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Effects of Wood and Paper Products on National Economy in Korea: An Input-output Analysis

Young-Wan Goo[1], Seung-Nyeon Kim[2 †]

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ABSTRACT

This study uses the input－output model applied from 2000 to 2019 to examine the economic effects of wood and paper products on the Korean economy. The main results of this analysis are as follows. First, although the proportion of wood and paper products being manufactured in the Korean economy has decreased, the inducement effects of the production, value-added, and employment of most of the wood and paper products remained higher than those of the other manufactured goods in 2019. Second, the inducement effects of the production and value-added of most of the wood and paper products increased between 2010 and 2019, whereas the import inducement effect was lowered since 2010. Third, both the backward and forward linkage effects of paper product, which have the largest portion in value-added among the group of wood and paper products, were higher than those of the other manufactured goods in 2019. These findings indicate the importance of wood and paper products through industrial inducement effects in the Korean economy.

Keywords: *Wood and paper products, production inducement effect, value-added inducement effect, employment inducement effect, forward and backward linkage effects*

1. Introduction

Wood and paper products are closely related to our daily life. Wood and paper products are necessities of daily living and economic activities, and they also have recently received increasing attention from the eco-friendly aspect. Consumption of wood and paper products is steadily increasing, and the amount of imports of those products from foreign countries such as China and Indonesia has been growing due to insufficient production in Korea. In particular, the demands for packaging

1 Department of Economics, Chungbuk National University, Cheongju, 28644, Republic of Korea, Professor
2 Department of Economics, Hankuk University of Foreign Studies, Seoul, 02450, Republic of Korea, Professor.
† Corresponding Author: E-mail: snkim@hufs.ac.kr (Address: Department of Economics, Hankuk University of Foreign Studies, Seoul, 02450, Korea)

paper and sanitary paper products are increasing significantly in recent period due to wide spread of the corona virus. Since wood and paper products occupy an important part of the national economy in Korea, there is a need to analyze the impact of these industries on the overall economy.

Recently, a notable change is the increase in non-face-to-face economic activities due to the corona outbreak, which results in the increase in demand for packaging paper related to online shopping. Moreover, there have been rising efforts to use recyclable paper and eco-friendly wood products instead of potentially harmful packaging and building materials to the environment. These changes relevant to wood and paper products may have greater impact to the national economy as well as wood and paper industries.

The input-output analysis is a representative methodology for examining the importance of wood and paper products in the national economy and the relationship with other industrial sectors. The input-output table shows how particular goods are used as intermediate goods for other goods and how they are used for final consumption. Using this table, it is possible to analyze production inducement, value added inducement, import inducement, and employment inducement of the wood and paper products in relation to other products, and to analyze the forward and backward linkage effects with related products. Rose and Miernyk (1989), [1] Akhabbar, et al. (2011), [2] and Lee, et al. (2019) [3] surveyed the input-output analysis in various aspects of economic research.

There are several previous studies that examined the inducement effects related to wood and paper products using the input-output approach. Lee, et al. (2007) [4] analyzed the economic effect of government subsidies on forest fire damage in Gangwon-do, Han (2013) [5] investigated the effect of arboretums on the national and regional economy, and Lee, et al. (2017) [6] examined the economic inducement effects of forest road construction. These papers examined the economic effects of a specific project on the wood and paper industry. Kim, et al. (2010) [7] analyzed the contribution of paper products to the national economy based on the data of 2007, but it does not cover recent changes of the industry. Min (2020) [8] analyzed the economic inducement effect of forestry and wood industries by using the 2015 input-output table, which focuses on the structure of wood industry for a specific year of 2015.

The previous papers provide some relevant information to understand the effects of wood and paper industry, but no study has been conducted to analyze the long-term trend of the economic inducement effects of wood and paper products on the national economy. Therefore, the purpose of this paper is to analyze the inducement effects of wood and paper products with a long-term perspective, and to investigate the long-term changes of the forward and backward linkage effects with other industries. Based on this long-term analysis, the value of wood and paper industries and their effects on the national economy could be adequately evaluated and it would provide implications for the future development of the industries.

This paper is organized as follows. Section 2 briefly reviews the input-output analysis and product classification of the paper and wood products. Section 3 analyzes the results and meanings of the inducement effects, and section 4 provides conclusions and implications of this study.

2. The Input-output Model and Classification of Wood and Paper Products

2.1 The input-output model

The private sector, government, import, and end-user demand, which constitute a country's

national economy, would induce production, value added, employment, and end-user demand by interaction. The input-output table is a useful model that analyzes the relationship between industries by composing the industry structure into input-output structures. In the input-output table, the following matrix equations can be derived using the input-output relationship of the products of each industry sector. [9]

$$\begin{pmatrix} a_{11}\, a_{12} \cdots a_{ij} \cdots a_{1n} \\ a_{i1}\, a_{i2} \cdots a_{ij} \cdots a_{in} \\ a_{n1}\, a_{n2} \cdots a_{nj} \cdots a_{nn} \end{pmatrix} \begin{pmatrix} X_1 \\ \vdots \\ X_i \\ \vdots \\ X_n \end{pmatrix} + \begin{pmatrix} Y_1 \\ \vdots \\ Y_i \\ \vdots \\ Y_n \end{pmatrix} - \begin{pmatrix} M_1 \\ \vdots \\ M_i \\ \vdots \\ M_n \end{pmatrix} = \begin{pmatrix} X_1 \\ \vdots \\ X_i \\ \vdots \\ X_n \end{pmatrix}$$

where i and j represent each industry sector, a_{ij} is the input coefficient from i to j, X_i is the output of the i sector, Y_i is the end-user demand for i sector, and M_i is the import of the i sector. This can be changed into the following equation:

$$AX+Y-M=X \quad [1]$$

Here, A is the input coefficient matrix, X is the output vector, Y is the end-user demand vector, and M is the import vector. The amount of waste generated is omitted in equation (1)By rearranging Equation (1) for X, the following Equation (2) is derived.

$$X=(I-A)^{-1}(Y-M) \quad [2]$$

where $(I-A)^{-1}$ is called the production inducement coefficient. The production inducement coefficient shows the multiplier effects of a end-user demand on production in each industrial sector.

Value-added is also induced by the production induced. The coefficient representing this relationship is the value-added inducement coefficient.

$$V=A^vX \quad [3-1]$$

where V is the value-added vector. By substituting Equation (2) into Equation (3-1), the following value-added equation can be derived.

$$V=A^v(I-A^d)^{-1}(Y-M) \quad [3-2]$$

where $A^v(I-A^d)^{-1}$ is the value-added inducement coefficient.

By substituting import inducement equation, $A^mX+Y^m=M$, into Equation (2), the following import inducement coefficient can be derived, where A^m is the import input vector, Y^d is the end-user demand for domestic products, and Y^m is the end-user demand for imported goods.

$$M=A^m(1-A^d)^{-1}(Y^d-Z)+Y^m \quad [4]$$

where $A^m(1-A^d)^{-1}(Y^d-Z)$ is the import inducement coefficient.

Induced production in turn creates demand for labor. The coefficient representing this relationship is the employment inducement coefficient. It can be derived by multiplying both sides of Equation (2) by $L_w/X=l_w$.

$$L_w=l_w(I-A)^{-1}(Y-M) \quad [5]$$

where L_w is the number of employed, $l_w(I-A)^{-1}$ is the employment inducement coefficient.

The backward and forward linkage effects represent the relative size effects of the interdependence between each sector. Backward linkage effect of i industry is derived by dividing the sum of the column values of the production inducement coefficient in i industry by the average value of production inducement coefficient of the entire industry as follows.

Backward linkage effect of i industry

$$= \frac{\sum_{i}^{n} a_{ij}}{\frac{1}{n}\sum_{i}^{n}\sum_{j}^{n} a_{ij}}$$

The forward linkage effect of i industry induces production by being an input for another industry. It is an index derived by dividing the sum of the row values of the production inducement coefficient in i industry by the average value of production inducement coefficient of the entire industry as follows.

Forward linkage effect of i industry

$$= \frac{\sum_{j}^{n} a_{ij}}{\frac{1}{n}\sum_{i}^{n}\sum_{j}^{n} a_{ij}}$$

When the values of the both linkage effects are greater than 1, it can be seen that the linkage effects of industry i on the entire industry are larger than average of the all industries.

2.2 Input-output tables and classification of wood and paper products

The input-output table measured by the Bank of Korea reports the statistics every 5 years as the base year, and in general, extension tables are published for the next 4 years from the base year. When a base year changes, there are generally changes in the measurement method to reflect new product classification standards or new approaches in the national income account, so we need to be careful to use the input-output table in studying time series analysis. To solve this problem, the Bank of Korea provides the connection tables for some of different periods, but the Bank does not provide the statistics for the whole period based on one recent base year.

The period of analysis in this paper is from 2000 to 2019, so the input-output tables of 2000, 2005, 2010, 2015, and 2019 are used. The Bank of Korea provides connection tables of 2015-2010 and 2005-2000-1995, so we can analyze the data with two base years which are 2005 and 2015. The data of 2000 and 2005 have the same base year of 2005, and the data of 2010, 2015 and 2019 have the same base year of 2015. For the case of 2010, the extension table based on the 2005 standard is also available, so the years of 2000, 2005 and 2010 could be compared with the input-output statistics measured by the same base year of 2005. Thus, this study analyzes the changes of the effects of wood and paper products from 2000 to 2010 using the base year of 2005 and the changes from 2010 to 2019 using the base year of 2015.

The input-output statistics are composed of two approaches, the input-output table and the supply-use table. The input-output table shows production structures based on commodities, and the supply-use table records production structures based on industries. The supply-use table has the advantage of being able to better reflect the real economy by assuming that one industry can produce multiple products. However, the Bank of Korea started releasing the supply-use tables in 2010, so it is difficult to analyze the period before 2010. Since this study analyses the periods from 2000, input-output tables are used for a long-term time series analysis.

In the commodity classification of the input-output table, wood and paper products are major parts in the main category of wood, paper, and printing as shown in Table 1. The medium category is divided into wood and wood products, pulp and paper products, and printing and reproduction of recorded media. This study focuses on wood and paper products excluding printing and reproduction of recorded media. It is because recently the relationship between the group of wood and paper products and the group of printing and reproduction of recorded media has become weak as the

Table 1. Wood and paper products in commodity classification

Basic category	Small category	Medium category	Main category
Lumber	Wood	Wood and wood products	Wood, paper, printing
Plywood			
Reinforced and recycled wood			
Building wood products	Wood products		
Wood containers and loading plates			
Other wood products			
Pulp	Pulp	Pulp and paper products	
Printing paper	Paper		
Other base paper and paperboard			
Corrugated cardboard and corrugated cardboard products	Paper products		
Paper container			
Paper stationery and office paper			
Sanitary paper products			
Other paper products			
Printing and reproduction of recorded media	Printing and reproduction of recorded media	Printing and reproduction of recorded media	

Note: Based on the classification in the 2015 input-output table
Source: Bank of Korea (2019)

portion of audio and video materials, computerized record medium reproduction printing and reproduction of recorded media has increased significantly. Activities to publish the printed materials such as newspapers, books, and magazines are classified as the medium category of newspaper and publishing services under the main category of information communication and broadcasting services.

Table 2 shows value-added shares of wood and

Table 2. Wood and paper products in value-added relative to total products (%)

	2000 (A)	2005	2010[1] (B)	2010[2] (C)	2015	2019 (D)	(B)-(A)	(D)-(C)
Wood	0.099	0.069	0.061	0.063	0.07	0.062	-0.038	-0.001
Wood products	0.057	0.075	0.063	0.058	0.065	0.057	0.006	-0.001
Pulp	0.019	0.007	0.015	0.009	0.005	0.001	-0.004	-0.008
Paper	0.298	0.194	0.160	0.189	0.169	0.170	-0.138	-0.019
Paper products	0.274	0.286	0.328	0.254	0.278	0.249	0.054	-0.005
Sum of wood and paper (E)	0.747	0.631	0.627	0.573	0.587	0.539	-0.120	-0.034
Manufactured goods[3] (F)	29.193	28.529	30.655	30.768	29.491	28.033	1.462	-2.735
(E)/(F)	2.559	2.212	2.045	1.862	1.990	1.923	-0.513	0.060

Note 1) Based on base year of 2005
2) Based on base year of 2015
3) Simple average of manufactured goods in main category

paper products in the Korean economy. In this paper, the term "wood and paper products" indicates "wood and wood products" and "pulp and paper products" at medium category in Table 1. In 2019, wood and paper products accounted for 0.539% of total value-added in Korea. Paper products accounted for the largest share at 0.249%, followed by paper, wood, wood products, and pulp. The proportion of pulp is 0.001% which is a small portion in value-added created in Korea.

The share of value-added of wood and paper products has gradually decreased since 2000. While the shares of some commodities such as wood product and paper product increased in the 2000s, but the shares of all wood and paper products decreased in the 2010s. The share of manufactured goods in total value-added also decreased in the 2010s, but it had increased in the 2000s. The drop in the share of value-added of wood and paper products appears to be caused by an increase in productivity of other manufactured goods and rising share of the service sector in the overall industrial structure. Since 2010, however, the ratio of value-added of wood and paper products to manufactured goods has increased from 1.862% to 1.923%, we can see that the importance of wood and paper products is gradually recovering in the recent decade because of technology development.

3. Analysis of Effects Based on the Input-output Table

The production inducement effects of wood and paper products are shown in Table 3. As of 2019, the production inducement coefficient of pulp is the largest at 2.534, and paper has the smallest at 1.867. Except for paper, all wood and paper products show higher production inducement coefficients than manufactured goods. The production inducement coefficient has generally increased since 2000. In the 2010s, the coefficient of manufactured goods decreased slightly, whereas all of the coefficients in the wood and paper product group except wood products increased. Therefore, wood and paper products showed a relatively increasing trend in production inducement effect compared to manufactured goods in the 2010s.

Table 4 shows the value-added inducement effect of wood and paper products. As of 2019, the value-added inducement coefficient of paper products is the largest at 0.745 and paper has the smallest value at 0.637. From 2000 to 2010, the value-added inducement coefficients decreased for all of the wood and paper products, but they increased after that. This trend is the same for manufactured goods. In 2000, only paper products had a higher value-added inducement coefficient than

Table 3. Production inducement coefficient

	2000 (A)	2005	2010[1] (B)	2010[2] (C)	2015	2019 (D)	(B)-(A)	(D)-(C)
Wood	1.666	1.775	1.787	1.771	1.889	2.005	0.121	0.234
Wood products	1.958	2.052	2.03	2.04	1.979	2.007	0.072	-0.033
Pulp	1.671	1.932	1.732	1.636	1.799	2.534	0.061	0.898
Paper	1.752	1.873	1.833	1.842	1.847	1.867	0.081	0.025
Paper products	2.164	2.138	2.084	2.195	2.133	2.230	-0.080	0.035
Manufactured goods[3]	1.999	2.064	2.071	1.961	1.969	1.957	0.072	-0.004

Note 1) Based on base year of 2005
2) Based on base year of 2015
3) Simple average of manufactured goods in main category

Table 4. Value-added inducement coefficient

	2000 (A)	2005	2010[1] (B)	2010[2] (C)	2015	2019 (D)	(B)-(A)	(D)-(C)
Wood	0.535	0.511	0.489	0.540	0.645	0.682	−0.046	0.142
Wood products	0.635	0.657	0.612	0.650	0.662	0.675	−0.023	0.025
Pulp	0.614	0.515	0.564	0.552	0.836	0.713	−0.050	0.161
Paper	0.582	0.573	0.488	0.553	0.639	0.637	−0.094	0.084
Paper products	0.676	0.707	0.64	0.687	0.743	0.745	−0.036	0.058
Manufactured goods[3]	0.663	0.650	0.590	0.603	0.663	0.657	−0.073	0.054

Note 1) Based on base year of 2005
2) Based on base year of 2015
3) Simple average of manufactured goods in main category

manufactured goods, but in 2019, the coefficients of all wood and paper products except paper were higher than manufactured goods, which indicates improvement of wood and paper products relative to other manufactured goods in the value-added inducement effect.

The import inducement effect of wood and paper products are shown in Table 5. As of 2019, the import inducement coefficient of paper is the largest at 0.363, and it is the lowest for paper products at 0.255. Compared with manufactured goods, import inducement coefficients of all wood and paper products except paper were smaller than that of manufactured goods. From 2000 to 2010, the import inducement coefficients increased for all wood and paper products, but they decreased after that. This is the same as the trend of changes in manufactured goods. In 2000, all wood and paper products except paper products had higher import inducement coefficients than manufactured goods, but in 2019, all products except paper showed lower import inducement coefficients than manufactured goods, indicating that the import inducement effect of wood and paper products became relatively low. It implies that production in wood and paper products requires less demand for importing goods compared to manufactured goods.

In order to compare the employment inducement coefficients in two different periods, we need to be cautious because of the two reasons. First, the unit

Table 5. Import inducement coefficient

	2000 (A)	2005	2010[1] (B)	2010[2] (C)	2015	2019 (D)	(B)-(A)	(D)-(C)
Wood	0.465	0.489	0.511	0.460	0.355	0.318	0.046	−0.142
Wood products	0.365	0.343	0.388	0.350	0.338	0.325	0.023	−0.025
Pulp	0.386	0.485	0.436	0.448	0.164	0.287	0.050	−0.161
Paper	0.418	0.427	0.512	0.447	0.361	0.363	0.094	−0.084
Paper products	0.324	0.293	0.360	0.313	0.257	0.255	0.036	−0.058
Manufactured goods[3]	0.337	0.350	0.410	0.397	0.337	0.343	0.073	−0.054

Note 1) Based on base year of 2005
2) Based on base year of 2015
3) Simple average of manufactured goods in main category

of final demand to derive the coefficient is based on the current price. Second, since the linkage table for the employment inducement coefficient in different years is not available, comparison of the coefficients with different base years would come with errors. The first problem can be solved by converting the unit of current price to real values using the producer price index as explained below, but for the second problem we do not have a fundamental solution, so it is necessary to understand the coefficient value as an approximation of changes in employment effects.

According to the input-output table published by the Bank of Korea, the employment inducement coefficient refers to the number of workers directly or indirectly induced in the overall production in the economy when the value of final demand for a specific product increased by 1 billion won at current price. To compare the employment inducement coefficients in time series data, we convert the current price value of 1 billion won to the real value using the producer price index with 2015 as the base year.

Table 6 shows the employment inducing effect of wood and paper products. As of 2019, the employment inducement coefficient of paper products is the largest at 10.32, and paper is the smallest at 6.20. Except for paper, all products show higher employment inducement coefficients than manufactured goods. Looking at the trend of the coefficients since 2000 until 2019, it appears that the employment inducing effects of wood and paper products have all decreased, which is the same as that of manufactured goods. However, with the exception of wood products, the decrease in the employment inducement coefficients of the wood and paper products was smaller than that of manufactured goods. In particular, among these products, paper products had the highest level of employment inducement coefficient in 2019, and the decrease in the coefficient of the product for the whole period was relatively small compared to other products.

Table 7 shows the index of power of dispersion which indicates backward linkage effect of wood and paper products. As of 2019, the power index of pulp is the largest at 1.312, and paper has the smallest at 0.967. The indexes of pulp and paper products are larger than that of manufactured goods, and the rest of the products are smaller than manufactured goods. As for the changes of the index by product after 2000, the indexes of wood products and paper products slightly decreased, while the rest of the products did not show a clear trend. Comparing 2000 and 2019 with manufactured goods, there was no significant change in relative size except that the indexes of wood and pulp increased more compared to manufactured goods.

Table 6. Employment inducement coefficient

	2000 (A)	2005	2010	2015	2019 (B)	(B)−(A)
Wood	12.71	9.54	7.56	8.77	8.74	−3.97
Wood products	21.23	16.43	15.00	10.42	9.32	−11.92
Pulp	13.05	5.05	5.76	7.47	9.98	−3.07
Paper	7.25	6.20	8.30	6.76	6.20	−1.04
Paper products	11.40	10.05	11.14	10.45	10.32	−1.08
Manufactured goods[1)]	13.75	10.93	10.24	8.74	7.80	−5.94

Note 1) Simple average of manufactured goods in main category

Table 7. Index of power of dispersion for backward linkage effect

	2000 (A)	2005	2010[1] (B)	2010[2] (C)	2015	2019 (D)	(B)-(A)	(D)-(C)
Wood	0.887	0.921	0.916	0.932	0.991	1.038	0.029	0.106
Wood products	1.043	1.065	1.041	1.073	1.039	1.039	−0.002	−0.034
Pulp	0.890	1.002	0.888	0.861	0.944	1.312	−0.002	0.451
Paper	0.933	0.971	0.940	0.969	0.970	0.967	0.007	−0.002
Paper products	1.152	1.109	1.069	1.155	1.120	1.155	−0.083	0.000
Manufactured goods[3]	1.079	1.071	1.063	1.084	1.066	1.056	−0.016	−0.028

Note 1) Based on base year of 2005
2) Based on base year of 2015
3) Simple average of manufactured goods in main category

Table 8 shows the index of sensitivity of dispersion indicating the forward linkage effect of wood and paper products. As of 2019, the sensitivity index of paper products is the largest at 1.279, while pulp is the smallest at 0.625. Compared with manufactured goods, the indexes of paper and paper products are larger than that of manufactured goods, and the rest of the products show significantly lower values than manufactured goods. Since 2000, it appears that the indexes have generally decreased, while the index of manufactured goods increased slightly in the 2000s. When the indexes of wood and paper products with manufactured goods for the two years of 2000 and 2019 are compared, there is no significant change in relative size except that the indexes of wood and paper decreased more compared to manufactured goods.

4. Conclusions

In this study, the impact of wood and paper products on the national economy was analyzed in terms of interrelation of industries using the input-output table. In particular, we conduct time series analysis for the period from 2000 to 2019 and derive implications necessary for the growth of wood and paper industry in the future.

Wood and paper products do not account for a

Table 8. Index of sensitivity of dispersion for forward linkage effect

	2000 (A)	2005	2010[1] (B)	2010[2] (C)	2015	2019 (D)	(B)-(A)	(D)-(C)
Wood	1.044	0.991	0.938	0.907	0.817	0.768	−0.106	−0.139
Wood products	0.688	0.692	0.661	0.688	0.727	0.686	−0.027	−0.002
Pulp	0.784	0.779	0.769	0.623	0.650	0.625	−0.015	0.002
Paper	1.739	1.294	1.285	1.264	1.152	1.072	−0.454	−0.192
Paper products	1.552	1.402	1.464	1.280	1.292	1.279	−0.088	−0.001
Manufactured goods[3]	1.034	1.038	1.042	1.095	1.062	1.051	0.008	−0.044

Note 1) Based on base year of 2005
2) Based on base year of 2015
3) Simple average of manufactured goods in main category

large portion of the national economy, and their share has decreased until recently. In terms of inter-industry effects, however, wood and paper products showed substantial effects on the national economy in terms of the effects of production inducement and value-added inducement compared to other manufactured goods. In particular, for the period between 2010 and 2019, the coefficients of production inducement and value-added inducement of most of wood and paper products increased. It implies that an increase in demand for one unit of these products would expand production of other industries by inducing effects in production and value-added, and these effects are stronger in recent period.

As for the backward and forward linkage effects, although we do not see a significant trend in wood and paper products compared to manufactured goods, the two effects of paper product, which has the largest portion in value-added among the group of wood and paper products, were higher than those of manufactured goods in 2019.

These findings indicate the importance of wood and paper products through industrial inducement effects in Korean economy. Demand for wood and paper products is expected to increase steadily in the future as there will be more need of responding to climate change and social demand for eco-friendly products. In the case of more production of these products, we expect that the effects of production inducement and value-added inducement to other industries could make substantial positive impacts to the growth of the whole economy.

In order to make the positive results of wood and paper products in our analysis to become a reality, domestic business sector needs to respond to new demands for these products and develop their capabilities to produce competitive products. To this end, it is necessary for private companies to actively invest for innovative technology and reflect consumer preference, and the government needs to support private sector in responding to climate change and environmental issues at the long-term perspective. These efforts would enhance the quality of wood and paper products for the future and let the industry reinforce its contribution to the national economy.

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