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Impacts of Economic Growth on Forest Products Consumption in Korea

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ABSTRACT

The paper examined econometrically the impacts of economic growth on forest products consumption in Korea for the period of 1980-2013. Economic growth was expressed by total GDP, construction GDP and manufacturing GDP. The relationship between forest products consumption and economic growth was represented by bivariate vector autoregressive(VAR) model or vector error correction(VEC) model. The causality from economic growth to forest products consumption was measured by the Granger causality test. We found that the consumption of most forest products was Granger-caused by total GDP. This means that causality runs from total GDP to the consumption of most forest products. And we confirmed that construction GDP caused the consumption of hardwood roundwood, softwood lumber and plywood with each other. And, we also confirmed that manufacturing GDP caused the consumption of plywood, particleboard and chemical pulp with each other. In conclusion, economic growth worked as the cause of increase in the consumption of most forest products in Korea.

Key words - Causality test, Economic growth, Forest products consumption, Vector autoregressive model, Vector error correction model

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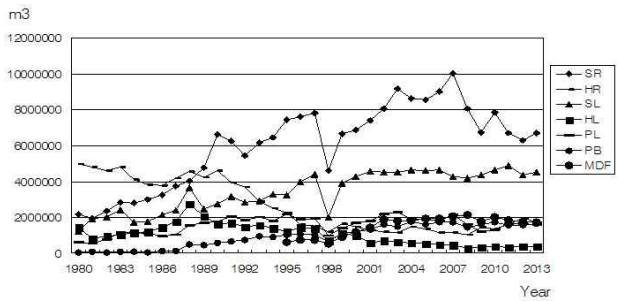
I. Introduction

Korea has experienced economic growth since the 1960s. The consumption of most forest products increased with the economic growth(Fig. 1 - 2). So we can assume that the economic growth had impact on the increase in forest products consumption in Korea. However, we do not know the economic growth caused the increase in forest products consumption.

This study confirmed econometrically the causality from economic growth to forest products consumption using Korean data. In general, GDP is used as the proxy of economic growth(Son, 1991; Ferguson et al., 2000; Cho & Kang, 2012).

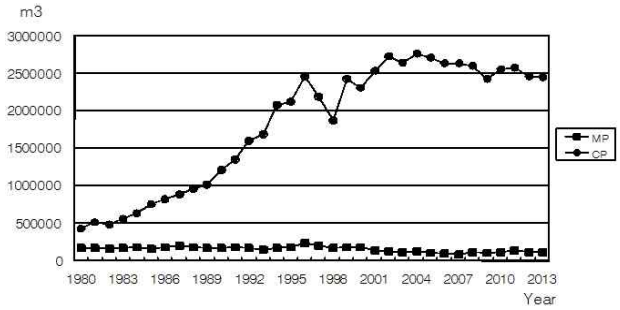
And GDP can be included as explanatory variable in forest products demand function by income theory. The relationship between forest products consumption and GDP was represented by bivariate vector autoregressive or vector error correction model. The causality from GDP to forest products consumption was measured by the Granger causality test.

Nine forest products commodities were considered: softwood roundwood, hardwood roundwood, softwood lumber, hardwood lumber, plywood, particleboard, MDF, mechanical pulp and chemical pulp.



(SR: softwood roundwood, HR: hardwood roundwood, SL: softwood lumber, HL: hardwood lumber, PL: plywood, PB: particleboard, MDF: medium density fiberboard)

Fig. 1. Change in forest solidwood products consumption.



(MP: mechanical pulp, CP: chemical pulp)

Fig. 2. Change in forest fiberwood products consumption.

There are rare causality studies on forest products sector. The causality study was used to identify the inter-market relationships of forest products in the Pacific Northwest. The causality tests demonstrated that export sawlog and lumber prices lead the movement of domestic sawlog prices(Yin & Xu, 2003). On the other hand, there is a study on the impacts of economic growth on the global timber market. A partial equilibrium model was applied to the global timber market in order to assess the impacts of economic growth. However, they did not analyze the causal relationship(Tromborg et al., 2000).

The relationship between construction output and economic growth has been discussed by construction economists. Most of the previous studies found a positive correlation between GDP and various measures of construction output(Yiu et al., 2004). Also, Granger causality methodology was used to investigate the relationship between construction activity and aggregate economy. Using data from Hong Kong, GDP tends to lead the construction flow (Tse & Ganesan, 1997). On the other hand, residential construction causes GDP in Western Europe(Wilhelmsson & Wigren, 2011).

There are a few causality studies between construction materials consumption and economic growth. The causal relationship between aluminum consumption and economic growth was estimated for

twenty rich economies for the period of 1970~2009. Unidirectional causality running from aluminum consumption to GDP was uncovered, while GDP was found to cause aluminum consumption(Jaunky, 2012). And the causal relationship between steel consumption and economic growth was estimated in Korea between 1975 and 2008. The results showed the existence of causality running from GDP to steel consumption(Huh, 2011). On the other hand, the causality between steel consumption and economic growth was estimated for six Southeast Asian countries for the time span of 1972~2009. The results showed the existence of causality running from steel consumption to economic growth(Ra, 2011).

The objective of this study is to confirm econometrically the causality from GDP to forest products consumption using Korean data. The result provides the relationship between forest products sector and economic growth in Korea. That is, we confirm whether economic growth increased forest products consumption. So the result may contribute to an improved understanding of forest products sector in Korea.

II. Materials and Methods

2.1 Data collection

Data collected are as follows:

Korean forest products(softwood roundwood, hardwood roundwood, softwood lumber, hardwood lumber, plywood, particleboard, MDF, mechanical pulp and chemical pulp) consumption

Korean real total GDP, construction GDP and manufacturing GDP Data for the period of thirty-four years from 1980 to 2013 were used. The data used are at the yearly level. This produced 34 observations for forest products consumption and GDP.

2.2 Methods

To figure out the causal relationship from GDP to forest products consumption, Granger causality test was used in case of bivariate vector autoregression (VAR) model. Granger causality test suggests the three-stage procedure for the estimation. The first-step is to determine whether each time series data is stationary. The natural logarithm level data and the natural logarithm first-differenced conversion data were tested by unit root test using Augmented Dickey and Fuller(ADF) statistics. The second step is to investigate the bivariate cointegration between each forest products consumption and GDP converted to the natural logarithm data using Johansen's cointegration test. Finally when each time series data is stationary after the first-difference and there is no presence of cointegration between both level data, the VAR Granger causality test was used.

On the other hand, when each time series data is not stationary and there is the presence of cointegration between both level data, the vector error correction(VEC) Granger causality test was used(Cho, 2013).

The estimated bivariate vector autoregression(VAR) for each forest products consumption takes the following form:

$$Y_t = c + \sum_{i=1}^{n} a_i Y_{t-i} + \sum_{i=1}^{n} b_i X_{t-i} + u_t \quad (1)$$

$$X_t = c + \sum_{i=1}^{n} a_i Y_{t-i} + \sum_{i=1}^{n} b_i X_{t-i} + v_t \quad (2)$$

where Y_t is forest products consumption, X_t is GDP, and u_t and v_t are uncorrelated with its own lagged values and all of the right-hand side variables.

The estimated bivariate vector error correction (VEC) for each forest products consumption takes the following form:

Table 1. Result of unit root test.

Variable	Lag length	Original data	First differenced data
		D-F test statistics	D-F test statistics
Softwood roundwood	1	-1.98	-4.90**
Hardwood roundwood	1	-1.53	-2.80*
Softwood lumber	1	-1.65	-6.52**
Hardwood lumber	1	-1.06	-5.04**
Plywood	2	-2.72	-6.12**
Particleboard	1	-0.95	-4.67**
MDF	1	-0.63	-3.58**
Mechanical pulp	1	-1.33	-4.82**
Chemical pulp	1	-1.70	-3.99**
Total GDP	1	1.66	-4.82**
Construction GDP	1	-2.30	-3.10**
Manufacturing GDP	1	2.28	-4.35**

The values represent augmented Dickey-Fuller test statistics.
The critical value at 5%(10%) significance level is -2.97(-2.62).
**Reject the null hypothesis that the time series is nonstationary at 5%(10%) significance level.

$$Y_t = c + a_1 ECT_{t-1} + \sum_{i=1}^{n} b_i Y_{t-i} + \sum_{i=1}^{n} c_i X_{t-i} + u_t \quad (3)$$

$$X_t = c + a_1 ECT_{t-1} + \sum_{i=1}^{n} b_i Y_{t-i} + \sum_{i=1}^{n} c_i X_{t-i} + v_t \quad (4)$$

where Y_t is forest products consumption, X_t is GDP, ECT is the error correction term obtained from cointegration that is normalized with respect to each variable, and u_t and v_t are uncorrelated with its own lagged values and all of the right-hand side variables.

The choice of lags is important. Insufficient lags can yield autocorrelated errors, while too many lags reduce the power of the test. Thus the robustness of the results was checked with a varying number of lags. The lag length of the model was set on the criterion of Akaike(Kwon, 2011).

Equations (1), (2) or (3), (4) were estimated by ordinary least squares(OLS) method. OLS estimation can produce efficient estimates.

We assume the causal relationship from GDP to forest products consumption, that is, GDP causes forest products consumption.

III. Results and discussion

3.1 Unit root test

Table 1 shows the result of unit root test. All the absolute estimated values in the third column did not exceed the absolute critical value at 5% significance level. That is, all the time series are nonstationary,

Table 2. Result of cointegration test.

Variable	Total GDP		Construction GDP		Manufacturing GDP	
	Lag length	L-R test statistics	Lag length	L-R test statistics	Lag length	L-R test statistics
Softwood roundwood	1	17.71**	1	11.83	1	12.35
Hardwood roundwood	1	7.52	1	12.46	1	8.56
Softwood lumber	1	20.48**	1	16.05**	1	16.90**
Hardwood lumber	1	11.76	1	13.88	2	13.57
Plywood	2	24.21**	2	25.18**	1	17.54**
Particleboard	1	10.99	1	10.98	1	10.16
MDF	1	8.31	1	10.62	1	8.14
Mechanical pulp	1	9.65	1	9.45	1	11.89
Chemical pulp	1	25.13**	1	13.74	1	13.69

The values represent augmented Likelihood-Ratio test statistics.
The critical value at 5% significance level is 15.41.
**Reject the null hypothesis of no cointegration of forest products consumption and GDP at 5% significance level.

and therefore have systematic trends, which may be eliminated using differenced values.

For the first differenced data, the fourth column shows that all the absolute estimated values exceeded the absolute critical value at 5% significance level. That is, all the time series are stationary in the first differenced level. It means that stationary series were obtained by using year-to-year differencing in the original level.

3.2 Cointegration test

Table 2 shows the result of the cointegration test of forest products consumption and GDP. Firstly, total GDP does not have cointegration with the consumption of hardwood roundwood, hardwood lumber, particleboard, MDF and mechanical pulp with each other. So, vector autoregressive model was used with differenced data for total GDP and the consumption of hardwood roundwood, hardwood lumber, particleboard, MDF and mechanical pulp with each other. However, total GDP has cointegration with the consumption of softwood roundwood, softwood lumber, plywood and chemical pulp with each other. So, vector error correction model was used for total GDP and the consumption of softwood roundwood, softwood lumber, plywood and chemical pulp with each other.

Secondly, construction GDP and forest products consumption do not have cointegration with each other except the softwood lumber and plywood. So, vector autoregressive model was used with differenced data except the softwood lumber and plywood. And vector error correction model was used for the softwood lumber and plywood.

Thirdly, manufacturing GDP and forest products consumption do not have cointegration with each other except the softwood lumber and plywood. So, vector autoregressive model was used with

Table 3. Result of the causality test between forest products consumption and total GDP with VAR.

Hypothesis	Lag length	F-statistic	P-value	Causality
TGDP does not Granger cause HR	1	1.18	0.29	GDP ↛ HR
TGDP does not Granger cause HL	1	3.44*	0.07	GDP → HL
TGDP does not Granger cause PB	1	4.58**	0.04	GDP → PB
TGDP does not Granger cause MDF	1	0.46	0.50	GDP ↛ MDF
TGDP does not Granger cause MP	1	0.13	0.72	GDP ↛ MP

(HR: hardwood roundwood, HL: hardwood lumber, PB: particleboard, MDF: medium density fiberboard, MP: mechanical pulp)
***(**, *)Reject the null hypothesis of no causality between change in forest products consumption and change in total GDP at 1%(5%, 10%) significance level.

differenced data except the softwood lumber and plywood. And vector error correction model was used for the softwood lumber and plywood.

3.3 Causality test

Table 3 shows the result of the causality test from change in total GDP to change in forest products consumption with VAR. There appeared to be evidence of the causal relationships from change in total GDP to change in the consumption of hardwood lumber and change in the consumption of particleboard. That is, change in total GDP caused change in the consumption of hardwood lumber and change in the consumption of particleboard.

Hardwood lumber is used as the low-grade material for interior construction and furniture. And, particleboard is used as the raw material for kitchenware.

Table 4 shows the result of the causality test from change in total GDP to change in forest products consumption with VEC. There appeared to be evidence of the causal relationships from change in total GDP to change in the consumption of softwood roundwood, softwood lumber, plywood and chemical pulp with each other. That is, change in total GDP caused change in the consumption of softwood roundwood, softwood lumber, plywood and chemical pulp with each other.

Table 4. Result of the causality test between forest products consumption and total GDP with VEC.

Hypothesis	Lag length	t-statistic	P-value	Causality
TGDP does not Granger cause SR	1	-4.65**	0.04	GDP → SR
TGDP does not Granger cause SL	1	-6.51**	0.02	GDP ↛ SL
TGDP does not Granger cause PL	2	-6.02**	0.02	GDP ↛ PL
TGDP does not Granger cause CP	2	-3.86*	0.06	GDP → CP

(SR: softwood roundwood, SL: softwood lumber, PL: plywood, CP: chemical pulp)
***(**, *)Reject the null hypothesis of no causality between change in forest products consumption and change in total GDP at 1%(5%, 10%) significance level.

Table 5. Result of the causality test between forest products consumption and construction GDP with VAR.

Hypothesis	Lag length	F-statistic (*t-statistic)	P-value	Causality
CGDP does not Granger cause SR	1	0.00	0.95	GDP ↛ SR
CGDP does not Granger cause HR	1	3.25*	0.08	GDP → HR
CGDP does not Granger cause HL	1	0.28	0.60	GDP ↛ HL
CGDP does not Granger cause PB	1	0.09	0.77	GDP ↛ PB
CGDP does not Granger cause MDF	1	0.22	0.64	GDP ↛ MDF

(SR: softwood roundwood, HR: hardwood roundwood, HL: hardwood lumber, PB: particleboard, MDF: medium density fiberboard, MP: mechanical pulp, CP: chemical pulp)
***(**, *)Reject the null hypothesis of no causality between change in forest products consumption and change in construction GDP at 1%(5%, 10%) significance level.

Softwood roundwood is used as the raw material for lumber and wood-based panels. And, softwood lumber is used as the material for residential construction. Plywood is used as the raw material for concrete formwork, interior construction and furniture. And, chemical pulp is the raw material for white paper and art paper.

Table 5 shows the result of the causality test from change in construction GDP to change in forest products consumption with VAR. There appeared to be evidence of the causal relationship from change in construction GDP to change in the consumption of hardwood roundwood. That is, change in construction GDP caused change in the consumption of hardwood roundwood.

Hardwood roundwood is used as raw material for lumber and wood-based panels.

Table 6 shows the result of the causality test from change in construction GDP to change in forest products consumption with VEC. There appeared to be evidence of the causal relationships from change in construction GDP to change in the consumption of softwood lumber and change in the consumption of plywood. That is, change in construction GDP caused change in the consumption of softwood lumber and change in the consumption of plywood.

Softwood lumber is used as the material for residential construction. Consumption of softwood lumber increased owing to the domestic housing construction boom in the 1980s. During the financial crisis, especially in 1998, softwood lumber consumption declined greatly(Joo, 2008). In the USA,

Table 6. Result of the causality test between forest products consumption and construction GDP with VEC.

Hypothesis	Lag length	F-statistic (*t-statistic)	P-value	Causality
CGDP does not Granger cause SL	1	-6.87**	0.02	GDP ↛ SL
CGDP does not Granger cause PL	2	-5.16**	0.03	GDP ↛ PL

(SL: softwood lumber, PL: plywood)
***(**, *)Reject the null hypothesis of no causality between change in forest products consumption and change in construction GDP at 1%(5%, 10%) significance level.

Table 7. Result of the causality test between forest products consumption and manufacturing GDP with VAR.

Hypothesis	Lag length	F-statistic (*t-statistic)	P-value	Causality
MGDP does not Granger cause SR	1	2.71	0.11	GDP ↛ SR
MGDP does not Granger cause HR	1	0.18	0.67	GDP ↛ HR
MGDP does not Granger cause PB	1	3.20*	0.08	GDP → PB
MGDP does not Granger cause MDF	1	0.85	0.36	GDP ↛ MDF
MGDP does not Granger cause MP	1	0.19	0.67	GDP ↛ MP
MGDP does not Granger cause CP	1	3.50*	0.07	GDP → CP

(SR: softwood roundwood, HR: hardwood roundwood, HL: hardwood lumber, PB: particleboard, MDF: medium density fiberboard, MP: mechanical pulp, CP: chemical pulp)
***(**, *)Reject the null hypothesis of no causality between change in forest products consumption and change in manufacturing GDP at 1%(5%, 10%) significance level.

residential construction accounts for two-thirds of the consumption of softwood lumber(Lefaix-Durand et al., 2009). On the other hand, new city and house construction have induced greater softwood lumber consumption.

Plywood is used as the material for concrete formwork and interior construction. However, plywood for interior construction was replaced by particleboard and MDF.

Table 7 shows the result of the causality test from change in manufacturing GDP to change in forest products consumption with VAR. There appeared to be evidence of the causal relationship from change in manufacturing GDP to change in the consumption of particleboard and change in the consumption of chemical pulp. That is, change in manufacturing GDP caused change in the consumption of particleboard and change in the consumption of chemical pulp.

Particleboard is used as the raw material for kitchenware. And, chemical pulp is most of wood pulp consumption

Table 8 shows the result of the causality test from change in manufacturing GDP to change in forest products consumption with VEC. There appeared to be evidence of the causal relationships from change in manufacturing GDP to change in the consumption of plywood. That is, change in manufacturing GDP caused change in the consumption plywood.

Plywood is used as the raw material for furniture. However, plywood for furniture was replaced by particleboard and MDF.

The paper examined econometrically the impacts of

Table 8. Result of the causality test between forest products consumption and manufacturing GDP with VEC.

Hypothesis	Lag length	F-statistic (*t-statistic)	P-value	Causality
MGDP does not Granger cause PL	2	-5.18**	0.03	GDP ↛ PL

(SL: softwood lumber, PL: plywood)
***(**, *)Reject the null hypothesis of no causality between change in forest products consumption and change in manufacturing GDP at 1%(5%, 10%) significance level.

economic growth on forest products consumption in Korea for the period of 1980-2013. Nine forest products commodities were considered. Economic growth was expressed by total GDP, construction GDP and manufacturing GDP. We tried to confirm whether economic growth caused forest products consumption in Korea.

There appeared to be evidence of the causal relationship from change in total GDP to change in the consumption of most forest products. That is, change in total GDP caused change in the consumption of most forest products.

And we confirmed that changes in hardwood roundwood consumption, softwood lumber consumption and plywood consumption were caused by construction GDP. The investment on construction sector increased with economic growth, and the consumptions of hardwood roundwood, softwood lumber and plywood also increased as the materials of construction. That is, economic growth caused the increase in the consumptions of hardwood roundwood, softwood lumber and plywood via construction sector.

Also we confirmed that changes in plywood consumption, particleboard consumption and chemical pulp consumption were caused by manufacturing GDP. The investment on manufacturing sector increased with economic growth, and the consumptions of plywood, particleboard and chemical pulp also increased as the materials of manufacturing. That is, economic growth caused the increase in the consumptions of plywood, particleboard and chemical pulp via manufacturing sector. However, the export-oriented manufacturing industries like mobile industry and car industry occupies most of manufacturing GDP. The forest products industry is not export-oriented manufacturing industry in Korea.

In conclusion, economic growth worked as the cause of increase in the consumption of most forest products in Korea.

IV. Acknowledgement

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