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Development of the Roundwood Demand Prediction Model

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Abstract : This study compared the roundwood demand prediction accuracy of econometric and time-series models using Korean data. The roundwood was divided into softwood and hardwood by species. The econometric model of roundwood demand was specified with four explanatory variables; own price, substitute price, gross domestic product, dummy. The time-series model was specified with lagged endogenous variable.

The dummy variable reflected the abrupt decrease in roundwood demand in the late 1990's in the case of softwood roundwood, and the boom of plywood export in the late 1970's in the case of hardwood roundwood. On the other hand, the prediction accuracy was estimated on the basis of Residual Mean Square Errors(RMSE). The results showed that the softwood roundwood demand prediction can be performed more accurately by econometric model than by time-series model. However, the hardwood roundwood demand prediction accuracy was similar in the case of using econometric and time-series model.

Key words **:** *roundwood demand, prediction accuracy, econometric model, time-series model*

Introduction

Korean roundwood consumption has increased about twice since the 1970's. If dividing roundwood into softwood and hardwood by species, softwood roundwood consumption increased and hardwood roundwood consumption decreased. Korea depends most of roundwood consumption on import from foreign countries. Main softwood roundwood import species were Douglas fir and Hemlock from U.S. in the 1970's and 1980's. However, because of the export regulation of roundwood produced in the public forest of U.S. western region after 1992, and the abrupt increase in radiata pine export of New Zealand after the late 1980's, most of softwood roundwood import species has been Radiata pine from New Zealand since the 1990's. On the other hand, main hardwood roundwood import species was Rauan from Indonesia in the 1970's. However, because of the export regulation of roundwood produced in Indonesia after the middle 1980's, most of hardwood roundwood import species has been MLH (Mixed Low-Quality Hardwood) from Papua New Guinea and Solomon since the middle 1980's.

There are a few studies on roundwood demand modeling using Korean data; Oh and Lee(1980), Kim and Park(1980), Sung(1987), Park and Jo(1989) in the 1980's, Youn and Kim(1992), Seok(1992) in the 1990's. All studies used econometric model. No study was ever done using time-series model.

This article compared the prediction accuracy of econometric and time-series model to develop the most efficient demand prediction model of roundwood in Korea. The first objective of this article is to estimate roundwood demand using econometric and time-series model. And the second objective is to compare the prediction accuracy of econometric and time-series model.

Research Methods

1. Data collection

Roundwood consumption was calculated through the production plus import minus export of roundwood. Roundwood price was represented by import price, because most of roundwood consumed are from foreign countries in Korea. Import price was calculated through dividing import value by import quantity. GDP was collected as a rough proxy for the domestic usage of wood-based final product. Import price and GDP were deflated.

Data for the period of thirty-five years from 1970 to 2004 were used. The data used are at the yearly level.

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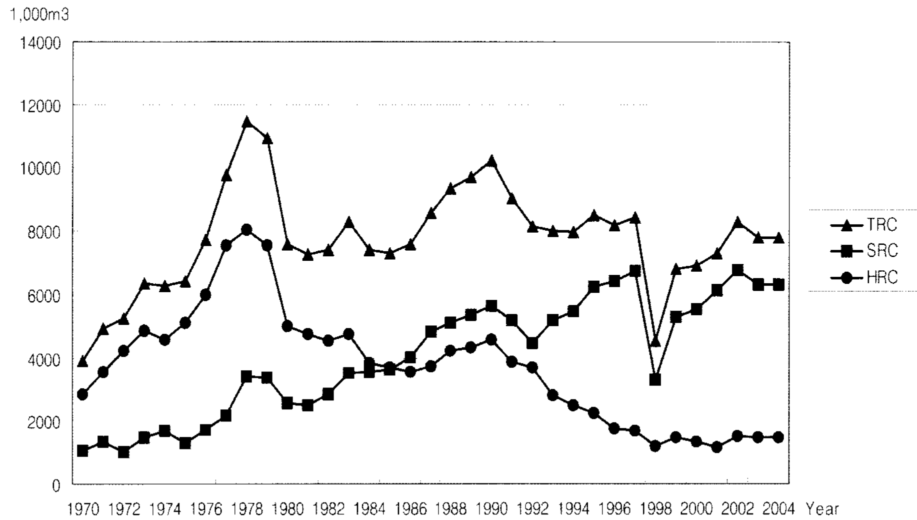

TRC: Total Roundwood Consumption
SRC: Softwood Roundwood Consumption
HRC: Hardwood Roundwood Consumption

Figure 1. Roundwood consumption trend by species.

This produced thirty-five observations.

Data collected are as follows:
1) Korean roundwood consumption
2) Korean softwood roundwood import price
3) Korean hardwood roundwood import price
4) Korean gross national product(GDP)

Data sources are as follows:
1) Statistical Yearbook of Forestry. Korea Forest Service
2) Statistics of Forest Products' Trade. Korea Forest Service
3) Statistical Yearbook of Foreign Trade. Korea Customs Service
4) Korean Statistical Information System. Korea National Statistical Office

2. Model specification and estimation

1) Econometric model

In the forest economics literature, roundwood demand is typically derived from a wood-based industry production function. In line with this literature, Korean wood-based industry output can be described using the production function

$$X_t = f(K_t, L_t, R_t) \quad (1)$$

where X_t is wood-based output, K_t is capital input, L_t is labor input, and R_t is roundwood input needed to produce an amount of X_t.

Since roundwood demand is determined to a significant degree by final product demand, one should probably include variable describing the final product demand. Simplifying the model, we can derive the demand function for roundwood.

$$R_t = f(P_t, DX_t) \quad (2)$$

where R_t is roundwood demand, P_t is roundwood price, and DX_t is the domestic usage of final product.

Consequently, we can express the empirical equation of Korean roundwood demand as

$$QD_t = a_0 + a_1 P_t + a_2 \overline{P}_t + a_3 GDP_t + a_4 D + \varepsilon_t \quad (3)$$

where QD_t is roundwood quantity, P_t is roundwood price, $\overline{P}_t$ is substitute price, GDP_t is gross domestic product, D is dummy variable, and ε_t is error term.

GDP was used as a rough proxy for the domestic usage of final product. Dummy variable was used to solve the problem of unrealistic assumption that roundwood consumption propensity is the same all over the whole period. That is, it was used to reflect the abrupt change in socio-economic situation influencing on roundwood consumption or the change in roundwood consumption structure itself occurring over long time. Especially, in the case of Korea that roundwood consumption structure connects with foreign sector closely, the assumption that roundwood consumption structure maintains identically over long time is unrealistic. So, the usage of dummy variable is necessary.

It was assumed that increases in substitute price and gross domestic product effect positively roundwood demand, while an increase in own price decreases its demand, which implies that $a_1 \leq 0$, $a_2 \geq 0$ and $a_3 \geq 0$ in equation (3).

Equation (3) was estimated by ordinary least squares (OLS) method using software EViews 3.1.

2) Time-series model

A univariate time series model, the Box-Jenkins ARIMA model provides a method of decomposing the demand quantity series into its components, such as autoregressive(AR) and moving average(MA). The general autoregressive-moving average model of order p and q, denoted by ARMA(p, q), is given by

$$Y_t = \alpha_1 Y_{t-1} + \ldots + \alpha_p Y_{t-p} + \xi_t + \beta_1 \xi_{t-1} + \ldots + \beta_q \xi_{t-q}, \xi_t \sim NID(0, \sigma^2) \quad (4)$$

Univariate ARIMA models are often used for prediction, but the prediction is naive in the sense that it just extrapolates on the past movement of the series under consideration. However, at a minimum, the prediction provides a yardstick for assessing the performance of more elaborate multivariate models. The most simple univariate model is the random walk, which is just an AR(1) process.

$$Y_t = \alpha Y_{t-1} + \varepsilon_t, \varepsilon_t \sim N(0, \sigma^2 I) \quad (5)$$

where α=1, and the optimal prediction for the next period is simply the current value, regardless of the prediction horizon. Due to the trends of the roundwood consumption series, a random walk with drift dummies was chosen as the baseline model for prediction.

$$QD_t = a_0 + a_1 QD_{t-1} + a_2 D + \varepsilon_t \quad (6)$$

where is QD_t roundwood quantity, QD_{t-1} is roundwood quantity one year before, D is dummy variable, and ε_t is error term.

Equation (6) was estimated by ordinary least squares (OLS) method using software EViews 3.1. The lagged value of endogenous variable appeared only on the right-hand side of the equation. So, there was no simultaneity. Therefore, OLS estimation can produce efficient estimates.

3. Prediction accuracy

There are a number of different measures of prediction accuracy, none of which can be regarded unambiguously as the best. The most widely used measure is probably the root mean squared error(RMSE), given below.

$$RMSE = \sqrt{\frac{1}{h+1}\sum_{t=s}^{s+h}(f_t - a_t)^2} \quad (7)$$

where the prediction sample is t=s, s+1,..., s+h, h being the number of prediction periods, and the actual and predicted values in period t are denoted as a_t and f_t, respectively. The prediction error statistics depend on the scale of dependent variable, but since we are comparing predictions for the same series across different models, this is not a problem.

The RMSE can be decomposed to three components; the bias proportion, variance proportion, and covariance proportion. The bias proportion indicates how far the mean of the predictions is from the mean of the actual series, variance proportion indicates how far the variation of the predictions is from the variation of the actual series, and covariance proportion measures the remaining unsystematic prediction errors.

Results and Discussion

1. Function estimation

1) Softwood roundwood demand function

(1) Econometric model

Equation (8) is the result of softwood roundwood demand estimation by econometric model. Softwood roundwood demand(QSD_t) was explained by own price(SP_t), hardwood roundwood price(HP_t), gross domestic product(GDP_t), and dummy variable(D). Dummy variable was used to reflect the late 1990's (1998) when roundwood consumption decreased abruptly because of economic recession. T-statistics are in parentheses below the coefficients.

$$\underset{(0.75)}{QSD_t = 728.6} - \underset{(-1.31)}{12.3SP_t} + \underset{(4.65)^{***}}{24.0HP_t} + \underset{(5.57)^{***}}{0.1GDP_t} - \underset{(-2.09)^{**}}{923.9D} \quad (8)$$

The result showed that the coefficient signs of all variables were as expected. The detailed test results are shown in Table 1. The econometric model has good explanatory power. And there is no autocorrelation.

(2) Time-series model

Equation (9) is the result of softwood roundwood demand estimation by time-series model. Softwood roundwood demand of any period(QSD_t) was explained by the demand in the previous period(ASD_{t-1}). Dummy variable was used to reflect the late 1990's (1998) when roundwood consumption decreased abruptly because of economic recession. T-statistics are in parentheses below the coefficients.

$$QSD_t = 612.3 + 0.90QSD_{t-1} - 474.6D \qquad (9)$$
$$\quad (1.82)^{*} \quad (11.40)^{***} \quad (-0.95)$$

The result showed that the coefficient signs of all variables were as expected. The detailed test results are shown in Table 1. The time-series model has good explanatory power. And there is no autocorrelation.

Table 1 compared the estimation results of softwood roundwood demand function by models. The significance levels of F-statistics in both models rejected the hypothesis that all coefficients are zero. In the case of softwood roundwood demand function, the estimation by econometric model showed higher explanatory power than that by time-series model.

Table 1. Comparison of the estimation results of softwood roundwood demand function by models.

	F-ratio	P>F	Adj.R^2	DW
Econometric	73.11***	0.00	0.91	2.08
Time-series	65.90***	0.00	0.81	2.36

***Reject the null hypothesis that all coefficients are zero at 1% significance level

2) Hardwood roundwood demand function

(1) Econometric model

Equation (10) is the result of hardwood roundwood demand estimation by econometric model. Hardwood roundwood demand(QHD_t) was explained by own price (HP_t), softwood roundwood price(SP_t), gross domestic product(GDP_t), and dummy variable(D). Dummy variable was used to reflect the late 1970's (1977-1979) when plywood export was the highest. T-statistics are in parentheses below the coefficients.

$$QHD_t = 1145.5 - 17.8HP_t + 37.4SP_t + 0.1GDP_t + 3398.1D \qquad (10)$$
$$(1.08) \quad (-2.07)^{*} \quad (3.99)^{***} \quad (1.90)^{*} \quad (10.02)^{***}$$

The result showed that the coefficient signs of all variables were as expected. The detailed test results are shown in Table 2. The econometric model has good explanatory power. And there is no autocorrelation.

(2) Time-series model

Equation (11) is the result of hardwood roundwood demand estimation by time-series model. Hardwood roundwood demand of any period(QHD_t) was explained by the demand in the previous period(QHD_{t-1}). Dummy variable was used to reflect the late 1970's (1977-1979) when plywood export was the highest. T-statistics are in parentheses below the coefficients.

$$QHD_t = 389.6 + 0.35QHD_{t-1} + 2311.8D \qquad (11)$$
$$(5.31)^{***} \quad (2.89)^{**} \quad (4.98)^{***}$$

The result showed that the coefficient signs of all variables were as expected. The detailed test results are shown in Table 2. The time-series model has good explanatory power. And there is no autocorrelation.

Table 2 compared the estimation results of hardwood roundwood demand function by models. The significance levels of F-statistics in both models rejected the hypothesis that all coefficients are zero. In the case of hardwood roundwood demand function, the estimations by econometric and time-series model showed similar explanatory power.

Table 2. Comparison of the estimation results of hardwood roundwood demand function by models.

	F-ratio	P>F	Adj.R^2	DW
Econometric	29.92***	0.00	0.88	1.71
Time-series	55.07***	0.00	0.87	2.09

***Reject the null hypothesis that all coefficients are zero at 1% significance level

2. Prediction accuracy

1) Softwood roundwood demand function

We can compare the prediction accuracy of softwood roundwood demand function by models on the basis of the residual mean square errors(RMSE) and its components. Table 3 is the result of comparing the prediction accuracy of softwood roundwood demand function by models. The lower the RMSE value, the better the prediction. For the econometric model, less than one percent of the prediction error consisted of systematic bias, while for the time-series model, nine percent of the prediction error consisted of systematic bias. The variance

Table 3. Comparison of the prediction accuracy of softwood roundwood demand function by models.

Model	RMSE	Bias proportion	Variance proportion	Covariance proportion
Econometric	555.05	0.00	0.02	0.98
Time-series	1173.98	0.09	0.38	0.53

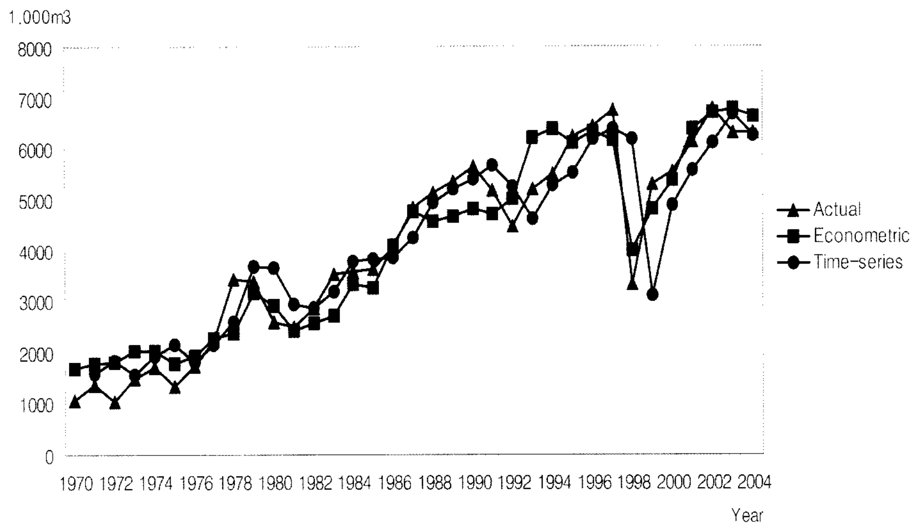

Figure 2. Comparison of the actual and estimated values of softwood roundwood consumption by models.

proportion is smaller for the econometric model. For the time-series model, 53 percent of the prediction error is totally random, but for the econometric model, this value is as high as 98 percent. That is, most of the predicted errors from the econometric model are due to nonsystematic random noise. In summary, based on the RMSE and its decomposition, the econometric model provides better predictions than the time-series model. That is, the softwood roundwood demand can be more accurately predicted by econometric model than by time-series model in Korea. The estimated values from the econometric and time-series models and the actual values of softwood roundwood consumption are shown in Figure 2.

2) Hardwood roundwood demand function

We can compare the prediction accuracy of hardwood roundwood demand function by models on the basis of the residual mean square errors(RMSE) and its components. Table 4 is the result of comparing the prediction accuracy of hardwood roundwood demand function by models. The RMSE values are similar for both econometric and time-series models. For both econometric and time-series models, less than one percent of the prediction error consisted of systematic bias. The variance proportions are similar for both econometric and time-series models. And the covariance proportions are also similar for both models. In summary, based on the RMSE and its decomposition, the econometric and time-series models appear to provide roughly equally good predictions. That is, the hardwood roundwood demand can be

Table 4. Comparison of the prediction accuracy of hardwood roundwood demand function by models.

Model	RMSE	Bias proportion	Variance proportion	Covariance proportion
Econometric	463.37	0.00	0.03	0.97
Time-series	489.63	0.00	0.06	0.96

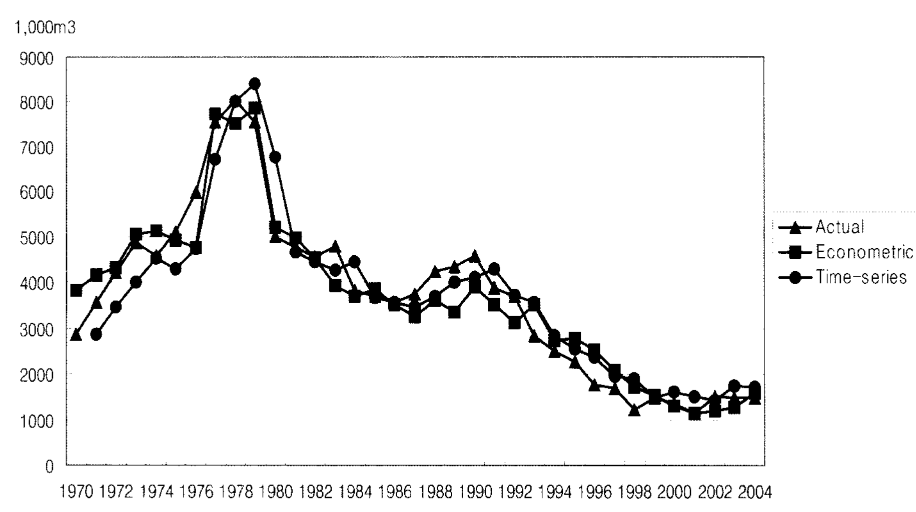

Figure 3. Comparison of the actual and estimated values of hardwood roundwood consumption by models.

series models in Korea. The estimated values from the econometric and time-series models and the actual values of hardwood roundwood consumption are shown in Figure 3.

Conclusion

This study presented a first attempt to compare the roundwood demand prediction accuracy of econometric and time-series models using Korean data. The roundwood was divided into softwood and hardwood by species. The econometric model of roundwood demand was specified with four explanatory variables; own price, substitute price, gross domestic product, dummy. The time-series model was specified with lagged endogenous variable. The dummy variable reflected the abrupt decrease in roundwood demand in the late 1990's in the case of softwood roundwood, and the boom of plywood export in the late 1970's in the case of hardwood roundwood. On the other hand, the prediction accuracy was estimated on the basis of Residual Mean Square Errors (RMSE).

In the case of softwood roundwood demand function, the estimation by econometric model showed higher explanatory power than that by time-series model. And the softwood roundwood demand prediction can be performed more accurately by econometric model than by time-series model.

In the case of hardwood roundwood demand function, the estimations by econometric and time-series model showed similar explanatory power. And the prediction accuracies of hardwood roundwood demand was similar in the case of using econometric and time-series model.

References

1. Hall, R., Lilien, D., Sueyoshi, G., Engle, R., Johnston, J., and Ellsworth, S. 1999. EViews manual. Quantitative Micro Software Inc.
2. Kim, J. and Park, H. 1980. The research on Korean long-term timber demand prediction. J. of Korean Forest Society 50: 29-35.
3. Korea Customs Service. 2005. Statistical Yearbook of Foreign Trade.
4. Korea Forest Service. 2005. Statistical Yearbook of Forestry.
5. Korea Forest Service. 2005. Statistics of Forest Products' Trade.
6. Korea National Statistical Office. 2005. Korean Statistical Information System.
7. Oh, H. and Lee, K. 1980. The outlook of Korean timber industry and market.Research paper of Korea Rural Economic Institute 14.
8. Park, T. and Cho, E. 1989. Korean long-term timber demand prediction. Research paper of Korea Forest Policy Research Forum.
9. Seok, H. 1992. The economic analysis of Forestry in Korea. Research paper of Korea Rural Economic Institute 264.
10. Sung, G. 1986. The research on consumption trend and demand prediction of timber in Korea. Research paper of Korea Forest Research Institute 35: 33-42.
11. Youn, Y. and Kim, E. 1992. The research on timber demand in Korea. J. of Korean Forest Society 81: 124-138.

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