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# The factors influencing corrugated board supply and demand In Iran: Simultaneous equations models

Ajang Tajdini\*, Amir Tavakkoli, Ahmad Jahan Latibari and Mehran Roohnia

Department of Wood and Paper Science and Technology, Karaj Branch, Islamic Azad University, Karaj, Iran, P. O. Box 31485-313, Karaj, Iran.

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Corrugated board is considered as a valuable commodity for packaging at both international and domestic markets. Therefore, for the development of corrugated board production industry in Iran and understanding the variation in demand and supply for this product, it is necessary to identify the consumption and production patterns as well as the most important and effective variables on its status. Based on this information, forecasting the future situation will be possible. In this study, due to the existence of reciprocal relation between demand and supply, the simultaneous equations system was used. Coefficients of the model were estimated applying 3-stage least squares (3SLS) procedure with the time series data from the duration of 1981 to 2007. The study results indicated that in the demand function, the variables including, intercept, GNP in previous period, population, consumer price index (CPI), added value of industrial sector (AVOIS), the war dummy is significantly influential at 0.05% level. However, the price variable did not show any effect that indicates that this product is a necessity good. In the supply function, intercept, consumption, production and imports quantities in previous period, inflation rate and price in previous period simultaneously influence corrugated board production. The absence of any relation between product price/raw material price ratio and production also proves that the corrugated board is a necessary good, because the impacts of explanatory variables on its supply and demand are consistent with economic theories.

**Key words:** Simultaneous, supply, demand, corrugated board, Iran.

## INTRODUCTION

Development and expansion of packaging industry facilitated the rapid expansion of corrugated board production. Furthermore, the unique characteristics especially ease of recycling helped corrugated board to be considered as valuable commodity for packaging. Consequently, there has been astonishing interest in both production and consumption of corrugated board. Tavakkoli (2009) reported that the production and consumption quantities of this product in Iran have gradually increased from 97500 and 97000 tons in 1981 to 452000 and 445000 tons, respectively, in 2007. This indicates the average annual growth rate of 13.46 and

13.28% for corrugated board production and consumption. The data reveal that in the studied period, almost all of total consumption was supplied through domestic production. Even though, forest rich countries are fortunate to be able to produce this type of board, but others are suffering from limitation in raw material supply and they are mostly dependent on recycling old corrugated containers to fulfill the demands. In this respect, Iran is operating two mills producing liner board and fluting paper from hardwood virgin pulp. However, the capacity of these mills is not sufficient to satisfy the national needs.

Therefore, 12 mills using old corrugated container (OCC) as raw material are also operating in this sector. Even though, the data from one Middle East country is reported but it is representative of almost all Middle East and Central Asian countries.

\*Corresponding author. E-mail: [ajang.tajdini@kiau.ac.ir](mailto:ajang.tajdini@kiau.ac.ir). Tel: +98 261 3203575.

Therefore, as a consequence of raising consumption and the strategic importance of corrugated board as well as its relatively high advantages of production, establishing of new mills to produce this commodity is among the countries investment priorities. To provide sufficient and needed information for the development of this industry, it is necessary to provide better understanding of the forces driving the demand and supply of corrugated board.

Irrespective of the fact that numerous studies have concentrated on the variables which determine the supply, demand and price of different commodities, but only few researchers studying the pulp and paper industry actually addressed the issue of simultaneity. Most of the previous research examined the demand and price functions individually. These studies cover the work of Prestemon and Buongiorno (1993), Brooks et al. (1995), Aftasi (1996), Chas-Amil and Buongiorno (2000), Kangs and Baudin (2003) and Hemmasi et al. (2006).

In this respect, the demand and supply relations can be estimated using traditional 2-stage least squares (2SLS) method. Even though this method was initially developed based on the assumption that all the available data are stationary, but Hsiao (1997a, b), Hsiao et al. (2005), Golinell and Rovelli (2005) and Shrestha and Tan (2005) have extended the application of the structural dynamic simultaneous equations models on non-stationary variables. Luo (2003) estimated U.S linerboard supply and demand functions using simultaneous equations system for the monthly data from January, 1982 to December, 1999 applying 2SLS procedure.

The results indicated that linerboard is price and income inelastic, and plastic packaging should be considered as substitute material. The use of a production function approach, which can be used to develop either cost or profit functions, is another procedure to derive the output demand and input supply functions through the application of Hotelling's Lemma to the profit or cost function as a dual of the production function.

Nagubadi and Zhang (2006) used an econometric approach to study the production structure and input substitution in sawmill and wood-preservation industry in Canada from 1958 to 2003. Unlike the index number approach, the econometric approach (trans-log function) enables researchers to estimate the parameters of interest, that is, elasticities of factor substitution, elasticities of factor demand, and economics of scales. Li (2009) for masters of science thesis used a trans-log cost function to specify the production structures of the softwood lumber industry in three U.S. regions (the West Coast, the Inland, and the South), and four Canadian regions (Ontario, the British Columbia Coast, the British Columbia Interior and Quebec), from 1988 to 2005.

First, two separate production models were specified and analyzed; one was a "U.S. model" for the U.S. regions, and the other was a "Canada model" for the Canadian regions. Second, all seven regions were included in one production model, a "U.S.-Canada

model".

The term "stationary" is used to define a condition that must be assessed for time series analysis. A time series is said to be stationary if the mean and auto-covariance of the series do not depend on time. This means that the series does not have an upward or downward trend over time. Standard estimation procedures cannot be applied to a model that contains a non-stationary variable (Hamilton, 1994).

Also, a non-stationary time series has a possibility of spurious regression. This means that in regression a time series variable on another time series variable(s), one often obtains a very high  $R^2$  (in excess of 0.9) even though there is no meaningful relationship between the two variables. Sometimes we expect no relationship between two variables, yet a regression of one on the other variable often shows a significant relationship. This situation exemplifies the problem of spurious, or nonsense regression (Gujarati, 2004). Therefore, we should check whether a series is stationary or not before using it in a model. The formal method of testing the stationary character of a series is the unit root test.

An appropriately specified demand and supply econometric model that estimates total consumption and production is helpful to describe the interaction of consumers and corrugated board industries. Such a model characterizes the effects of factors influencing the balance between quantities consumed and produced, as well as the price and income of corrugated board production. The model can also be used to estimate the effects of explanatory variables on market conditions. The purpose of this study is to estimate a system of dynamic econometric model using annual data for the period of 1981 to 2007 and systematic approach of iterative 3-stage least squares (3SLS). The reason to use simultaneous equations is the existence of reciprocal relations between economic variables in our research, such as the volume of supply and demand.

Furthermore, in this system due to the existence of the correlation between residual terms in structural equations of supply and demand, the 3SLS method was selected. This method is different from 2SLS method. The three-stage least-squares method generalizes the two-stage least-squares method to take account of the correlations between equations in the same way that SUR generalizes OLS.

In fact, the difference between 2SLS and 3SLS is in correlation between the error terms across the equation. The strength and perfection of this method among the other systemic approaches with full information maximum likelihood (FIML) is another reason.

However, both methods are consistent and efficient (Gujarati, 2004). Price elasticities of corrugated board supply and demand can be derived from the estimated model. By comparing the result of our model with those of previous studies, this research emphasizes the implication of including delayed (lagged) quantity dependent variables in market modeling.

## MODEL SPECIFICATION AND DATA

In order to enrich and strengthen our understanding of corrugated board industry as well as to obtain consistent estimates of both the supply and demand in Iran as a representative country in the Middle East, we incorporated some degree of oligopoly in our research. Despite stiff competition exists in Iran corrugated board industry, but due to formation of association among the producers and low import price, a kind of hidden oligopoly is imposed in the market.

Meanwhile, demand and supply of corrugated board in Iran as endogenous variables were considered as a function of several explanatory variables. The procedure used in selecting the variables was based on the theoretical background of demand and supply theories and influential macroeconomic data.

Corrugated board supply and demand were estimated by applying simultaneous equations according to the 3SLS procedure and the time series data for the period of 1981 to 2007. The functional form for supply and demand equations was in the form of log-log equations, which allows direct interpretation of estimated coefficients in terms of elasticity (Gujarati, 2004). This model includes two logarithmic equations for supply and demand, and each for corrugated board is defined subsequently.

### Demand function

The demand for corrugated board is a function of variation in influential variables including macroeconomic data and other variables based on the law of demand so, we assume the demand equation as follows:

$$\ln X_t^d = C_1 + C_2 \ln P_{X_t} + C_3 \ln GNP_{t-1} + C_4 \ln J_t + C_5 \ln CPI_t + C_6 \ln AD_t + C_7 \ln IP_t + C_8 D59_t + C_9 D69_t + U_t^d \quad (1)$$

In the previous equation,  $X_t^d$  is the corrugated board demand,  $P_{X_t}$  is the domestic corrugated board price as the most important effective factor,  $GNP_{t-1}$  is the gross national product of Iran in the previous,  $J_t$  is the population of Iran,  $CPI_t$  is the consumer price index as an index of consumer goods and services price,  $AD_t$  is the added value for the industry sector of Iran due to the use of corrugated board mainly as a packaging material in industries,  $IP_t$  is the production Index of large-scale mills in Iran,  $D59_t$  and  $D69_t$  are the war and subsidy dummy variables in the studied period  $U_t^d$  is a demand residual term.

According to the foregoing function, it is expected that the coefficient sign of variables will be as follows:

$$C_2 < 0, C_3 > 0, C_4 > 0, C_5 < 0, C_6 > 0, C_7 > 0, C_8 > 0, C_9 > 0$$

### Supply function

The derived log-transformed corrugated board supply equation can be expressed as a function of influential variables based on supply theory. Similar to the demand equation, the corrugated board supply equation includes variables from previous year (lagged quantity) to represent delayed responses to market signals.

$$\ln X_t^s = C_{10} + C_{11} \ln X_{t-1}^s + C_{12} \ln X_{t-1}^d + C_{13} \ln IF_t + C_{14} \ln (P_{X_{t-1}} / P_{S_{t-1}}) + C_{15} \ln IM_{t-1} + C_{16} \ln PI_{t-1} + C_{17} D59_t + C_{18} D69_t + U_t^s \quad (2)$$

Where  $X_t^s$  is the corrugated board supply,  $X_{t-1}^s$  is the supply quantity in the previous period,  $X_{t-1}^d$  is demand for corrugated board in the previous period,  $IF_t$  is the rate of inflation,  $P_{X_{t-1}} / P_{S_{t-1}}$  is the product price in the previous period - the raw material price in the previous period as a ratio of corrugated board,  $IM_{t-1}$  is the quantity imported

of particleboard to Iran in the previous period,  $PI_{t-1}$  is the production costs of corrugated board in the previous period.

The lagged dependent variables were included in the corrugated board supply model because according to dynamic equilibrium of supply and demand, any changes in supply of corrugated board will occur after that the first lag in these variables.  $D59_t$  and  $D69_t$  are the war and a subsidy dummy variable in the studied period and  $U_t^s$  is the supply residual terms. It is expected that the coefficient sign of variables will be as follows:

$$C_{11} < 0, C_{12} > 0, C_{13} < 0, C_{14} < 0, C_{15} > 0, C_{16} < 0, C_{17} > 0, C_{18} > 0$$

The consumption data is evaluated based on an apparent consumption method (consumption = domestic production + import - export). The time series data were obtained from different sources in Iran for the period of 1981 to 2007. Available and dependable sources of the data includes Iran corrugated Board Manufacturer Association, Statistical Center of Iran, the Ministry of Industries and Mines, and Iran Foreign Trade Annual Book. All data related to consumer price index (CPI), production Index of large-scale mills, added value for the industry sector, and gross national product (in billion rials) as well as the annual rate of inflation were collected from the Central Bank of Iran, and the values were deflated based on the year 1997.

Since, we were faced with imposed war for the period of 1980 to 1987, and it influenced both the production and consumption of goods such as corrugated board, then this factor was used as a dummy variable.

Also, since prior to 1990, government allocated subsidy to corrugated board, therefore, to determine the impact of this factor on production and consumption, we added the subsidy dummy variable.

Recently, we are faced with the introduction of plastic containers as substitute for corrugated board cartons. However, this product was introduced since 2001. Therefore, it is not included in our estimation. Also, the lack of import for corrugated board prior to 1996, in this equation, import quantity in previous period is applied without logarithmic form. For this period, this variable takes zero and since there is not zero  $\ln$ , therefore the import variable in studied period is used without  $\ln$  in the equation. To find out if any series is stationary, the regression was run on:

$$y_t = c + \sum_{i=1}^n \alpha_i y_{t-i} + u_t \quad (3)$$

Where  $y_t$  is the vector of Iranian demand and supply quantities of corrugated board. Also, it was found if the absolute value of any  $\alpha_i$  was statistically equal to one on the basis of the  $t$  statistic. The estimated coefficient was divided by its standard error to compute the statistics, and the results were referred to the Dickey-Fuller table. If the absolute computed value exceeded the Dickey-Fuller absolute critical value, then the hypothesis that the given time series is non-stationary was rejected. If, on the other hand, it was less than the absolute critical value, the time series was found to be non-stationary.

The tests was run with an intercept and a trend and intercept but not a trend. If the series was non-stationary, it was transformed by taking the first differences over 1 year. The previous procedure was repeated until a stationary series was achieved (Kim et al., 2003).

Lags of exogenous and endogenous variables have impacts on corrugated board supply and demand because response of dependent variables to changes in independent variables may take several time periods. However, these lagged variables are mainly correlated with current corrugated board supply.

## RESULTS

The results of the unit root test indicate that, except of the

variable of inflation rate that in the logarithmic form was stationary at the 5%, the first and second differentiation of other variables in their log-transformation will be stationary. Therefore, variables are designated as  $I(0)$ , or integrated of the order 0,  $I(1)$ , or integrated of the order 1,  $I(2)$ , or integrated of the order 2, and then introduced to the model. Before the estimation, we examined the equations considering the identifiability and all of them are assigned the order and rank conditions over the identified condition. Then, we were able to estimate the coefficients that are summarized in Table 1.

As observed in the demand function, the intercept (the average effects of all omitted variables from model on dependent variable) was estimated as -0.13, which is significant at the 5% level. Price elasticity of demand for particleboard was estimated at -0.65, which is not significant, indicating that this variable does not affect the demand.

Buongiorno and Kang (1982) expressed that the short term price elasticity is in the range of -0.10 for paper to -0.25 for paper and board in the U.S market. Chas-Amil and Buongiorno (2000) found that the demand for paper and paperboard was price-inelastic in the European Union, with price elasticities ranging from 0.13 to 0.30.

The coefficient of gross national product in the previous year was estimated as 0.32, which is significant at 5%. The coefficient shows that a one percent increase in GNP in the previous year causes the current demand for corrugated board to increase by 0.16%, and a positive sign of the coefficient was also expected.

Also, the small income elasticity is in accordance with other studies. Luo (2003) in similar research on linerboard acknowledged that income elasticity for short-run are 0.17 to 0.25 and suggested that linerboard is a normal commodity. The other important variable affecting demand for a given good is population.

The results show that the coefficient of this variable is estimated as 21.40, which indicate that any one percent increase in population could increase corrugated board demand by 21.40%. The coefficient of consumer price index variable is estimated as 2.07, which indicates that this variable has negative effect on demand for corrugated board. This enables us to express that any one percent increase in CPI could decrease the demand for corrugated board by -2.07%. The coefficient of added value for the industrial sector variable is estimated as 2.36 that shows one percent increase in this index could increase demand for corrugated board as packaging material by 2.36%. The coefficient of production index of large – scale mills variable was not significant.

Therefore this variable has no effect on demand for corrugated board, because it has been observed that large size household commodities are being packed by shrink packing which is being increasingly used in industrialize countries.

The coefficient of war dummy variable is estimated as 0.25 which is significant at 5%. In the derived function, the coefficient of determination ( $R^2$ ) was calculated as

0.87, which indicates that explanatory variables are responsible for 87% of the variation of the dependent variable. This is the reason for the best fit of the demand function.

In the supply function, the intercept was estimated as 0.07, and it was not statistically significant. The corrugated board supply coefficient with the first lagged quantity was estimated as -26.07, which indicates that any increase in supply of corrugated board in the previous year will decrease the domestic production by 26.07%. The coefficient of demand quantity with the first lagged quantity was estimated as 24.81, which indicates that any one percent increase in corrugated board demand in the previous year will increase the supply in the following year by 24.81%.

The coefficient of rate of inflation variable was estimated as -0.09 that indicates one percent increase in inflation rate in the country could decrease the corrugated board production by 0.09%. The coefficient of the product price-raw material price ratio with the first lagged quantity was not significant at the 5% level. The coefficient of the first lagged quantity of import variable was estimated as -0.0001, which indicates that any increase in imports of corrugated board in the previous year will decrease the domestic production quantity by 0.0001%.

The minus sign of the coefficient is completely in accordance with our expectations, although the small value of the coefficient reveals that corrugated board is fairly inelastic with respect to imports. The coefficient of cost price variable for corrugated board in the previous years was estimated as -0.55 that indicates one percent increase in production costs of the mentioned product could decrease its supply by 0.55% in the following year. The coefficient of determination ( $R^2$ ) was evaluated as 0.91, indicating that explanatory variables will respond to 91% of dependant variable (supply) variations.

## DISCUSSION

The results of simultaneous estimation of corrugated board supply and demand equations using the available annual data for the period of 1981 to 2001 and the 3SLS procedure revealed interesting findings. The strength of the applied system lies in its potential to handle the existence of interactions among variables and the robust results derived from the utilized data.

The ineffectiveness of the corrugated board price on its demand indicates that this commodity as a necessity good plays an essential role in industrial goods packaging and consequently consumers are obligated to buy it at any cost. Although, such finding is not consistent with previous studied. For example, Luo (2003), Buongiorno and Kang (1982) and Chas-Amil and Buongirono (2000) found that the response of demand to price for paper and paperboard is significant but inelastic (small magnitude of own-price elasticity).

The positive effect of GNP in the previous year on the

**Table 1.** Demand and supply 3SLS estimates.

Variable	Coefficients	Standard error	T Statistics
<b>Demand function <math>\text{LnX}_t^d</math> : Dependent variable</b>			
Constant	-0.13	0.06	-1.89
$\text{LnPX}_t$	0.26	0.19	1.39
$\text{LnGNP}_{t-1}$	0.16*	0.05	2.10
$\text{LnJ}_t$	21.40*	9.14	2.34
$\text{LnCPI}_t$	-2.70*	0.58	-3.52
$\text{LnAD}_t$	2.36*	0.94	2.50
$\text{LnIP}_t$	1.22	1.006	-1.21
D59 <sub>t</sub>	0.25*	0.05	4.38
D69 <sub>t</sub>	0.29	0.07	1.57
R <sup>2</sup> =0.87			
<b>Supply function <math>\text{LnX}_t^s</math> : Dependent variable</b>			
Constant	-0.07	0.11	-0.64
$\text{LnX}_{t-1}^s$	-26.07*	9.33	-2.79
$\text{LnX}_{t-1}^d$	24.81*	9.26	2.67
$\text{LnIF}_t$	-0.09*	0.04	-2.43
$\text{Ln}(PX_{t-1}/PS_{t-1})$	-0.34	0.79	-0.43
$\text{IM}_{t-1}$	-0.0001*	3.78E-0.5	-2.80
$\text{LnPT}_{t-1}$	-0.55*	0.13	-3.95
D59 <sub>t</sub>	0.02	0.08	0.29
D69 <sub>t</sub>	-0.12	0.08	-1.45
R <sup>2</sup> =0.91			

\*indicates Statistical significant at 5% level.

current demand for corrugated board indicates that in case the economic situation improves, then the industrial activities and performance will pick up and consequently industrial production and consumption of more packaging material in the following year will rise.

According to demand theory, the consumers' population is an effective explanatory variable; therefore, the correlation between population and demand indicates that any increase in population will cause higher consumption of all kinds of goods and services which initiates higher needs for packaging.

The negative influence of changes in the CPI indicates that any fluctuation in the prices paid for consuming goods and services will affect the demand for corrugated board as well as its price, again indicating that the studied product is a normal commodity. Such finding is completely consistent with macroeconomic theories and definition of consumer price index.

There is a positive relationship between the added value for industrial sector and corrugated board demand, which indicates that, while the different industries in any country will produce more goods to reach more income and consequently demand for packaging material will increase.

The absence of a significant effect of the production index of large-scale mills on demand for corrugated

board indicates that this product is used to pack various products of small-scale mills and is a common packaging material among all producers and various products.

An interesting variable in our study is the war dummy variable inserted in the equations due to imposed war, which indicates that there is a positive effect between this variable and demand for corrugated board. This finding indicates that upon beginning of the imposed war against Iran, demand for corrugated board was increased because country was forced to develop fast dispatch and forwarding of different products to the front lines and consequently the demand increased. Of course, this is on the contrary to common believe that if any country is in the war economy, then the consumption of common goods will decrease, but corrugated board is unique, because of its packaging potential.

To our knowledge, during World War II, corrugated board industry was faced with similar situation and was able to fulfill the needs of war logistics by producing more suitable packaging material for the dispatch of war needed commodities to the front countries, which Iran had to do during imposed war.

The adverse impact of the supply in the previous year on the current supply indicates that in case of corrugated board, the producers supply is greater than the available demand (excess supply). Thus, due to decrease in the

market price, the production quantity in the following period will decrease. The increase in the current supply of corrugated board due to increased demand in the previous year, proves that the manufacturers desire to achieve higher income and consequently more profit.

It is obvious to observe that the rate of inflation did not cause any positive effect on corrugated board, because such relationship is quiet evident. Any increase in this rate is due to ascending growth of prices and as a result decreases the demand for different products and their supply. It is obvious to observe that the rate of inflation did not cause any positive effect on corrugated board, because such relationship is quiet evident. Any increase in this rate is due to ascending growth of prices and as a result decreases the demand for different products and their supply. The adverse impact of corrugated board import in a previous year on the current supply indicates that any increase in import of the product will reduce its price in the domestic market and therefore, producers are likely to continue the trend of reducing price in the following year, which will decrease the supply of studied product.

Although, based on the mentioned results, this product is inelastic with respect to imports. The lack of relation between product price versus raw material price ratio in the previous year with current supply of corrugated board shows that this product is a necessity good and there is sufficient demand for it.

Therefore, the price fluctuations impose any influence on its production. The negative relation between cost price in the previous year and current supply of corrugated board is in accordance with economic theories, because any rise in the production costs of corrugated board will reduce production quantity to prevent further loss in the following year.

## CONCLUSION

The positive and negative effects of all explanatory variables on the dependent variables equations (supply and demand quantities of corrugated board) are in accordance with expectations and are based on theoretical principles (the theories of demand and supply). Corrugated board as a intermediate good for packaging is not sensitive to price changes, such finding is similar with the lack of product price versus raw material price with the first lagged on the current supply of corrugated board, although negative impact of consumer price index on demanded corrugated board is due to decrease in demand for consuming goods and services.

In contrast, Improvement indicators such as incom consumers and added-value for industrial sector is caused to increase in demand for corrugated board, therefore the rapid expansion of this industry is primarily correlated with Iran's economic development. Supplied corrugated board is affected by variables such as supply,

demand and import of this product with the first lagged, therefore the volume of demand for corrugated board is a main factor for producers.

The adverse impact of inflation rate in the supply side is similar with CPI in the demand side. The results indicated that almost all of total consumption was supplied through domestic production, so any increase in imported corrugated board is a negative factor on its production in Iran and these two products are substitute for each other.

Our estimation is based on the data from one of the Middle East countries (Iran), but in principle such results are expected to apply not only to the Middle East but also to most fiber-deficient regions.

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