An Econometric Analysis of Paper Production
and Wastepaper in Japan

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Introduction

In 1990, total demand of industrial woods is about 112 million m^3 in Japan. Within this figure, 41 million m^3 is for pulp and chip. The rate of wood for pulp and chip is 37.0% in 1990. This rate has been increasing, namely 18.7% in 1965, 23.7% in 1970, 28.0% in 1975, 32.6% in 1980, 35.2% in 1985. Thus, the importance of wood for pulp and chip is increasing more and more. These woods become finally paper or paperboard. Although total demand has been almost unchangeable around 100 million m^3 for these 20 years in Japan, the consumption of paper and paperboard has been increased (Table 1). This is the basic reason why the rate of wood for pulp and chip has increased.

Recently, the environmental problem is one of the important social issues. As of paper and paperboard, the resource-saving or recycling of wastepaper is well discussed. The recycling problem is one of the topics discussed in the world congress called the Earth Summit held in Rio de Janeiro in June, 1992. In 1991, the law on the promotion of usage of renewable resources, called "recycling law", was put under enforcement in Japan. In this law, paper industry is pointed as specific industry that is related to this law. Generally in Japan, a garbage collection by local self-government body is free till now, but recently, several cities came to require the charge. Thus, the circumstances on paper and wastepaper are changing now.

In this paper, a statistical relationship on production of paper and paperboard since 1960 in Japan is analyzed. This paper is located as a sort of basic analysis aiming for future structuring of the econometric model of paper production including the recycling sector of wastepaper. Yuize and Yukutake[17], Nomura[12] and Forestry Agency[2] have made econometric analyses on paper and paperboard in Japan. Yoshida[16] is a unique researcher on the production function of wood-based industries including paper industry. However these models did not make enough analyses on wastepaper. In Nomura's model, wastepaper consumption is included. Kawanishi[7] showed the plot-type model including the market of wastepaper with pulp for intermediate market sector. In this paper, only the quantitative side is discussed. On the analysis on price mechanism, only a short discussion is going to be done at a relevant place.

This analysis consists of the following four chapters. First is on the consumption sector. The trends of the paper consumption are going to be discussed. Especially, the relationship between the paper consumption and GNP is analyzed statistically. Next is the relationship between the paper production and the consumption of materials. Third is the same analysis on paperboard. Fourth is the movement of collection and usage of wastepaper. In Japan, the collection-rate of wastepaper is almost 50% recently. Wastepaper is important not only for the resource-saving but also for the materials of paper and paperboard for the paper industry. Last, the statistical

Table 1.   Demand of timber classified by utilization

(1,000 m³)

Year	Total	Timber material				Fuelwood and wood for charcoal
		Sawlog	Pulp and chip	Plywood	Others	
1955	65,206	30,295	8,285	2,297	4,401	19,928
1960	71,467	37,789	10,189	3,178	5,391	14,920
1965	76,798	47,084	14,335	5,187	3,924	6,268
1970	105,027	62,009	24,887	13,059	2,724	2,348
1975	97,501	55,341	27,298	11,173	2,557	1,132
1980	110,164	56,713	35,868	12,840	3,543	1,200
1985	93,473	44,539	32,915	11,217	4,230	572
1990	111,677	53,887	41,344	14,516	1,383	517

Source: Ministry of Agriculture, Forestry and Fisheries, "Report on demand and supply of timber".
Note: Excluding log bedding for shiitake mushrooms.   Through 1959, excluding waste wood in forest
      land.

characteristics of the paper industry and the problems that have to be noticed in the construction of an econometric model are discussed.

Method

This analysis is focused on the statistical aspect of the production on paper and paperboard. As this paper does not deal with the price sector, a single-equation model is used as an econometric analysis. The application for simultaneous equation model will be discussed in future paper. The ordinary least squares method (OLS) is used for the evaluation of the coefficient of the equations. As this paper is a basic analysis in the construction of the further model, the number of variables used in this paper is less and limited, and the dummy variable is not used except in one equation.

In the respective equations, the figure that is shown in the parenthesis below the coefficient for each explanatory variable is t-statistics of the coefficient. R^2 means the coefficient of determination adjusted for the degree of freedom. DW means the Durbin-Watson ratio. DW ratio of all equations calculated in this paper is less than 2, and in case of most of the equations, it is less than 1, namely, it means the existence of positive serial correlation in random error. One of the reasons is that the price variables are all omitted and only the basic quantitative variables are adopted as the explanatory variable in this analysis. In addition, all the equations are linear form. As this analysis is extended to the period of 30 years, the usage of the log-linear form will improve this ratio. So, DW ratio is shown only as a reference in Note 1.

All variables used in this paper are listed in Table 2. The source of data is Ministry of International Trade and Industry[10] except GNP. All data are annual, and the research period is 1960–1990. The abridgment variable names listed in this table are used instead of variable names in all equations. And these abridgement names are also used sometimes in sentences. When the other variables not listed in this table are necessary, the explanations of abridgement names are written after the equation. The quantitative unit of ton and "t" used in this paper means metric ton.

Table 2. Variable list

Abridgment name	Variable name
GNP	Gross National Product (1985 real base)
Y1	Production of paper
Y2	Production of paperboard
SP	Domestic supply of paper and paperboard
CP	Collection of paper and paperboard
PD1	Domestic pulp as material for paper production
PI1	Imported pulp as material for paper production
WP1	Wastepaper as material for paper production
PD2	Domestic pulp as material for paperboard production
PI2	Imported pulp as material for paperboard production
WP2	Wastepaper as material for paperboard production

Note: Unit is 1,000 ton excluding GNP (billion yen).

Production of Paper and Paperboard

1. Movement of production and related indicator

Table 3 shows the indexes on production of paper and paperboard with the related indicators. The quantity of production of paper and paperboard is 28 thousands ton in 1990, this is over 6 times as of 30 years ago. With this production quantity, Japan is the second largest country next to U.S.A. (72 thousands ton). The share of production of Japan in the world is 11.8% (U.S.A. is 30%).

Paper industry is one of the most important industries in Japan. The shipment value is 8,461 billion yen in 1989, and this value is 2.8% of total shipment value of all industries. Paper industry is 12th highest shipment value industry within 22 industrial classifications. The number of all the

Table 3. Production and consumption

(1,000 t)

Year	Production			Consumption[1]	Population (1,000)	Consumption per population (Kg)	GNP[2] (billion yen)
	Total	Paper	Paperboard				
1955	2,204	1,613	590	2,126	89,276	23.8	25,082
1960	4,513	2,868	1,645	4,345	93,419	46.5	38,030
1965	7,299	4,219	3,079	7,085	98,275	72.1	102,010
1970	12,973	7,135	5,838	12,567	104,665	120.1	173,029
1975	13,601	7,711	5,890	13,054	111,940	116.6	215,632
1980	18,088	10,536	7,552	17,859	117,060	152.6	268,818
1985	20,469	11,790	8,679	20,253	121,049	167.3	323,959
1990	28,086	16,429	11,657	28,191	123,680	227.9	409,215

Source: Ministry of International Trade and Industry, "Yearbook of paper and pulp statistics", 1990ed., p. 31–32, p. 224., Economic Planning Agency, "Economic survey (Keizai youran)", every year ed.

[1] Consumption = Production + Import − Export.
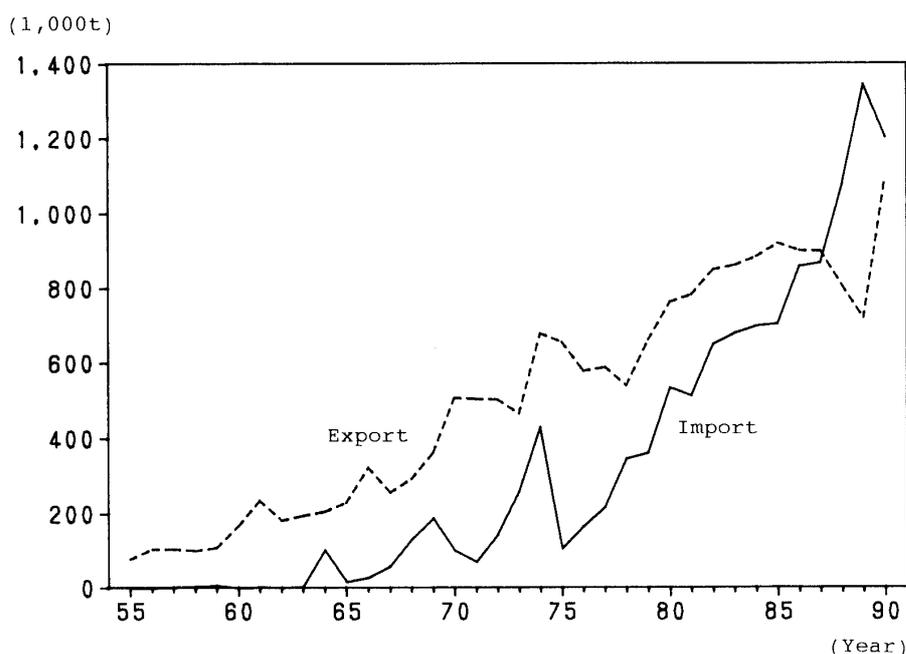
[2] 1985 real basis.

(1,000t)

Fig. 1.   Import and export of paper and paperboard.
Source: Ministry of International Trade and Industry, "Year-
           book of paper and pulp statistics", 1990ed., p. 224
           (1990).
Note: Customs clearance.

emloyees of paper industry is 282,000 persons.

The rate of trade[11] quantity on paper and paperboard in production quantity is low, namely less than 5%. However, both import quantity and export quantity tend to increase. The export quantity has been larger than the import quantity till 1986, but the import quantity has been raised and become almost equal to the export quantity in 1987. Recently, the import quantity is larger than the export quantity (Fig. 1). The main importing countries[11] from Japan in 1991 are Asian countries, namely Hong Kong (31%), China (11%), Shingapore (10%), South Korea (8%) and Taiwan (8%). Coat-paper and paperprint of higher quality are the important exporting commodities. On the other hand, the main exporting countries[11] to Japan in 1991 are U.S.A. (46%), Canada (19%), Finland (16%) and Taiwan (7%). Newsprint is the main commodity to export to Japan. Recently, trade problem on paper has occurred between Japan and U.S.A. (Note 2).

The movement of total consumption of paper and paperboard is almost equal to that of production. This is because, as import quantity and export quantity are almost equal, the quantity of consumption is almost equal to the quantity of production. By Japan Paper Association[5], the consumption of paper in 1990 classified by commodities is as follows: newsprint is 3,639,000 ton, paperprint and writing paper is 7,790,000 ton, paper for various information-machines (computer, copying machine and so on) is 1,508,000 ton. The consumption of the latter two categories has increased for these 10 years.

Generally, the degree of consumption of paper and paperboard is called "barometer of culture". The factor that increases the consumption of paper and paperboard is related to many activities, for example, increase of economic growth, increase of publication, increase of advertisement and so on. As shown in Table 3, the consumption quantity per population has increased continuously. Though this quantity was only 23.8 kg in 1955, it became 227.9 kg in 1990. This

figure is third biggest in the world, being next to U.S.A. (311.4 kg) and Sweden (230.7 kg).

2. Equations on production

The production of paper and paperboard is explained by GNP as the equations (1-1) and (1-2), respectively.

$$Y1 = 1228 + 0.0338 \text{ GNP} \qquad (R^2 = 0.974) \tag{1-1}$$
$$ (5.1) \quad (33.3)$$

$$Y2 = 1182 + 0.0241 \text{ GNP} \qquad (R^2 = 0.955) \tag{1-2}$$
$$ (5.2) \quad (25.2)$$

Both of the paper production and the paperboard production are well explained by GNP. In case of paper production, the quantity is almost horizontal during the period 1973-1981, but this period is corresponding to the low economic-growth period.

Japan Paper Association[5] estimated the relationship between consumption and GNP as equation (1-3) and (1-4) for the period 1981-1991 and for the period 1986-1991, respectively.

$$\text{Log } Y = 1.3543 \text{ Log GNP} - 3.1439 \qquad (R = 0.995) \tag{1-3}$$

$$\text{Log } Y = 1.3542 \text{ Log GNP} - 3.0927 \qquad (R = 0.983) \tag{1-4}$$

Y: domestic demand of paper and paperboard

The demand elasticity for GNP is 1.35, and is over 1. Namely, the increase rate of demand is over the increase of economic growth for these 10 years. As a reason of this recent increase in paper demand, the increase of paper demand for information-machines is important. Judged by investigations on the domestic demand per GNP (Japan Paper Association[5]), the figures in case of paperprint and paper for information-machines have increased. Japan Paper Association[4] estimated the same relationship for the period 1985-1990 as equation (1-5).

$$\text{Log } Y = 1.5284 \text{ Log GNP} - 4.1092 \qquad (R = 0.994) \tag{1-5}$$

Here, Y means the same as equation (1-3). As it changed only a year, the demand elasticity for GNP is different considerably. Forestry Agency[2] estimated the same relationship as equation (1-6) for the period 1970-1984. This equation is of the same fashion as equation (1-3).

$$\text{Log } Y = 0.6829 \text{ Log GNP} + 0.62986 \qquad (R = 0.950) \tag{1-6}$$

The demand elasticity for GNP is less than 1. This figure seems to be not stable. These results suggest that more detailed study is necessary on demand function.

Production and Materials

1. Paper

The materials of paper and paperboard production are divided into domestic pulp, imported pulp, wastepaper pulp and wastepaper (Fig. 2). As the proportion of wastepaper pulp is small, it is negligible and is omitted in this analysis. This movement is different from each other as it is between the case of paper and in that of paperboard. As easily understandable, in case of paper production, equation (2-1) is concluded between the quantity of production and quantity of consumption of materials.

$$Y1 = -97.96 + 0.9506 \ PD1 + 1.487 \ PI1 + 0.8775 \ WP1 \qquad (R^2 = 0.998) \qquad\qquad (2\text{-}1)$$
$$(-0.5) \quad (22.2) \qquad\quad (4.8) \qquad (4.7)$$

In terms of technical view, generally, the coefficient of wastepaper may be larger than that of pulp (Note 3). Nomura[12] used the same type of function for the determination of paper production (Note 4). As only the quantitative variables are dealt with in this paper, the substitutional relationship including the price mechanism is unable to be discussed. For the respective materials, equations of (2-2), (2-3) and (2-4) are resulted. And the movement of consumed quantity of each material is shown in Fig. 3.

$$PD1 = 1946 + 0.4840 \ Y1 \qquad (R^2 = 0.940) \qquad\qquad (2\text{-}2)$$
$$(9.3) \quad (21.3)$$

$$PI1 = -709.5 + 0.1923 \ Y1 \qquad (R^2 = 0.959) \qquad\qquad (2\text{-}3)$$
$$(-10.4) \quad (26.0)$$

$$WP1 = -2636 + 0.2147 \ Y1 + 5763 \ CP/SP \ (R^2 = 0.963) \qquad\qquad (2\text{-}4)$$
$$(-6.1) \quad (10.9) \qquad\quad (4.4)$$

As shown in equations (2-2) and (2-3), the quantity of consumption of domestic pulp and imported pulp is mainly explained by the quantity of paper production. In equation (2-2), the period when the rate of the least squares residual to observation is within 10–20% is 1960–1964 and 1971–1973. And in case of equation (2-3), the period when the same rate is over 20% is 1960–1966 and 1970–1977. This model does not seem to be fitted for the data before 1977. The import quantity of pulp has been increasing gradually as shown in Fig. 2. During the period 1973–1981, the growth-rate of domestic pulp is low and that of imported one is high. In future study, this change has to be clarified by using price variables. This residual could be deduced by using
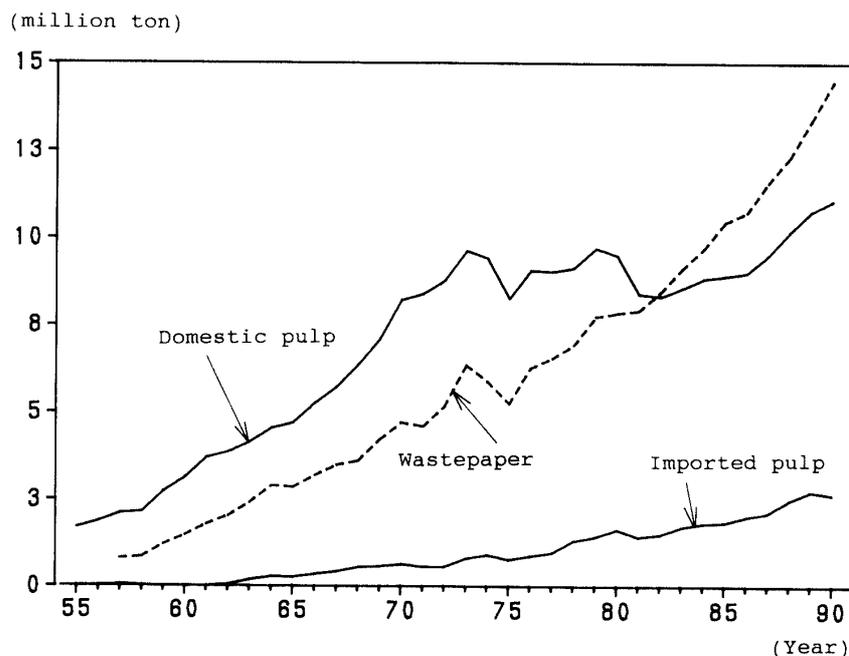

Fig. 2.   Materials of paper and paperboard.
Source: Ministry of International Trade and Industry,
          "Yearbook of paper and pulp statistics", 1955–
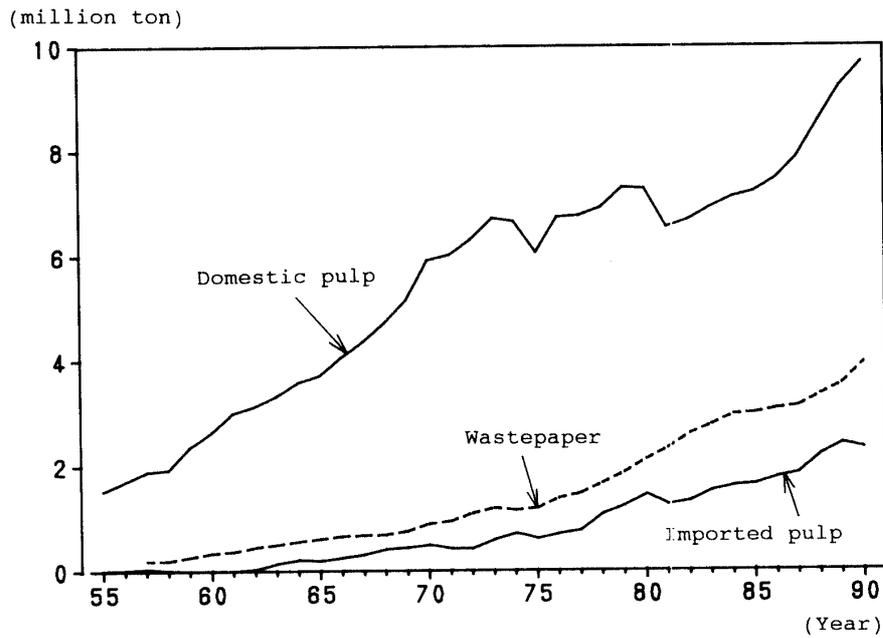   1990eds.

(million ton)

Fig. 3.   Materials of paper.
Source: See Fig. 2.

something like dummy variables.

In case of wastepaper, as shown in equation (2-4), it is necessary to add a variable like trend or dummy. The consumption of wastepaper has increased comparing to that of pulp. In this basic research, the collection-rate of wastepaper (CP/SP) is adopted as an explanatory variable. The rate of least squares residual to observation is often over 10% before 1979. In 1960–1962, 1970, 1974 and 1979, this rate is over 20%.
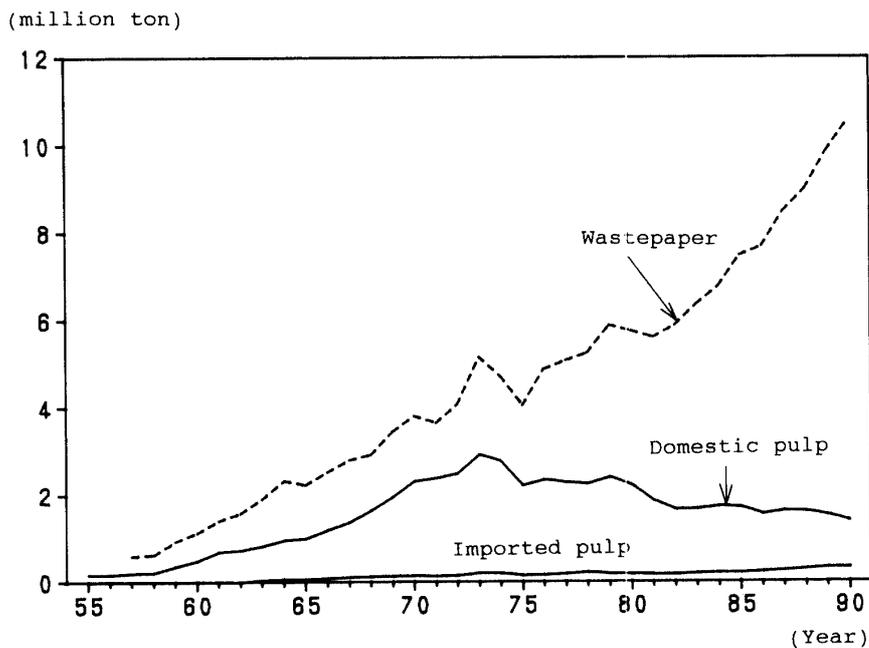
(million ton)

Fig. 4.   Materials of paperboard.
Source: See Fig. 2.

2. Paperboard

Also for paperboard, the same analysis as for paper is tried. The result is equation (3-1). The problem of coefficient of equation (3-1) is like that in case of equation (2-1).

$$Y2 = 161.2 + 0.8067 \ PD2 + 2.8423 \ PI2 + 0.8823 \ WP2 \qquad (R^2 = 0.999) \tag{3-1}$$
$$(2.6) \quad (20.5) \qquad (3.0) \qquad (30.3)$$

The movement of consumed quantity of each material is shown in Fig. 4. For each material, equations (3-2), (3-3) and (3-4) are calculated.

$$PD2 = -5.649 + 1.083 \ Y2 - 1.047 \ WP2 \qquad (R^2 = 0.975) \tag{3-2}$$
$$(0.1) \quad (31.5) \quad (-28.7)$$

$$PI2 = -40.35 + 0.032 \ Y2 \qquad (R^2 = 0.970) \tag{3-3}$$
$$(-5.7) \quad (30.5)$$

$$WP2 = 256.4 + 0.7140 \ CP \qquad (R^2 = 0.992) \tag{3-4}$$
$$(2.9) \quad (58.6)$$

In case of domestic pulp, consumed quantity of wastepaper is added to explanatory variable, as shown in equation (3-2). Judging from the sign of coefficient of WP2, the increase of wastepaper consumption results in the decrease of consumption of domestic pulp. In case of paper, this relationship is not observed. The rate of least squares residual to observation is over 10% in 1960, 1983-1984 and 1989-1990. Recently, the estimated result tends to be over the observed ones. As shown in Fig. 4, the domestic pulp has been decreasing since 1973. Recently, the wastepaper consumption is much more than the consumption of the domestic pulp.

The consumption quantity of the imported pulp has been quite less than the consumption of wastepaper and domestic pulp. Equation (3-3) shows that this consumption may partially be explained by production of paperboard. The residual is large before 1968, but this equation is almost fitted recently.

In case of wastepaper consumption, the explanatory variable is the quantity of wastepaper collection. The quantity of production is not selected as an explanatory variable. This result is comparable to that of paper.

Wastepaper Recycling

1. Abstract of wastepaper recycling in Japan

Total quantity of waste products from industry and household has been increasing since around 1985, especially in urban area, for example, a sepcial ward in Tokyo (Note 5). One of the reasons that have increased waste products lies in the increase of wastepaper. As already shown, the consumption of paper has been increasing gradually. Recently, various information-machines have been introduced for the office-automation. In the research on the actual condition of Tokyo Metropolis in 1989 fiscal year, the share of paper and related products is 40.3% of all the waste products. As calorific value is high in case of wastepaper, the increase of wastepaper raises the burden to incinerator. Recycling law was enforced under the above circumstances. Furthermore, several local self-governing bodies began to charge for the collection of waste goods dumped by all persons and companies including households (Note 6).

Owing to the fact that the consumption of paper and paperboard has increased for these 30

years as shown in Table 3, the wastepaper has also increased from the very nature of things. During the high growth period of economy, the demand for wastepaper has made a basis. Oil crisis occurred in 1973, it raised the cost of oil. Log price has also increased in around 1973 and 1980. Price of chip has increased, too. In addition, after the oil crisis in 1973, the economic growth-rate has decreased, and the paper industry is in depression. The usage of wastepaper was a key of the decreasing method of the cost. As the commodities made from wastepaper were dealt as second-classed ones at that time, paper companies often write clearly "we can not use wastepaper at all" on their commodities.

Recently, the environmental problems are discussed widely, for example, "1 to of wastepaper save 20 of standing tree (average diameter=14 cm, average height=8 m)". Wood-based industries including paper industry have often become a target by environmental activities because of the use of forest resources. Carrying their logic to extreme, they say that the paper industry cuts the green-resources including tropical forests and in the end brings the waste products in urban area. For the requirement from environmental problems, the use of wastepaper becomes more important. Recently, paper companies come to write "We use wastepaper" on their commodities, including an advertisement that the companies are cooperated in solving the environmental problems. This change means clearly the recent circumstances surrounding the paper companies.

The collection-rate of wastepaper remains almost 50% recently as shown in Fig. 5. As the consumption of paper and paperboard has increased, the quantity of collection of wastepaper has also increased at the same degree. Japan is one of the countries achieving the high collection-rate of wastepaper (Note 7). Japan Paper Association made a plan called "recycle 55 plan". The main object of this plan is to increase this rate from 50% to 55% by 1995. To realize this plan, the additive usage of wastepaper has to be promoted, especially in the field of the paper production that is still in low use-rate.
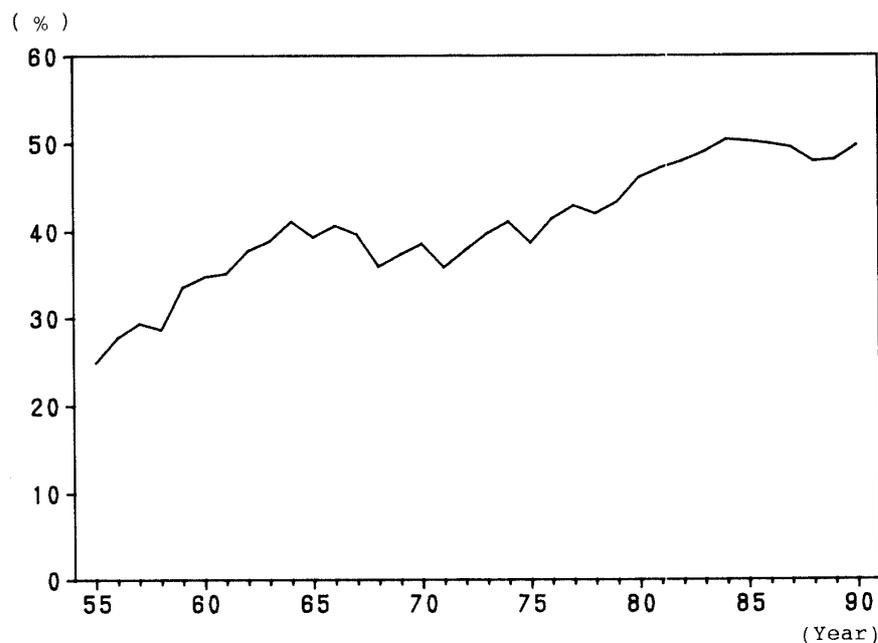

Fig. 5. Collection-rate of wastepaper.
Source: See Fig. 2.
Note: Rate equals the proportion of collection of
         waste paper to supply-quantity of paper and
         paperboard.

According to the Japan Paper Association[5], the system of the collection of wastepaper is as follows. In case of household, collection by various groups, for example, elementary school, children's association, town association and so on, and the existence of the system that trades wastepaper in substitution for toilet paper or tissue paper are important. The latter system is a characteristic system in Japan. This business is called "toilet-paper-exchange". Recently, this business is in a tight place by several reasons. As this business is rather labor-intensive, labor-shortage becomes main problem. The same labor-shortage occurs in the field of many physical works in Japan. The space for the stock of wastepaper tends to become difficult to maintain because of a raise in value of land price, especially in urban area. In addition, the price of wastepaper is sluggish. Thus, discontinuance of the business is being brought about one after another. In case of wholesale district, collectors turn around. In case of small-scale source of wastepaper, for example, small shopping district, building, railways station, markets and so on, the specific purchasers come and go around the source of wastepaper. In case of large-scale source of wastepaper, for example, corrugated cardboard factory, paper-ware factory, printing factory, bookbinding factory, publication company, newspaper publisher, department store, supermarket and so on, final dealers that ship wastepaper to paper company or the dealers that ship to final dealer collect directly. On account of almost the same reason applicable to the business called "toilet-paper-exchange", the recycling system has many problems.

Though the quantity is still less, export and import of wastepaper exist. Wastepaper is mainly imported from U.S.A. The imported wastepaper form U.S.A. has higher quality than the domestic wastepaper. It is also pointed out that the import of wastepaper of high quality is necessary for the maintenance of wastepaper quality. Generally speaking, the increase of collection-rate results in the decrease of quality. The change of exchange-rate has a possibility to reflect the wastepaper trade, but the total evaluation is not clear till now.

2. Equations on wastepaper

In this paragraph, the basic relationships betwen the collection quantity of wastepaper and all domestic supply of paper and paperboard are going to be discussed. Domestic supply of paper is approximately to be explained by GNP as equation (4-1). This is the same result of equation (1-1) or (1-2).

$$SP = 1963 + 0.0585 \text{ GNP} \qquad (R^2 = 0.970) \tag{4-1}$$
$$\quad (4.3) \quad (30.4)$$

The relation between the supply of paper and wastepaper is estimated as equation (4-2) or (4-3). As shown in Fig. 5, the collection rate is around 40% from the mid-1960's to the mid-1970's. As the rate of the least squares residual to observation is large during the first half of the whole researching period in equation (4-3), dummy variable (1960-1978=1, 1979-1990=0) is added in equation (4-4).

$$CP = -1308 + 0.5387 \text{ SP} \qquad (R^2 = 0.975) \tag{4-2}$$
$$\quad (-5.2) \quad (33.6)$$

$$CP = 895.4 + 0.4496 \text{ SP} - 1485 \text{ DUMMY} \qquad (R^2 = 0.992) \tag{4-3}$$
$$\quad (2.9) \quad (31.1) \qquad (7.9)$$

When the collection-rate (CP/SP) is dealt with as dependent variable, CP/SP is explained by time factor (T: year minus 1900) and dummy variable (1960-1978=1, 1979-1990=0), as shown in

equation (4-4).

$$CP/SP = 0.3167 + 0.0021\ T - 0.0713\ DUMMY \qquad (R^2 = 0.881) \qquad (4\text{-}4)$$
$$(5.0) \quad (2.8) \qquad (5.2)$$

From equation (4-4), trend factor is 0.2% annually, and dummy factor is 7.1%. As discussed in the previous paragraph, during the second half of the 1970's, several important changes have occurred in paper industry and in the market of materials. This factor may be reflected in this dummy factor. The estimation that includes the various economic indicators and price movements has to be discussed for more detailed research.

Discussion

In this paper, the statistical analysis on paper production is discussed, especially from the quantitative aspect. The problems and future possibilities of these equations are going to be discussed in this chapter.

The domestic demand for paper and paperboard is approximately explained by GNP. The same result has been pointed out by Japan Paper Association[5], Forestry Agency[2] and the other analysis. Only to know the total amount of paper consumption, GNP is the most useful indicator, but the demand elasticity for GNP is not always stable. By dividing GNP into several divisions and adopting these divided GNP values as explanatory variable, more stabel relationship will be realized. Kawanishi[6] estimated this relationship for the respective commodities separately for the period 1960-1979. By these results, the elasticity is different for the respective commodities (Note 8). Classification of paper like this will also contribute to the calculation of a more stable result. The prediction of domestic consumption of paper and paperboard is also important, in this sense, the indexes on business trend have to be studied. Business survey data, for example, BSI by Japan Paper Association, are also important (Note 9). In this analysis, annual data are used. However, for the short-term prediction, at least quarter-base data will be required. Yuize and Yukutake[17] used quarter-base data (Note 10).

An equation like (1-3) has been used for most of the analyses, but William and Nishizawa[15] estimated the demand for paper from the view point of the theory of consumer behavior during the period 1965-1981. Both-logarithm demand function is used in their analysis, and the exaplanatory variables are the price factor and the revenue factor. As of the latter, the sales amounts of all paper-related enterprises are used. The elasticity of sales is stable, but that of price is not constant. Recently, price structure has changed, for example, a movement of exchange-rate (Matsushita[9]). In this sense, the estimation including such price sector is also important.

In this paper, the relationship between production and materials is explained by the equations (2-1) and (3-1). However, more detailed equations are necessary on the materials input to production of paper and paperboard. Göttsching[3] shows the next equation concerning the lifetime of wastepaper.

$$TFI = (1-a)V + (a-a^2)C_1 + \cdots + (a^n - a^{n+1})C_n + \cdots \qquad (5\text{-}1)$$

Where: TFI = total fiber input

        a = wastepaper utilization rate $(0 \leq a \leq 1)$

        V = virgin pulp

        C_1 = wastepaper of first cycle

        C_2 = wastepaper of second cycle

C_n = wastepaper of nth cycle

In equations (2-1) and (3-1), WP1 and WP2 means all the wastepaper that is shown in the second and the latter member in equation (5-1), in another word, total of wastepaper that has another age. However, it is impossible to know the actual quantity of wastepaper classified by age-class. As Göttsching commented on Japan, export and import of both of paper and wastepaper are less than 5%, so this condition (5-1) is almost fulfilled. This is one of the reasons why the coefficient of determination is high as over 0.99 in equations (2-1) and (3-1). In the sense that the recycling is not done only once, it is also necessary for more study to add the variables that have time-lag, because paper and paperboard supplied in the previous year, two years ago, three years ago and so on will reflect the quantity of wastepaper used for the materials for the production of paper and paperboard.

In this paper, paper production and paperboard production are estimated separately. The equations on both sectors are almost the same structure, but there are several different points existed. In case of paper, domestic pulp consumption is explained by paper production. Wastepaper consumption is not selected as an explanatory variable of domestic pulp consumption. However, in case of paperboard, wastepaper consumption is selected as an exaplanatory variable, and the sign of coefficient is negative. Namely, the increase of wastepaper consumption leads to the decrease of domestic pulp consumption. The use-rate of wastepaper is 52.5% in 1991 for paper and paperboard, but as considered separately, it is 26.0% for paper and is 86.1% for paperboard. The increase of usage of wastepaper will now is mainly caused by the development of use-rate in the field of paperboard production. Thus, a relationship between domestic pulp consumption and wastepaper consumption is observed by the same equation (3-2). On the other hand, in case of paper production, the use of wastepaper has been advanced, but this increaing movement has not reached the clear decrease of consumption of domestic and imported pulp. Of course, price movement is also important. For example, in the model of Nomura[12], the wastepaper consumption is explained by pulp price, collection-rate of wastepaper and the consumption of paper and paperboard at the previous period. And the sign of the coefficient of pulp price is minus.

The collection-rate of wastepaper is now almost 50%. Japan Paper Association[5] shows the limitation of collection-rate as 65%. Equation (4-2) shows that the increase of paper production causes the increase of wastepaper collection. However, as shown in equation (4-4), the collection-rate is not increased easily in the short-term. The dummy variable is added in equation (4-4). There are some factors existed in the second-half of the 1970's. And now, the plan that intends to increase the rate from 50% to 55% may reflect the actual movement in some degree. FAO[1] estimated the future consumption of pulp and wastepaper in Japan as follows: 24,429,000 ton of pulp and 33,736,000 ton of wastepaper will be input in 2010 (Note 11). It seems to be difficult to deal the collection-rate as entirely endogenous variable. Nomura[12] also dealt the collection-rate as exogenous variable in his model. It is the second-best method to divide the rate into some factors, for example, the trend factor, political factor, price factor and so on. As Lintu[8] pointed out the fact that "the industrial potential and the increasing popular and governmental concern for environmental protection" for the recover of wastepaper is increasing in the world, therefore, this type of political factor on environment seems to be also important.

Last, a brief discussion on the log for pulp is going to be done. Fig. 6 shows the log consumption classified by the origin. As shown in this figure, the domestic log supply for pulp has
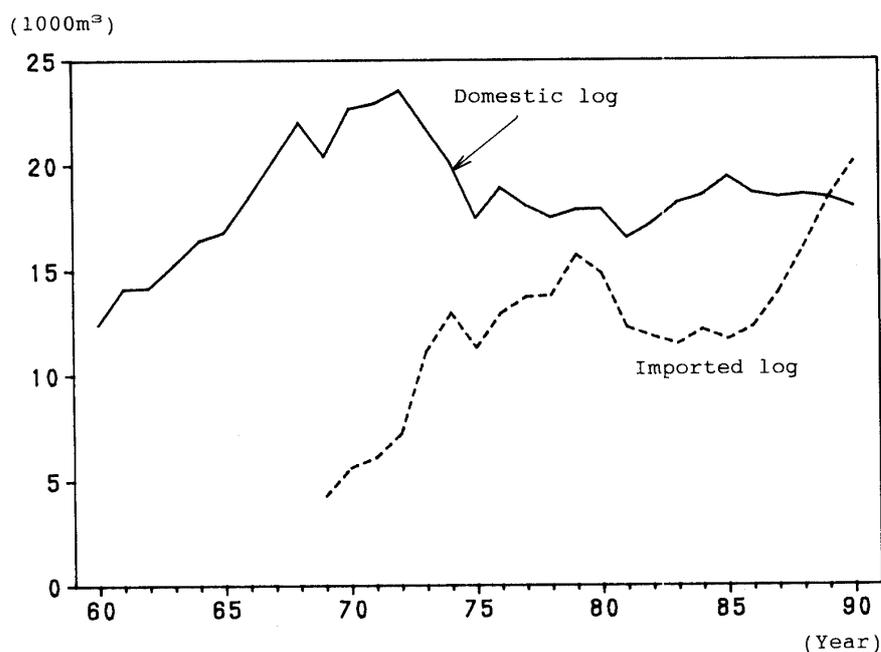
(1000m³)

Fig. 6. Consumption of log for pulp.
Source: See Fig. 2.
Note: Total of log and chip for pulp.

been almost constant for these 15 years. The increase in demand of paper and paperboard has caused the increasing of supply in the imported log. This was because, the timber supply in Japan was limited by several reasons and could not cope with increased demand at that time. In Japan, the log production has been getting less and less, on the other hand, the standing volume has been increasing. Several reasons have been discussed. Recently, labor-shortage is one of the main causes discussed. Also in case of log for lumber, the quantity of domestic supply has not increased at the high-demand period. This is almost the same in case of log for pulp. In addition, the change of exchange-rate of yen has risen rapidly since 1985. The rate has been raised almost double in 4 years. This rapid change has been reflected to almost all of economic sectors in Japan. In case of forest products trade, the rate of import of intermediate and finished goods has increased. This increase of finished goods is a general tendency observed at that time in Japan. This tendency has been continuing since having switched to a system of floating exchange-rates in forest products trade. The import quantities of almost all the commodities of forest products except log for lumber has increased as compared those in 1973. The rapid increase of import of log for pulp after 1985 is surprising, as shown in Fig. 6 (Note 12). In 1979, the imported price of chip from U.S.A. was raised rapidly, this is called "chip-shock", the paper industry has gotten a damage (Note 13). From this past experience, the excessive increase of dependence to imported log may contain something like a risk. It may change the structure of econometric model. On the other hand, Japan is the largest country importing the log for pulp. In this sense, the movement in Japan may reflect the international trade or price.

Summary

In this paper, several basic equations on the production of paper and paperboard for the basis of future construction of the econometric model are calculated. Annual time-series data

during the period 1960–1990 are used in this analysis. The main results and further research topics are as follows:

1. The domestic demand is approximately explained by GNP. However, the demand elasticity for GNP is changeable. Recently, this rate is over 1. The factors that determine this elasticity have to be clarified in future analysis.

2. The share of export and import of paper, paperboard and wastepaper is less than 5%, respectively. This rate is less than those of the other developed countries, and the paper market in Japan seems to be almost in the condition of self-sufficiency. However, as of the log for pulp, the imported one has been increasing, recently it is over the domestic one. It is important how to include a foreign sector in econometric model.

3. The materials input to paper and paperboard production is approximately explained by the quantity of production. However, in the case of paper, the consumption of wastepaper is explained by the paper production and the collection-rate. In case of paperboard, the substitutional relationship is observed between the domestic pulp and wastepaper. In the future, although the use-rate in paper production is expected to rise, such substitution may be observed.

4. The quantity of wastepaper collection has been increased in right proportion to the increase of paper supply. The collection-rate has been increased as trend, but recently this rate is almost constant, being around 50%. It is important to investigate the factors that determine this rate.

Notes

1) DW ratio of equations calculated in this paper are as follwos: equation (1–1) is 0.668, (1–2) is 0.923, (2–1) is 0.417, (2–2) is 0.116, (2–3) is 0.288, (2–4) is 0.780, (3–1) is 0.779, (3–2) is 0.522, (3–3) is 1.099, (3–4) is 0.711, (4–1) is 0.855, (4–2) is 0.650, (4–3) is 0.905, (4–4) is 1.238.

2) Trade problems have occurred between Japan and U.S.A. in various fields. U.S.A. has shown the following points for the problems of market structure of paper in Japan: (1) The rate of import of paper is low (about 4%) comparing to the case of U.S.A. (14%) or Europe (about 30%). (2) The existence of affiliation called "Keiretsu", (3) Japan do not purchase papers from foreign countries on the reason that the quality is no good. On April 23, 1992, the discussion on the market-open policy of paper between Japan and U.S.A. is over, and the notes that show the action for effort are exchanged between both governments.

3) By the following result that calculates paper and paperboard together, the coefficient of W is larger than that of P. $Y = -8.9536 + 0.8671 \, P + 1.0882 \, W$, $R^2 = 0.999$, Where: $Y = Y1 + Y2$, $P = PD1 + PD2 + PI1 + PI2$, $W = WP1 + WP2$.

4) Nomura[12] estimated paper production during the period 1965–1982. Though the equation is omitted on account of space consideration, consumption of pulp, consumption of wastepaper, capacity utilization-rate for paper production, paper consumption at the previous period and dummy variable are used as explanatory variables in the equation of paper production. And in case of paperboard production, consumption of pulp, consumption of wastepaper, capacity utilization-rate for paperboard production, labor for paperboard production, paper consumption at the previous period and dummy variable are used as exaplanatory variable.

5) The quantity of waste products in Tokyo special ward is as follows[14]: 3.8 million ton (1984), 4.0 million ton (1985), 4.3 million ton (1986), 4.5 million ton (1987), 4.8 million ton (1988) and 4.9 million ton (1989). During the period 1984–1989, 1.1 million ton has increased, this figure is larger than the quantity of waste products of several large cities in 1989, for example, Sapporo city (1.0 million ton), Nagoya city (0.9 million ton).

6) For example, Date city (in Hokkaido) requires 60 yen per one waste-package. This system was commenced in July, 1989. The cleaning office of city collects only the paid-waste-packages or waste-

packages wearing the specific seal that shows payment. As the result, the quantity of waste goods in 1990 detracted to 73% of that in 1989. Takeo city (in Saga prefecture) began to sell waste-packages at the price of 206 yen per 5 packages in 1989. Sendai city (in Miyagi prefecture) began to make specific waste-package (450 yen per 30 packages) in 1991. Takayama city (in Gifu prefecture) made a seal (70 yen) for waste-package in 1992.

7) Japan Paper Association[5] shows the following figures as the collection-rate of wastepaper of main countries in 1990: Japan (49.7%), Sweden (47.6%), Germany (44.7%), France (34.7%), U.S.A. (33.8%) and Finland (32.0%). As of the consumption-rate of wastepaper as defined by the proportion of consumption of wastepaper for production of paper and paperboard, the following countries show a high figure: Japan (52.0%), Germany (48.4%), France (46.7%), Italy (44.7%), China (30.4%), U.S.A. (27.6%) and U.S.S.R. (25.7%).

8) The demand elasticity for gross national expenditure is as follows[6]: 1.153 (paperboard), 0.432 (newsprint), 0.368 (paperprint), 0.627 (kraft paper), 0.850 (role paper).

9) Japan Paper Association[5] makes a business survey index on shipment, stock, rate of operation and revenue.

10) Following equation is used as paper production function in the model by Yuize and Yukutake[17]. The detail of dummy factor is omitted. $QR1 = -121120 + 86903 \ PR1/WSS + 0.62256 \ HR1 + 0.45565 \ QR1(-1)$. Where, QR1=Paper production, PR1=Wholesale price index, WSS=Wage rate, HR1=Paper shipment, QR1(−1)=Paper production at the previous period. This model was developed for short-term prediction. As this equation involves the variable with time-lag, namely QR1(−1), the variable that determines the level of the consumption is not necessary.

11) By FAO[1] estimation, the consumption of paper and paperboard is 48,962,000 ton in 2010. As this growth-rate is less than that of the production, Japan will become a net export country in the FAO analysis.

12) As of log for pulp in 1991, the export countries to Japan are as follows: U.S.A. (55.5%), Canada (16.6%), New Zealand (8.5%), Australia (7.1%), Chile (6.0%) and the others (6.2%) for coniferous trees, Australia (31.7%), U.S.A. (30.6%), Chile (21.7%), South Africa (5.3%) and the other countries (10.8%) for broadleaf trees. Judged by the analysis of Japan Paper Association[5], in case of coniferous tree, the main origin has been still North America, but the share has decreased, on the other hand, the shares of New Zealand and Australia have increased. In case of broadleaf tree, the share of Australia has decreased, and that of Chile has increased rapidly since 1986.

13) Schreuder and Anderson[13] pointed out the impact of "chip-shock" on Japan's pulp and paper industry. They referred to also the increase of wastepaper collection.

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