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ON CHARACTERISTICS AND CLASSIFICATION OF INTERNATIONAL TRADE COMMODITY REGARDING TRANSPORTAION MODE CHOICE

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ABSTRACT
Analysis/research of international trade and logistics by commodity-wise has generally been conducted by integrating the commodities into some groups using common statistical groupings with consideration of their industries, quality, uses, etc. However, this general integration of commodities may not be valid for transport mode/route choice analysis/modeling because mode/route choice is greatly affected by cargo characteristics such as volume, size, unit price, etc.
In this study, a new classification of commodities is proposed based on cargo characteristics using the inclusive database provided by Global Insight Inc., which offers the cargo value and volume by transport mode worldwide. Specifically, 77 commodities are integrated into 9 groups using transport mode ratio, unit price, container ratio, etc., which can express each commodity's cargo characteristic. This new classification reveals the differences with general integration of commodities. The chronological changes of the characteristics of each commodity and the differences of characteristics by combination of origin and destination area are also discussed.

Key Words: Mode Choice, International Trade, Commodity Classification, Global Insight

1. INTRODUCTION

Generally speaking, when conducting researches and studies on the logistics or international trade, analyses should be made by commodity or industry in as much detail as possible even if they target comprehensive international trade and freight flow. This is based on the idea that characteristics of industry and type of transport of commodity should be reflected as much as possible.
On the other hand, setting aside the study focusing on the movement of individual cargo or individual industry, when targeting the total trade amount in a country or the entire cargo flow across the region, such subdivisions are naturally limited from the viewpoints of model handling and data availability. In such cases, in the actual investigation, analysis and modeling, commodities or industries are often aggregated from a detailed statistical classification (e.g. industrial classification) according to the industrial characteristics (e.g. primary, secondary, and tertiary industry) or the nature of commodities (e.g. light industry and chemical industry).

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Even in the investigations and researches on the cargo flow, such aggregated classifications based on the industrial characteristics are often used. Although they are not directly considering the nature of the transport system, a certain correlation can be observed between the industrial and transport characteristics; e.g. a cargo of mining industry is normally shipped by bulk ship, and the weight per volume of agricultural and light industry products is so small that more containers are needed compared with those in other industries in the case of the same weight. However, the authors believe that the main reason the same commodity classification is chosen in the cargo flow analysis is due to a lack of other alternatives. Moreover, the choice of transport mode has become very complicated in the recent years; for example, for some cargoes such as wooden chips and some mineral resources, containers are becoming the dominant transport mode rather than bulk. As another example, the transport mode of some cargoes such as apparel and auto parts is flexible (e.g. a particular cargo can be transported by maritime container shipping normally but by air transport in emergencies).
As far as the authors know, there is almost no research to validate what is the optimal classification from the viewpoint of the analysis and modeling for mode and route choice of the cargo. Therefore, the authors propose an example of commodity classification considering characteristics of cargo from a viewpoint of “cargo transported” (hereinafter “characteristics of freight transport”). Concretely, by using the Global Trade Navigator provided by Global Insight Inc. (hereinafter referred to as "GI data"), which includes comprehensive information on trade and freight transport such as trade amount, freight volume by transport mode and container cargo transport, the authors classify commodities explicitly considering characteristics of freight transport such as unit price, containerized ratio, and modal share by transport mode. Also, commodity classification considering time series data and regional difference of the characteristics of freight transport are investigated. In Chapter 2, reviews on the traditional commodity classification and existing related studies as well as a concept on commodity classification in this paper are introduced. In Chapter 3, an overview of data used in this paper is explained. In Chapter 4, the methodology and results of the new commodity classification are shown. Finally, the achievement of the paper and future issues are summarized in Chapter 5.

2. REVIEW OF RELATED RESEARCH AND TRADITIONAL COMMODITY CLASSIFICATION AND CONCEPT OF THIS STUDY

2.1 TRADITIONAL COMMODITY CLASSIFICATION

Major statistical classifications of commodities, products, and industries used in Japan and worldwide are summarized in Table 1. For industrial classification, for instance, the Japan standard industrial classification provided in the statistical law is applied in the major statistical surveys in Japan such as the national census and industrial statistics. Internationally, the United Nations has developed the International Standard Industrial Classification (ISIC) and is promoting its use worldwide. Also, for commodity classification, Harmonized Commodity Description and Coding System (HS code) has been widely applied including trade statistics. HS code is organized into 21 sections and 96 chapters, and a further detailed code given to the commodities. It is said that all the commodities are classified by their materials, shape, use, etc.

Table 1. Overview of major industrial and commodity classifications of Japan and worldwide

	Industry		Commodity					
Classification Name	ISIC*1	Japan Standard Industrial Classification	HS*2	Japanese Trade Statistics	SITC*3	CPC*4	Japan Standard Product classification	Japan Port statistics Commodity Classification
Create Institutions	United Nations	Ministry of Internal Affairs, Japan	World Customs Organization	Ministry of Finance	United Nations	United Nations	Ministry of Internal Affairs	Ministry of Land, Infrastructure and Transport
Purpose	International guidelines to classify all economic activity	Categorize all economic activities relating to the production of goods and services	Classify all trade products transported material tangible	Grasp accurately the realities of the trade, to facilitate comparison with the international foreign trade	Guidelines for the promotion of trade statistics and the international comparison	international statistical classification harmony	To display the results of the statistical surveys commodity statistics standards	Classification of the commodities to be handled at the port
Applications	Promoting the maintenance of a healthy statistical system of each country and the promotion of international comparisons of the different types of economic activities in the economic, social and demographic data	Industry statistics Ministry of internal affairs economic census, Census of the Ministry of Internal Affairs, industrial statistical surveys (economic industrial Ministry)	Trade statistics (tariff) , Production statistics, transport statistics,	Trade statistics (tariff) etc.	Trade statistics	All products subject to trading and stock (transport materials, non-transport materials, service, building patent, copyright and others)	Statistics by product	Port statistics
Classification	Classification21 Maximum 4 Classification by digit	Classification 20 , Classified under 99 , Classification of small 529 , Subdivision of 1,455	21 chapters Maximum 6 Classification by digit	21 chapters Maximum by digit classification 9 (the digit 6 same as HS)	Classification 9 Maximum 4 Classification by digit	Classification 9 The most detailed classification 5 Digit	Classification 10 , Classified under 97 , Classification of small 678 , Subdivision of 3,634	Classification 8 , Classified under 82
Correspondence and other classifications	HS SITC CPC	ISIC	ISIC SITC CPC	HS	ISIC HS CPC	ISIC HS SITC	CPC	Unique product classification

*1 ISIC: International Standard Industrial Classification of All Economic Activities
*2 HS: Harmonized Commodity Description and Coding System
*3 SITC: Standard International Trade Classification
*4 CPC: the Central Product Classification

Meanwhile, in some databases originally developed for the purpose of covering and analyzing industrial and/or trade trends worldwide, a unique classification may be organized, though it usually corresponds with the standard classifications. For instance, Global Trade Analysis Project (GTAP) Database which contains the input-output table among more than a hundred countries adopts an original classification of industries (57 commodities in the latest version, GTAP 8) and indicates the correspondence to CPC (the Central Product Classification) code and ISIC (International Standard Industrial Classification of All Economic Activities) code. Global Trade Navigator provided by Global Insight Inc. also adopts the 77 original industrial classifications and indicates the correspondence to SITC code. The Asian Regional Input-Output Table between Japan and China prepared by the Institute of Developing Economies aggregates trade commodities into 5 classifications (Agriculture, Mining, Household consumption products, Basic industrial materials, and Processing and assembling), because it is organized from the data based on the different classifications for each Asian economy.

The commodity classifications in major logistics surveys of Japan are defined as follows. Port Statistics of Japan, which is mainly utilized for analyzing port activities and logistics, consists of the 81 original commodity classifications and aggregated into 8 groups. The reason that the classification in Port Statistics is historically different from the HS code is likely because the industrial view point has been adopted, especially for cargoes handled in ports. Also, in the Freight Cargo Census of Japan, although the target industries are decided based on the Japan Standard Industrial Classification, the commodity classification is based on that of port statistics with small modification. On the other hand, the National Import/Export Container Freight Flow Survey conducted every five year adopts the commodity classification with HS code, while the results aggregated by port statistics classification have also been published. The authors consider, however, even in Port Statistics of Japan, that its classification seems to be organized from the industrial

viewpoint. For instance, manufactured products are classified as chemical product, light industrial product, and the metal machine products; this classification does not directly take into account the characteristics of freight transport.

2.2 REVIEW OF EARLY STUDIES

The authors reviewed a few early studies on the commodity classification especially focusing on the characteristics of freight transport.

Ishikura, et al. classifies the commodities by cluster analysis and principal component analysis using three variables (i.e. trade value, trade volume, and unit price), focusing on the relationship between the unit price of goods and the share of transport mode (sea and air transport). These three variables, however, are closely related to each other because unit price is obtained by dividing the value by the volume. Furthermore, the variation of the unit price in a commodity is not considered, which is one of the important factors when considering a share of transport mode. In addition, the analysis mainly focuses on air transport and does not sufficiently consider the entire transport mode including bulk and container transport.

Tsuboi, et al. tries to develop a modal choice model for international air and container cargo transport, utilizing Japan Trade Statistics. By assuming the shipping costs and the number of days for transport between Tokyo and some foreign cities, and utilizing the falling rates of prices for electronic products, the transport modes which could be selected in the price range of electronic products (about ¥ 3~7 million/m^3) are calculated. It is quite interesting because it quantitatively examines the impact of the falling price rate to the transport mode choice, although the model developed is not based on the actual data.

Meanwhile, Anderson and van Wincoop and Hillberry discussed an aggregation problem: a bias of the predicted values by using aggregated data when predicting the future trade amount by nonlinear model such as a gravity model. Although the choice of transport mode is not explicitly considered in their model, they implicitly point out that, if two different commodities in terms of characteristics of freight transport such as modal share are classified into the same group and represented as an average value, it may deviate from the true value. For instance, generally, the share of air transport increases as the unit price of a cargo increases, but the increase rate in the share decreases as the unit price increases (see Figure 1). Therefore, if the representative point of the group is easily determined by its average, it cannot accurately represent the share of the group, as an example is shown in Figure 1. This implies that a commodity classification should be done so as to appropriately aggregate the information (or characteristics) of the cargo as much as possible depending on the purpose of the analysis.

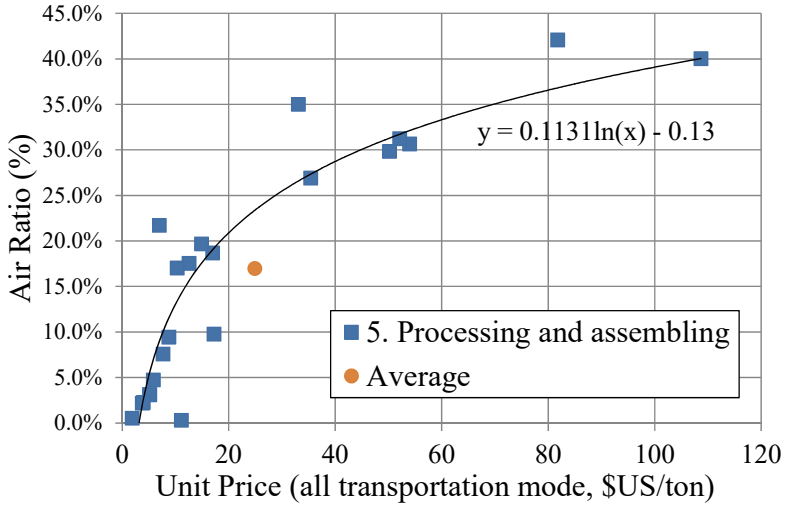

Figure 1. An example of the relationship between share of air transport and unit price; an average share of a commodity group "Processing and assembling" is not on its fitted curve. (source: GI data, 2003)

2.3 CONCEPT OF COMMODITY CLASSIFICATION IN THIS STUDY

In general, major factors in selecting the transport mode of cargo are considered, not only the physical factors such as volume, size, and density, but also the affordability of transport cost (which can be approximated by unit price), urgency for transport (which can be approximated by time value), and so on. Actually, some relationships are often observed among share of transport mode, containerized ratio, unit price, and total amount of volume. For instance, a commodity with a large share of air transport often has a high unit price (e.g. Figure 1), while a commodity with large amount of volume often has a low unit price.

When the analyzing characteristics of freight transport or developing a model taking it into account, there are two ways to consider the actual choice of transport mode;

1) Consider that the modal share is exogenously given and treat it as one of fixed characteristics (for instance, having the major mode represented as a unique transport mode by commodity in advance for simple analysis or modeling), and

2) Consider that the modal share is endogenously decided as an explained variable of the mode choice model.

In the case of estimating rough trade amount among countries by transport mode and commodity, the idea of 1), which gives representative transport mode for each commodity, allows rough trade amount to be estimated among countries by transport mode. In the case of estimating the transition of transport mode by change of transport circumstances, the idea of 2) allows a model to be developed for transport mode choice efficiently.

In this study, commodities are classified taking into account all related variables including the share of transport mode for simplified analysis and/or modeling, according to the idea 1).

3. OVERVIEW OF THE DATA USED

Statistics on international trade and international freight flow are provided by various research institutes and international organizations, but most are not comprehensive. Among them, GI data provides the actual value of trade and cargo flow data for more than

70 countries and regions worldwide.
This database provides the amount of value and cargo volume between the countries and regions by 17 trade concepts from A to Q (excluding intra-EU trade amount of value, cargo volume, and container volume by transport mode) (see Table 2). Commodities are classified into 77 commodities corresponding to the SITC code.
The 17 trade concepts and their values in 2003 (based on export, total value of the whole world) are shown in Table 2. Principally B should match C and D + E + F, and G should match H + I + J; however, they do not match accurately. This is probably because the data by transport mode are independently collected. In addition, the amount of each transport mode in the table does not include the amount within EU.
By using this database, the ratio of transport mode, unit price by transport mode, container ratio, air ratio, tons per TEU, etc. can be calculated, which are difficult to obtain from other databases.

Table 2. GI DATA (by Trade Concept, year 2003)

	Trade Concept		Value
Trade Value ($ billions)	A	Total(Real Value)	7,792.8
	B	Total(Nominal Value)	7,475.5
	C	Total(Nominal Value, calc. from Modes)	7,580.1
	D	Airborne(Nominal Value)	772.4
	E	Seaborne(Nominal Value)	3,487.8
	F	Overland/Other(Nominal Value)	924.5
Trade Metric Tons (billions)	G	Total	7,717.7
	H	Airborne	14.2
	I	Seaborne	5,072.5
	J	Overland/Other	670.2
	K	Dry Bulk	2,088.9
	L	Liquid Bulk (Tanker)	2,105.3
	M	General Cargo/Neo Bulk	267.4
	N	Container	609.2
Containers (millions)	O	20 Foot Containers	20,676.9
	P	40 Foot Containers	25,851.2
	Q	TEUs	73,307.3

4. COMMODITY CLASSIFICATION TAKING INTO ACCOUNT THE CHARACTERISTICS OF FREIGHT TRANSPORT INCLUDING MODE CHOICE

Focusing on the characteristics of commodities such as unit price and transport mode, some commodities have similar trends and others have different trends. In this chapter, commodity classification taking into account the characteristics of freight transport including the share of transport mode is examined.
Firstly the results classified by the data of a single year (2003) are shown; then their changes over the years and differences by regions are examined.

4.1 COMMODITY CLASSIFICATION USING THE DATA OF A SINGLE YEAR (2003)

(1) PROCEDURES AND RESULTS OF CLASSIFICATION
As variables that represent the characteristics of freight transport by commodities, the following five variables are selected. In order to reduce variables for easy understanding of

the characteristics, principal component analysis is then performed to aggregate these five variables into two variables. Finally, in order to find groups of similar type commodities, cluster analysis is performed to classify each commodity by its first and second principal component score. Both principal component analysis and cluster analysis are typical methodologies of multivariate analyses for classification of many variables. For details, please refer textbooks on multivariate analyses such as that by Jolliffe, Everitt, et al., etc.

- The total volume of cargo (Ton_Total = G, ton)
- Average unit price of all transport modes (UP_All = B/G, 1,000 $/ton)
- Variation of the unit price of the commodity (The difference between the unit prices of sea and air transport) (UP_Diff = D/H - E/I, 1,000 $/ton)
- Containerized ratio (Ratio_Con = N/I)
- Share of air transport (Ratio_Air = D/(D+E+F))

The alphabet representing the Trade Concept of GI data (see Table 2).

The results of the principal component analysis and the first and second principal component scores are shown in

Table 3 and Figure 2. In the first principal component, the coefficient of the principal component scores of Ratio_Air, UP_All, and UP_Diff are high. This indicates that the higher score of the first principal component represents the higher unit price and larger share of air transport. In the second principal component, the coefficient of the principal component scores of Ratio_Con is high and of Ton_Total is large in a negative direction. This indicates that the higher score of the second principal component represents the higher containerized ratio and the lower cargo volume.

By performing cluster analysis using these principal component scores for each commodity, 77 commodities are classified into nine clusters as a result. Figure 3 is a diagram plotted by the first and second principle component scores (numbers in the figure indicate each commodity number) and Figure 4 shows a schematic relationship between each cluster (dendrogram). This indicates that nine clusters can be integrated into three groups; Bulk Cargo Group (CL 2, CL 1, and CL 5), Container Cargo Group (CL 4 and CL 3), and Air Cargo Group (CL 8, CL 7, CL 6, and CL 9). Table 4 summarizes each cluster's characteristic and its major commodities.

In the bulk cargo group, in which Crude oil, Coal, Row wood, etc. are included, the commodities classified into CL 2 have less amount of volume compared with CL 1 and CL 5. For the commodities of CL 2, some portions of their volume are transported as container cargo.

In the container cargo group, in which Chemical products, Synthetic resins, etc. are included, the commodities in CL 3 are relatively low unit price and small share of air transport, while the commodities in CL 4 have high value of UP_Diff and their share of air transport ranges from 10 to 20%. In these commodities, it is assumed that some competition on transport mode choice occurs between air and container.

In the air cargo group, in which Organic chemicals, Drugs and medicines, Semi conductors, etc. are included, CL 6 and CL 9 consist of only one commodity, Aircraft and Organic chemicals respectively. CL 7 and CL 8 consist of the commodities with high unit price and large share of air transport.

Table 3. Principal component analysis results (2003, total worldwide)

Components	Unique value	Contribution ratio (%)	Cumulative contribution ratio (%)
1	2.442	48.8	48.8
2	1.245	24.9	73.7
3	0.664	13.3	87.0
4	0.519	10.4	97.4
5	0.129	2.6	100

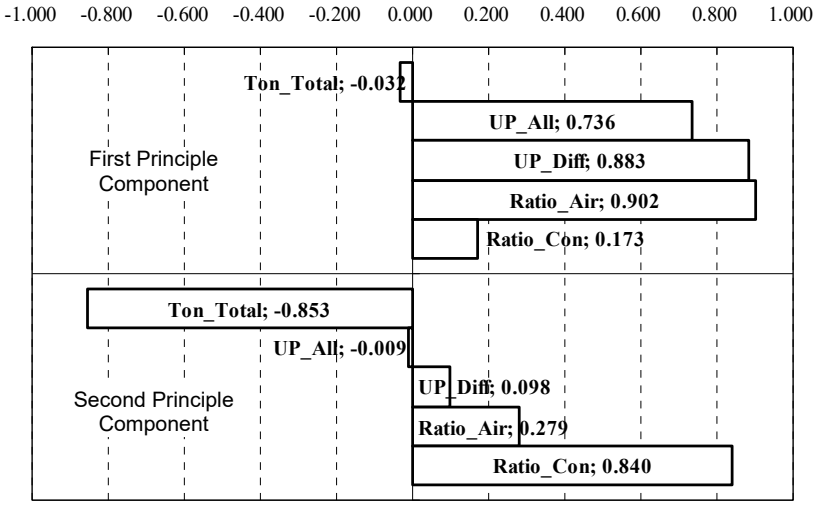

Figure 2. Coefficient of factors by principal component (2003, total worldwide)

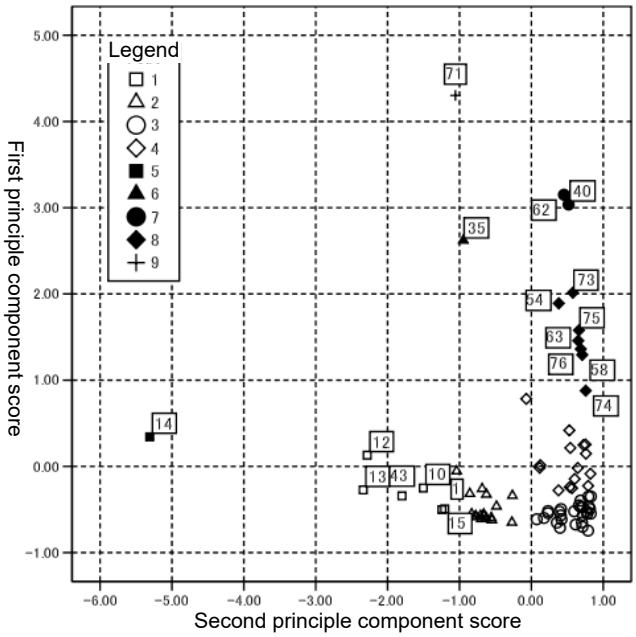

Figure 3. Principal component scores of each commodity by cluster (2003, total worldwide)

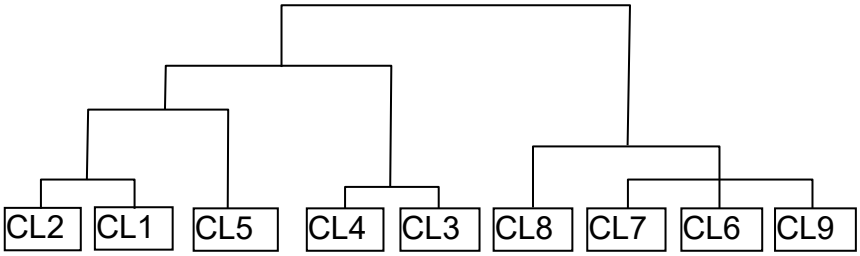

Figure 4. Dendrogram of each cluster (2003, total worldwide)

Table 4. The main characteristics of each cluster (2003, total worldwide)

Cluster		Features	Examples of commodities
Bulk cargo group	2	Low rate of container, low value	Fertilizer , Iron and steel , Auto completion , etc.
	1	Large amount of volume, mainly handled in bulk.	Coal , Cereal , etc.
	5	Large amount of volume, handled in bulk only	Crude oil
Container cargo group	4	Mainly handled in container, high value, large price difference, some handled by air	Chemical products, Electronic devices, Clothes, etc.
	3	Mainly handled in container, relatively low value	Synthetic resin, Paper, Auto parts, etc.
Air cargo group	8	High air ratio, high value	Computer, Electronic communication devices , etc.
	7	Mainly handled by air, higher value	Drugs and medicines, Semiconductor
	6	Large price differences, high air ratio	Organic chemicals
	9	Very high value	Aircraft

(2) COMPARISON WITH THE TRADITIONAL CLASSIFICATION

To confirm the difference between the traditional commodity classification and the classification proposed in this study, the classification of five categories (Agriculture, Mining, Household consumption products, Basic industrial materials, Processing and assembling) based on the traditional classification and the result of classification proposed in this study are compared (see Table 5). Many commodities categorized in the same category in the traditional classification are classified into different categories in the new classification. This implies that the commodities in the same industrial category have different characteristics of freight transport.

For instance, looking at the commodities classified as Agriculture in the traditional classification, some commodities are classified into the bulk or container cargo group in the new classification. The commodities in Basic industrial materials and Processing and assembling are classified into various cargo groups in the new classification. Among the commodities in Basic industrial materials, some commodities such as Non-metallic products and the Iron and steel are in the bulk cargo group and some commodities such as Organic chemicals and Drugs and medicines are in the air cargo group. Among the commodities in Processing and assembling, many commodities are classified into the container cargo group while Motor vehicles are classified into bulk cargo group.

Figure 5 shows the relationship between the share of air transport and unit price by commodity. The plot of each commodity is differentiated by the cluster to which it belongs. It is found that each cluster is so well-segmented that easy to decide its representative point, compared with the traditional commodity classification as exemplified in Figure 1.

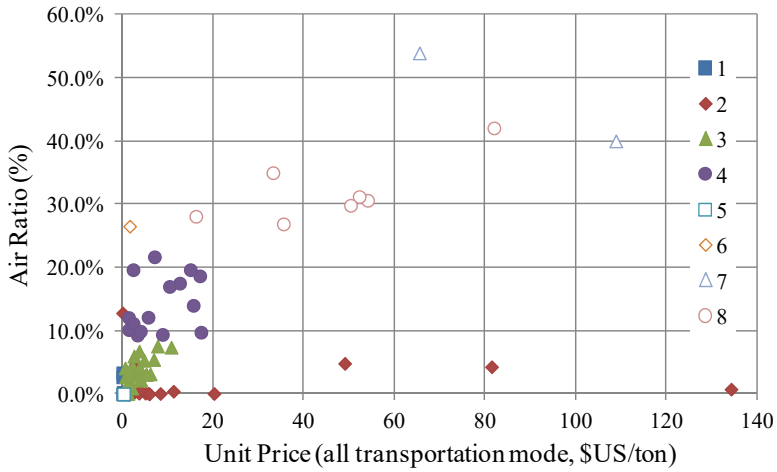

Figure 5. Relationship between share of air transport and unit price of each commodity shown by cluster (2003, total worldwide)

Table 5. Comparison between the traditional commodity classification (left) and the commodity classification proposed in this study (right) (2003, total worldwide)

Industrial Classification		Commodity	
1	Agriculture	1	Grain
		2	Oil Seeds
		3	Vegetables, Fruits and Eggs - req Refrigeration
		4	Vegetables and Fruits - non-Refrigerated
		5	Cork and Wood
		6	Natural Rubber
		7	Cotton
		9	Other Agriculture
		17	Meat/Dairy/Fish Requiring Refrigeration
		18	Other Meat/Dairy/Fish/Fruit/Vegetables
2	Mining	10	Stone, Clay and Other Crude Minerals
		12	Ores and Scrap
		13	Coal
		14	Crude Petroleum
		15	Natural Gas
		16	Scrap
		44	Briquettes and Coke
3	Household Consumption Products	8	Other Raw Textile Materials
		19	Sugar
		20	Animal Feed
		21	Animal and Vegetable Oils
		22	Other Food
		23	Beverages
		24	Tobacco
		25	Textiles
		26	Wearing Apparel
		27	Leather and Products
		28	Footwear
		29	Wood Products
		30	Furniture and Fixtures
		31	Waste Paper
		76	Other Manufacturing, nes.
4	Basic Industrial Materials	11	Crude Fertilizers
		32	Pulp
		33	Paper and Paperboard and Products
		34	Printing and Publishing
		35	Organic Chemicals
		36	Inorganic Chemicals
		37	Fertilizers and Pesticides
		38	Synthetic Resins
		39	Paints, Varnishes and Lacquers
		40	Drugs and Medicines
		41	Soap and Cleaning Preparations
		42	Chemical Products, nec.
		43	Petroleum Refineries
		45	Residual Petroleum Products
		46	Rubber Products
		47	Plastic Products, nec.
		48	Pottery, China etc.
		49	Glass and Products
		50	Non-Metallic Products, nec.
		51	Iron and Steel
		52	Non-Ferrous Metals
		53	Metal Products
5	Processing and Assembling	54	Engines and Turbines
		55	Agricultural Machinery
		56	Metal and Wood Working Machinery
		57	Special Industrial Machinery
		58	Office and Computing Machinery
		59	Machinery and Equipment, nec.
		60	Electrical Industrial Machinery
		61	Radio and TV
		62	Semi-conductors, Electronic Tubes,etc
		63	Other Communications Equipment
		64	Electrical Appliances and Houseware
		65	Electrical Apparatus, nec.
		66	Shipbuilding and Repairing
		67	Railroad Equipment
		68	Motor Vehicles
		69	Parts of Motor Vehicles
		70	Motorcycles and Bicycles
		71	Aircraft
		72	Transport Equipment, nec.
		73	Professional Equipment
		74	Photographic and Optical Goods
		75	Watches and Clocks
		77	Goods not classified by kind

Commodity		CL	Classified by commodity charactoristic
2	Oil Seeds	2	Bulky Cargo Group
5	Cork and Wood		
11	Crude Fertilizers		
16	Scrap		
19	Sugar		
20	Animal Feed		
21	Animal and Vegetable Oils		
32	Pulp		
36	Inorganic Chemicals		
37	Fertilizers and Pesticides		
44	Briquettes and Coke		
45	Residual Petroleum Products		
50	Non-Metallic Products, nec.		
51	Iron and Steel		
66	Shipbuilding and Repairing		
67	Railroad Equipment		
68	Motor Vehicles		
1	Grain	1	
10	Stone, Clay and Other Crude Minerals		
12	Ores and Scrap		
13	Coal		
15	Natural Gas		
43	Petroleum Refineries		
14	Crude Petroleum	5	
9	Other Agriculture	4	Container Cargo Group
26	Wearing Apparel		
34	Printing and Publishing		
41	Soap and Cleaning Preparations		
42	Chemical Products, nec.		
49	Glass and Products		
52	Non-Ferrous Metals		
53	Metal Products		
56	Metal and Wood Working Machinery		
57	Special Industrial Machinery		
59	Machinery and Equipment, nec.		
60	Electrical Industrial Machinery		
61	Radio and TV		
65	Electrical Apparatus, nec.		
77	Goods not classified by kind		
3	Vegetables, Fruits and Eggs - req Refrigeration	3	
4	Vegetables and Fruits - non-Refrigerated		
6	Natural Rubber		
7	Cotton		
8	Other Raw Textile Materials		
17	Meat/Dairy/Fish Requiring Refrigeration		
18	Other Meat/Dairy/Fish/Fruit/Vegetables		
22	Other Food		
23	Beverages		
24	Tobacco		
25	Textiles		
27	Leather and Products		
28	Footwear		
29	Wood Products		
30	Furniture and Fixtures		
31	Waste Paper		
33	Paper and Paperboard and Products		
38	Synthetic Resins		
39	Paints, Varnishes and Lacquers		
46	Rubber Products		
47	Plastic Products, nec.		
48	Pottery, China etc.		
55	Agricultural Machinery		
64	Electrical Appliances and Houseware		
69	Parts of Motor Vehicles		
70	Motorcycles and Bicycles		
72	Transport Equipment, nec.		
54	Engines and Turbines	8	Air Cargo Group
58	Office and Computing Machinery		
63	Other Communications Equipment		
73	Professional Equipment		
74	Photographic and Optical Goods		
75	Watches and Clocks		
76	Other Manufacturing, nes.		
40	Drugs and Medicines	7	
62	Semi-conductors, Electronic Tubes,etc		
35	Organic Chemicals	6	
71	Aircraft	9	

4.2 COMMODITY CLASSIFICATION USING THE DATA OVER THE YEARS (1998 - 2005)

Focusing on the time series variation of characteristics of freight transport for each commodity, the variables by commodity of the entire world over the years (1998, 2000, 2003, and 2005) is classified applying principal component analysis and cluster analysis, in the same manner as in section 4.1.

The result of principal component analysis is shown in Table 6 and the first and second principal component scores are shown in Figure 6. Figure 7 shows a plot of the cluster by each commodity on a surface of two principal component scores. Figure 8 shows a dendrogram of each cluster. The coefficients for principal component score and the characteristics of commodities represented by the first principal component and the second principal component are quite similar to those estimated by a single year analysis described in the previous section; only seven out of 77 commodities had changed their cluster over time.

The major commodities which had changed their cluster from 1998 to 2005 are as follows;

- Stone, clay and other crude minerals: changed from CL1 in 2003 to CL3 in 2005, although both clusters are included in the bulk cargo group.
- Radio and TV; changed from CL 2 in 2000 to CL 7 in 2003. CL2, CL 7, and CL 8 are included in the container cargo group. Among them, CL 7 and CL8 can be regarded as relatively large share of air transport and high unit price. Therefore, it can be said that Radio and TV has changed to the intermediate position between container cargo and air cargo. This is because its average unit price as well as the difference of unit price had become greater with the advent of high value-added TVs such as LCD and plasma TVs.
- Watches and clocks, and Other manufacturing, nes,; with the increase in their average unit price and the difference of unit price, they have changed from CL 8 in the container cargo group in 2003 to CL 6 in the air cargo group in 2005.

As described above, the unit price and transport mode choice behavior of a few commodities changed, resulting in the change of the cluster that they belong to; however, as a whole, in the recent 10 years the characteristics of freight transport have not significantly changed for most of commodities. The authors of course recognize that many commodities may change their characteristics of freight transport in future due to changes in the global economy and transport environment in the future.

Table 6. Results of principal component analysis (from 1998 to 2005, worldwide)

Components	Unique value	Contribution ratio (%)	Cumulative contribution ratio (%)
1	2.411	48.2	48.2
2	1.181	23.6	71.9
3	0.707	14.1	86.0
4	0.530	10.6	96.6
5	0.171	3.4	100.0

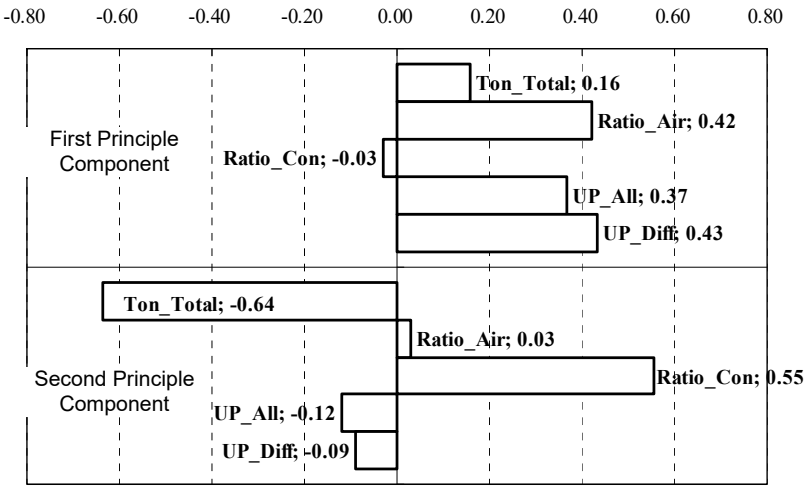

Figure 6. Coefficient of factors by principal component (from 1998 to 2005, worldwide)

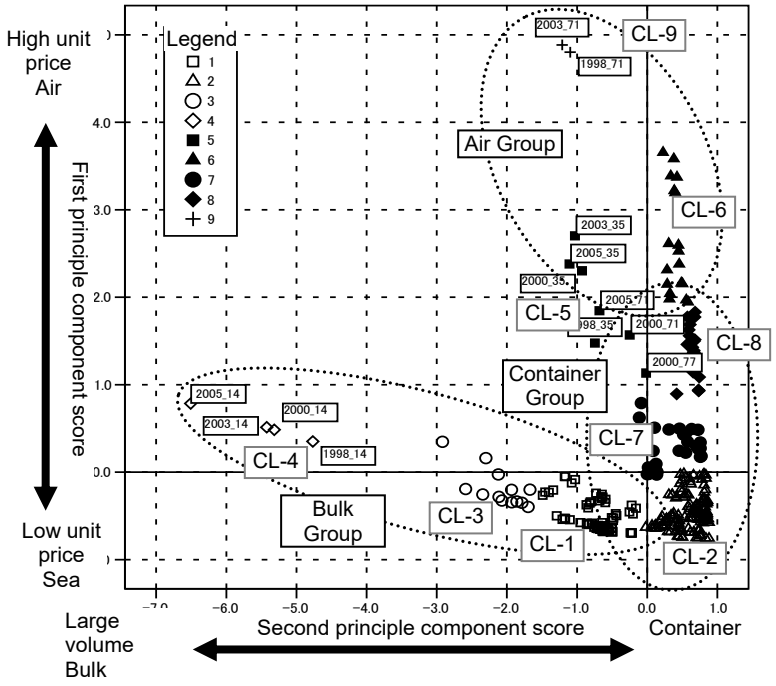

Figure 7. Principal component scores of each commodity by cluster (from 1998 to 2005, worldwide)

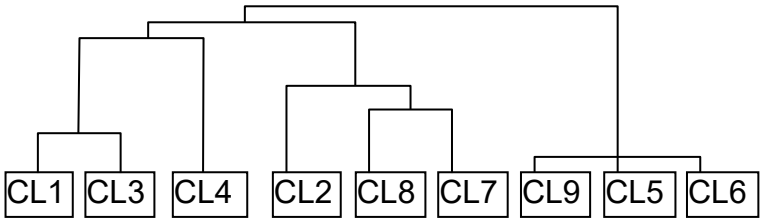

Figure 8. Dendrogram of each cluster (from 1998 to 2005, worldwide)

4.3 COMMODITY CLASSIFICATION USING REGIONAL DATA

Characteristics of freight transport of cargo such as transport mode choice and unit price are considered to vary among regions due to various reasons such as a composition of the commodity and transport distance. In this section, by dividing the world into three regions, i.e. Asia, North America, and Europe, the data by 77 commodities and 7 OD pairs (each pair of three regions and within Asia) in 2003 is classified by characteristics of freight transport, from the principle component analysis and cluster analysis shown in section 4.1 and 4.2.

The result of principal component analysis is shown in Table 7 and the first and second principal component scores are shown in Figure 9. Figure 10 shows a plot of the cluster by commodity on a surface of two principal component scores. Figure 11 is a dendrogram of each cluster. CL 5, CL 4, CL 1 and CL 2 are classified as the bulk cargo group, CL 3 and CL 6 are in the container cargo group, and CL 7, CL 9, CL 8, and CL 10 are in the air cargo group.

Table 8 shows a cluster of each commodity by OD pair. The table shows that the clusters to which most of the commodities belong are different with the different OD pairs. Commodities shaded in the table represent commodities whose cluster is consistent through all OD pairs. Of the total 77 commodities, 18 commodities remained in the same cluster by OD pair, out of which four commodities are classified in CL 2 (bulk cargo group) and 14 commodities in CL 3 (container cargo group). It is interpreted that these commodities do not change the characteristics of freight transport by region.

For other commodities, their clusters are different by OD pair. For these commodities, in the case of classification taking into account the characteristics of freight transport, it is needed to consider the origin and destination of cargo. It is particularly important to pay attention to the commodities of which the clusters vary widely by OD pair. These variations of commodities by region are considered mainly caused by the difference of composition of each commodity. In addition, the major reasons of the difference of mode choice of the commodity by region would be transport distance.

Hereinafter, detail analyses of the two commodities (i.e. Organic chemicals and Drugs and medicines) are shown as examples that the clusters vary by OD pair

Table 7. Principal component analysis results (by region, 2003)

Components	Unique value	Contribution ratio (%)	Cumulative contribution ratio (%)
1	2.196	43.9	43.9
2	1.242	24.8	68.8
3	.704	14.1	82.8
4	.548	11.0	93.8
5	.309	6.2	100.0

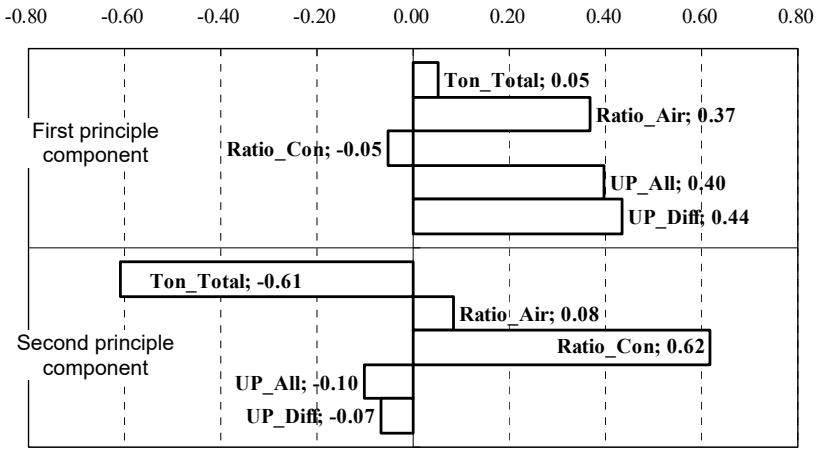

Figure 9. Coefficient of factors by principal component (by region, 2003)

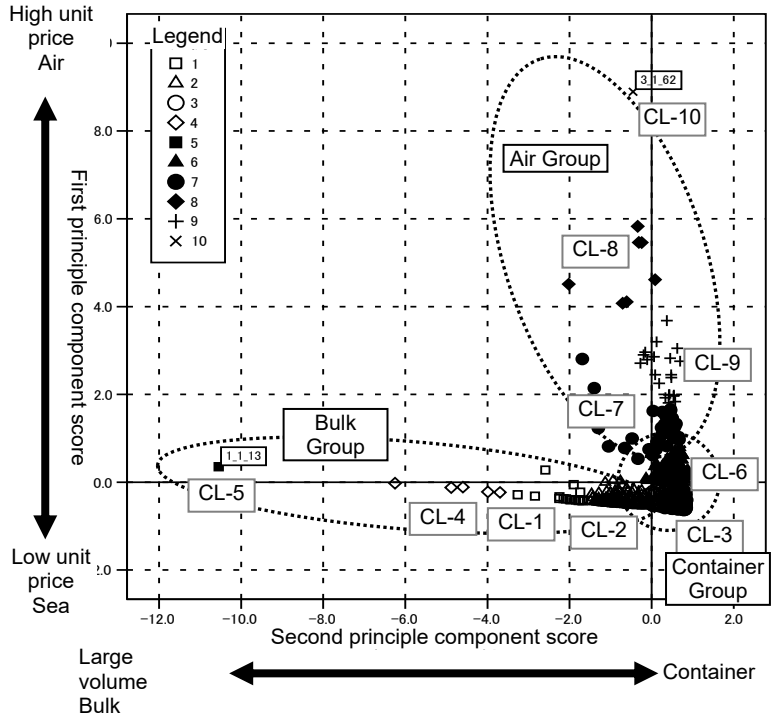

Figure 10. Principal component scores of each commodity by cluster (by region, 2003)

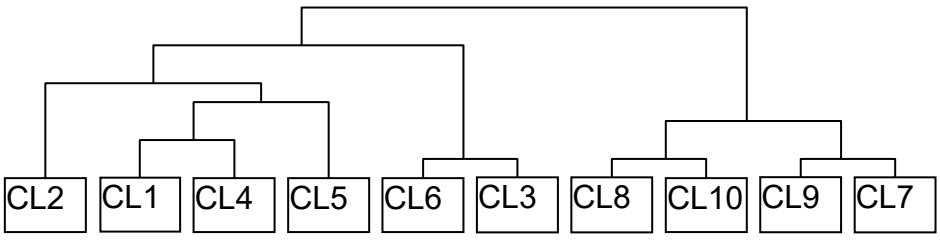

Figure 11. Dendrogram of each cluster (by region, 2003)

Table 8. The cluster of each commodity by OD pair (2003)

No	Commodity	From Asia			From NA		From Europe		Number of OD Pair of each cluster										Cluster distinction
		to Asia	to NA	to Europe	to Asia	to Europe	to Asia	to NA	5	4	1	2	3	6	7	9	8	10	
13	Coal	5	2	1	1	1	1	2	1	-	4	2	-	-	-	-	-	-	●
1	Grain	1	3	2	1	1	2	2	-	-	3	3	1	-	-	-	-	-	●
12	Ores and Scrap	1	2	7	2	1	2	6	-	-	2	3	-	1	1	-	-	-	●
14	Crude Petroleum	4	2	-	2	1	1	4	-	2	2	2	-	-	-	-	-	-	●
45	Residual Petroleum Products	2	2	2	2	1	2	2	-	-	1	6	-	-	-	-	-	-	●
15	Natural Gas	1	3	2	2	2	2	2	-	-	1	5	1	-	-	-	-	-	●
2	Oil Seeds	2	2	3	1	2	2	2	-	-	1	5	1	-	-	-	-	-	●
50	Non-Metallic Products, nec.	1	2	2	6	6	3	2	-	-	1	3	1	2	-	-	-	-	●
35	Organic Chemicals	1	9	7	2	7	7	8	-	-	1	1	-	-	3	1	1	-	●
16	**Scrap**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	**-**	
36	**Inorganic Chemicals**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	**-**	
66	**Shipbuilding and Repairing**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	**-**	
68	**Motor Vehicles**	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	**-**	
5	Cork and Wood	2	3	2	2	2	2	2	-	-	-	6	1	-	-	-	-	-	●
20	Animal Feed	2	3	2	2	2	2	2	-	-	-	6	1	-	-	-	-	-	●
21	Animal and Vegetable Oils	2	2	2	2	2	2	3	-	-	-	6	1	-	-	-	-	-	●
37	Fertilizers and Pesticides	2	2	3	2	2	2	2	-	-	-	6	1	-	-	-	-	-	●
44	Briquettes and Coke	2	2	2	3	2	2	2	-	-	-	6	1	-	-	-	-	-	●
10	Stone, Clay and Other Crude Minerals	4	2	2	2	2	2	2	-	1	-	6	-	-	-	-	-	-	●
11	Crude Fertilizers	2	3	2	2	3	2	2	-	-	-	5	2	-	-	-	-	-	●
19	Sugar	2	2	2	3	2	2	3	-	-	-	5	2	-	-	-	-	-	●
32	Pulp	2	3	3	2	2	2	2	-	-	-	5	2	-	-	-	-	-	●
67	Railroad Equipment	2	3	2	6	2	2	2	-	-	-	5	1	1	-	-	-	-	●
43	Petroleum Refineries	4	2	2	2	2	2	4	-	2	-	5	-	-	-	-	-	-	●
17	Meat/Dairy/Fish Requiring Refrigeration	2	3	3	2	2	3	3	-	-	-	3	4	-	-	-	-	-	●
31	Waste Paper	3	2	-	2	3	3	2	-	-	-	3	3	-	-	-	-	-	●
29	Wood Products	2	3	3	3	3	2	3	-	-	-	2	5	-	-	-	-	-	●
33	Paper and Paperboard and Products	3	3	3	3	2	3	2	-	-	-	2	5	-	-	-	-	-	●
55	Agricultural Machinery	3	3	3	3	2	3	2	-	-	-	2	5	-	-	-	-	-	●
38	Synthetic Resins	2	3	3	3	3	3	3	-	-	-	1	6	-	-	-	-	-	●
69	Parts of Motor Vehicles	3	3	3	3	3	3	2	-	-	-	1	6	-	-	-	-	-	●
4	Vegetables and Fruits - non-Refrigerated	3	3	2	3	3	3	6	-	-	-	1	5	1	-	-	-	-	●
6	Natural Rubber	3	2	3	3	6	3	3	-	-	-	1	5	1	-	-	-	-	●
3	**Vegetables, Fruits and Eggs - req Refrigeration**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
7	**Cotton**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
8	**Other Raw Textile Materials**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
18	**Other Meat/Dairy/Fish/Fruit/Vegetables**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
22	**Other Food**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
23	**Beverages**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
24	**Tobacco**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
25	**Textiles**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
30	**Furniture and Fixtures**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
39	**Paints, Varnishes and Lacquers**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
41	**Soap and Cleaning Preparations**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
46	**Rubber Products**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
48	**Pottery, China etc.**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
64	**Electrical Appliances and Houseware**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**7**	**-**	**-**	**-**	**-**	**-**	
27	Leather and Products	3	3	3	3	3	3	6	-	-	-	-	6	1	-	-	-	-	●
52	Non-Ferrous Metals	3	3	3	3	3	3	7	-	-	-	-	6	-	1	-	-	-	●
72	Transport Equipment, nec.	3	3	3	3	3	3	6	-	-	-	-	6	1	-	-	-	-	●
34	Printing and Publishing	3	3	3	6	6	3	3	-	-	-	-	5	2	-	-	-	-	●
47	Plastic Products, nec.	3	3	3	6	6	3	3	-	-	-	-	5	2	-	-	-	-	●
49	Glass and Products	3	3	3	6	6	3	3	-	-	-	-	5	2	-	-	-	-	●
53	Metal Products	3	3	3	6	6	3	3	-	-	-	-	5	2	-	-	-	-	●
9	Other Agriculture	3	3	3	6	6	3	6	-	-	-	-	4	3	-	-	-	-	●
26	Wearing Apparel	3	3	3	6	6	3	6	-	-	-	-	4	3	-	-	-	-	●
28	Footwear	3	3	3	7	6	3	6	-	-	-	-	4	2	1	-	-	-	●
59	Machinery and Equipment, nec.	3	3	3	6	6	3	6	-	-	-	-	4	3	-	-	-	-	●
65	Electrical Apparatus, nec.	3	3	3	7	7	3	6	-	-	-	-	4	1	2	-	-	-	●
70	Motorcycles and Bicycles	3	3	3	6	6	3	6	-	-	-	-	4	3	-	-	-	-	●
42	Chemical Products, nec.	3	7	3	6	6	3	6	-	-	-	-	3	3	1	-	-	-	●
56	Metal and Wood Working Machinery	3	6	3	7	7	3	6	-	-	-	-	3	2	2	-	-	-	●
57	Special Industrial Machinery	3	6	3	7	7	3	6	-	-	-	-	3	2	2	-	-	-	●
60	Electrical Industrial Machinery	3	6	3	7	7	3	7	-	-	-	-	3	1	3	-	-	-	●
61	Radio and TV	3	6	3	6	7	3	7	-	-	-	-	3	2	2	-	-	-	●
76	Other Manufacturing, nes.	3	3	3	7	9	6	9	-	-	-	-	3	1	1	2	-	-	●
40	Drugs and Medicines	3	9	6	7	9	6	9	-	-	-	-	1	2	1	3	-	-	●
54	Engines and Turbines	3	6	6	9	9	6	7	-	-	-	-	1	3	1	2	-	-	●
58	Office and Computing Machinery	6	7	3	9	9	6	9	-	-	-	-	1	2	1	3	-	-	●
74	Photographic and Optical Goods	6	6	3	7	7	6	7	-	-	-	-	1	3	3	-	-	-	●
77	Goods not classified by kind	6	7	6	7	7	3	7	-	-	-	-	1	2	4	-	-	-	●
73	Professional Equipment	6	6	6	9	9	6	9	-	-	-	-	-	4	-	3	-	-	●
75	Watches and Clocks	6	6	6	9	9	6	8	-	-	-	-	-	4	-	2	1	-	●
63	Other Communications Equipment	6	7	6	9	9	6	7	-	-	-	-	-	3	2	2	-	-	●
62	Semi-conductors, Electronic Tubes,etc	7	9	6	10	8	8	8	-	-	-	-	-	1	1	1	3	1	●
71	Aircraft	8	7	7	8	9	7	9	-	-	-	-	-	-	3	2	2	-	●

*Commodities shaded in this table indicate “no cluster difference among OD pairs”.

(1) ORGANIC CHEMICALS

Organic chemicals are classified into five clusters by OD pair. From Table 8, within Asia, it is classified into CL 1, while to Asia from North America into CL 2; both belong to the bulk cargo group. These classifications are assumed due to the large volume of cargo and small difference of unit price compared to the other OD pairs. In the other OD pairs, they are classified into CL 7, CL 8, and CL 9 which belong to the air cargo group. The reasons are the large difference of unit price and large share of air transport. This result means that the characteristics of freight transport vary widely by region, even for the same commodity.

Figure 12 shows a diagram plotted by the difference of unit price (UP_Diff) and share of air transport (Ratio_Air). Because average unit price of all transport modes by OD pair is rather small (less than 10,000 US$/t), the difference of unit price between transport mode is used in a horizontal axis. It is generally observed that a higher difference of unit price leads a larger share of air transport; however, the share of air transport from North America to Europe is relatively high (around 35%) but difference of unit price is almost the same as that within Asia.

According to a detailed commodity analysis (in HS 9 digit) of which the result is omitted due to the paper limitation, the main factor of transport mode choice in Organic chemicals is unit price. Therefore, the differences of freight transport characteristics by OD pairs are considered due to the variety of the detailed composition of the commodity by region.

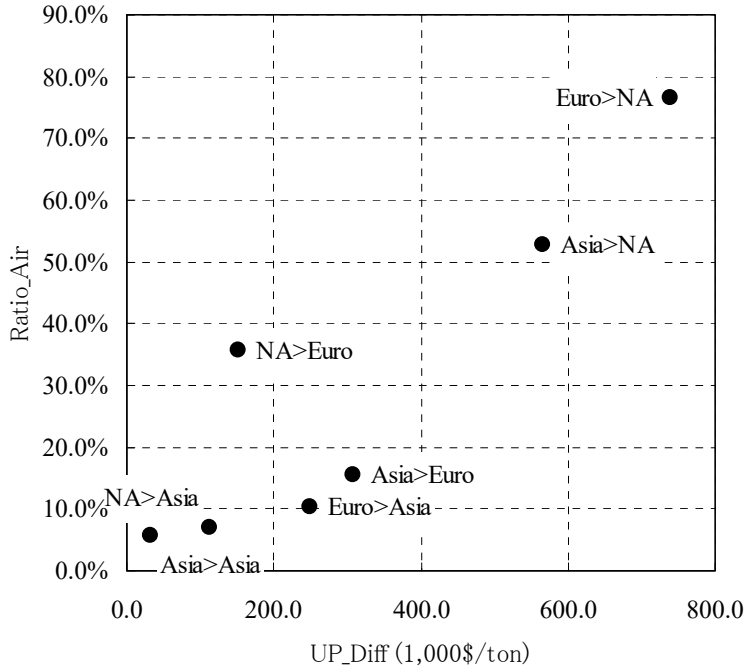

Figure 12. Diagram plotted by the difference of unit price (UP_Diff) and share of air transport (Ratio_Air) by each OD pair (Organic chemicals)

(2) DRUGS AND MEDICINES

Drugs and medicines are classified into four clusters by OD pair. Within Asia, it is classified into CL3, while between Asia and Europe (both directions) into CL6, both in the container cargo group. For other OD pairs, it is classified into the air cargo group, i.e., CL8, CL9, and CL7. Because the total volume of Drugs and medicines do not greatly differ among regions, the clusters to which such commodities belong depend on the differences in average unit price and the transport mode by OD pair.

Figure 13 shows a diagram plotted by cargo unit price (UP_All) and share of air transport (Ratio_Air) by each OD pair. Between Asia and North America, unit price and share of air transport in both directions are almost similar, while in between Asia and Europe, North America and Europe, share of air transport in both directions are similar but unit price are different. Focusing on the cargo from Asia, unit price are almost same among within Asia, to Europe, and to North America, while share of air transport are different among each direction; therefore, it can be said that for the transport mode choice in Drugs and medicines, there might be some factors other than unit price affecting the mode choice.
In general, Drugs and medicines are often transported by air transport because strict temperature control is required (e.g. in HS code 300210000; blood, vaccine, etc.). On the other hand, according to interviews with a logistics company, cargoes which do not require strict temperature control as a finished product are transported by maritime container shipping with reefer container. The reasons for the small share of air transport within Asia may be explained by the short distance compared to the cargo to North America and Europe, and the ease of quality control of the finished product.

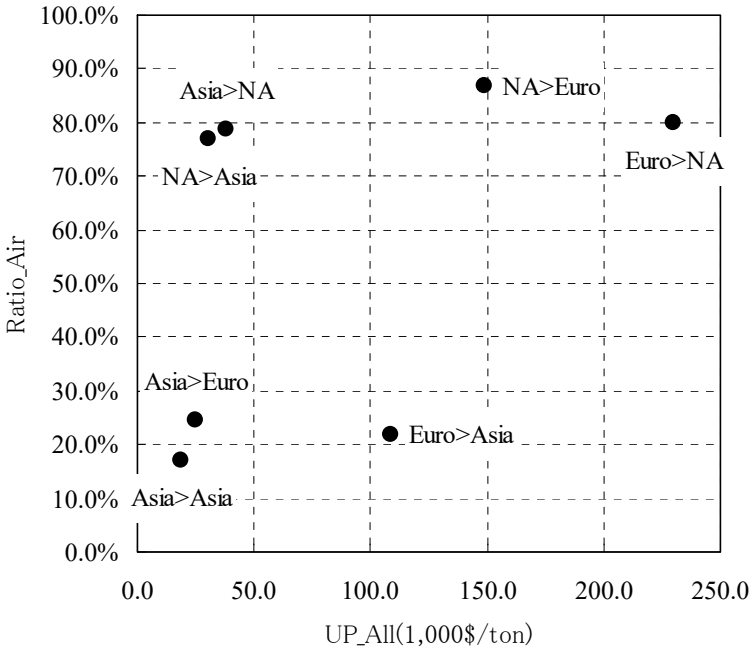

Figure 13. Diagram plotted by the difference of unit price (UP_Diff) and share of air transport (Ratio_Air) by each OD pair (Drugs and medicines)

5. CONCLUSION

This study shows an example of classification based on the characteristics of freight transport, applying the technique of multivariate analysis. There are few studies which try to classify the cargo based on the characteristics of freight transport.
This study reveals the following findings;

- The groups, that have been classified and aggregated based on the characteristics of freight transport, differ from the traditional classifications which are based on the industry and the characteristics of the material.
- The cluster that each commodity belongs to has not changed much chronologically in recent years (only seven out of 77 commodities had changed the cluster they belong to). In other words, the grouping the authors proposed is relatively consistent against

time change.

- On the other hand, the cluster that each commodity belongs to varies by origin and destination. The reason why the grouping is so inconsistent may be partly explained by the differences of detailed composition of each commodity by OD pair as in the case of Organic Chemicals, while partly explained by the differences of distance by OD pair as in the case of Drugs and Medicines.

The consistency of the classification over time implies that this new classification may be effective for time series analysis. At the same time, the exceptional results (e.g. Radio and TV as shown in Section 4.2) indicate which cargo should be focused on as examples that the characteristics of freight cargo has been changed in recent years. On the other hand, the inconsistency of the classification by OD pair implies that difference of region and distance are quite significant for the classification of commodity in terms of characteristics of freight cargo. This implication also seems reasonable because it indicates an importance of geographical (or regional) modeling of freight transportation including mode choice. Another implication from the classification analysis by OD pair is that more broken-down definition of commodity is needed. The 77 commodity categories in GI data are sometimes not sufficient for the purpose of understanding the characteristics of each cargo as shown in the analysis of Organic chemicals and Drugs and medicines in Section 4.3. However, there is no database covering the whole international freight transport in such detailed commodity categories as GI data; therefore, we need to carefully combine and use both the existing worldwide databases such as GI data and each country's statistics through a deep understanding of the characteristics of each database.

For future research from now on, the authors consider much detail analyses are needed, in order to grasp a relationship between features of cargo and freight transportation choice. One direction of detail analysis may be done by detail OD pair, not in a continental level as shown in this paper. This kind of analysis is possibly done by GI data since it is provided by more than 50 countries. Another direction of detail analysis may be done by detail commodity, by focusing on a specific country in which detail trade data is available such as Japan. At any rate, the authors believe that research on classification of commodity is significantly needed, although there are still quite few.

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