	370	260	256	10	8	80	79.5	2,198	Brick	8	5	40	63.6	1,430	Block
23	310	260	256	13	8	104	86.6	2,198	Brick	12	5	60	79.9	1,430	Block
24	408	234	362	10	6	60	78.9	2,322	Brick	8	3	24	63.1	1,236	Block
25	560	250	324	8	6	48	92.6	2,094	Pinwheel	8	4	32	92.6	1,446	Pinwheel
26	502	275	308	8	7	56	91.3	2,306	Pinwheel	8	4	32	91.3	1,382	Block
Average				12	10	138	87	2236		11	6	75	76	1372	

age. On the other hand, the pallet loading pattern was found to have been changed from 25 of 26 items to 3 brick pattern items and 22 block pattern items. When it is distributed as a general product, the pallet loading efficiency simulation was performed according to the product standard, and the loading pattern which has the best loading efficiency was used depending upon the simulation results, In case of delivery to MWC, it is analyzed that most of them were consist of block type loading pattern. These results infer the fact that the manufacturer's packaging system considering logistics efficiency was not implemented when constructing a product for delivery to a specific company, This situation shows that the packaging have been carried out with the pallet loading stage and loading pattern preferred by the supplier.

3. Analysis of perceived differences between manufacturers, distributors and logistics companies

This time, a questionnaire analysis was conducted on the measurement variable, “Will the overall efficiency of the supply chain be improved if the packaging system operation considering the SCM aspect” is considered as the subject of this study? In order to compare the average according to the industry, one-way ANOVA(Analysis of Variance), Scheffe's ex post test was performed to see if there was a statistically significant difference. The results of one-way ANOVA Table 3 and Scheffe's post-test Table 4 showed statistically significant differences.

As described above, the verification items were verified by chi-square for the research model established according to the purpose of this study. As a result of the analysis, it was found that there was a statistically significant difference as $\chi^2 =$ 178.500 as shown in Table 5. Overall, the largest number of responses is “yes” to 112 (48.3%), ' Not like that' was the least respondent (10%, 4.3%), Manufacturers and logistics companies answered “yes” the most, The most common response was that retailers were “is average”. Through this research model, logistics efficiency may be lowered if the packaging is configured with the highest priority on the operational effi-

Table 3. Results of one-way ANOVA

Business Type	N	Mean	Standard Deviation	Standard Error	95% Confidence Interval		Minimum	Maximum
					Minimum	Maximum		
Manufacture	101	4.31	0.524	0.052	4.20	4.41	3	5
Distributor	71	2.94	0.475	0.056	2.83	3.06	2	4
Logistics	60	4.17	0.526	0.068	4.03	4.30	3	5
Total	232	3.85	0.792	0.052	3.75	3.96	2	5

$p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Table 4. Results of Scheffe post-hoc analysis (Manufacturer: a, Distributor: b, and Logistics: c)

Business Type	N	Mean	Standard Deviation	F (p-value)	Scheffe
Manufacture	101	4.31	0.524	164.131*** (0.000)	b < c = a
Distributor	71	2.94	0.475		
Logistics	60	4.17	0.526		

$p < 0.05$*, $p < 0.01$**, $p < 0.001$***

Table 5. Chi-Square Test Results

Division		Not like that	is average	Yes	it really is	Total	χ2(p-value)
Manufacture	Frequency	0	3	64	34	101	178.500*** (0.000)
	Rows %	0.0%	3.0%	63.4%	33.7%	100.0%	
	Columns %	0.0%	4.8%	57.1%	70.8%	43.5%	
Distributor	Frequency	10	55	6	0	71	
	Rows %	14.1%	77.5%	8.5%	0.0%	100.0%	
	Columns %	100.0%	88.7%	5.4%	0.0%	30.6%	
Logistics	Frequency	0	4	42	14	60	
	Rows %	0.0%	6.7%	70.0%	23.3%	100.0%	
	Columns %	0.0%	6.5%	37.5%	29.2%	25.9%	
Total	Frequency	10	62	112	48	232	
	Rows %	4.3%	26.7%	48.3%	20.7%	100.0%	
	Columns %	100.0%	100.0%	100.0%	100.0%	100.0%	

$p < 0.05$*, $p < 0.01$**, $p < 0.001$***

ciency of the store rather than considering the overall efficiency of the supply chain, including consumers, distributors, manufacturers, environmental issues, and logistics efficiency. Considering the overall efficiency in the supply chain rather than the top priority, this indicates that the logistics efficiency will be improved if the packaging system is operated.

Conclusion

This study combined case study and questionnaire analysis, In the case study, we conducted a study on the domestic manufacturer A company by analyzing pallet loading efficiency of RRP products and pallet loading efficiency of MWC delivered products. As a result of pallet loading efficiency simulation of 50 RRP products of Manufacturer A, it was 80.0% based on T-11 type pallet, It was confirmed that 17.4% was lower than 97.4% of average loading efficiency of 69 standard standards. In the analysis of loading efficiency based on T-12 pallet, 84.3% was found, It was confirmed that 15.2% is lower than the average load efficiency of 99.5% of 40 standard standards. These results suggest that RRP's characteristics reflect the pursuit of retailer's operational efficiency rather than the entire package design. On the other hand, the manufacturer's company produced the product and delivered it to MWC A in the form of RRP, resulting in lowered pallet loading efficiency through the change of the loading pattern and the adjustment of the number of loads. The number of loading stages (L/P) and the loading height of pallets were lowered for all 26 items, The pallet loading pattern was found to be changed from 25 of 26 items to 3 brick pattern items and 22 block pattern items. This result confirms that the packaging is carried out with the number of pallet loading stages and loading patterns preferred by the suppliers when constructing products for delivery to specific companies. On the other hand, the results of the questionnaire analysis on the measurement variable “If the packaging system operation considering the SCM aspect will improve the overall efficiency in the supply chain,” which is also the subject of this study, are statistically significant at the significance level of 0.000 with $\chi^2 = 178.500$. There was a difference. Manufacturers and logistics companies answered “yes” the most, The most responsive “is average” for distributor is that packaging can be configured with the highest operational efficiency. This indicates that logistics efficiency will be improved if the packaging system is operated in consideration of the overall efficiency in the supply chain rather than the retailer store operation. This is because of the strong interaction between packaging and supply chain activities, many packaging systems affect the performance criteria of the supply chain, Packaging personnel should also ensure that packaging systems meet the primary objectives of product protection while meeting other essential requirements. Therefore, as a result of confirming the impact of packaging design considering the SCM aspect on logistics efficiency, it indicates the importance of closer collaboration between manufacturers and distributors. If it contributes to the improvement of logistics efficiency, it shows that the institutional approach such as incentives to distributors and active supplementation are needed.

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