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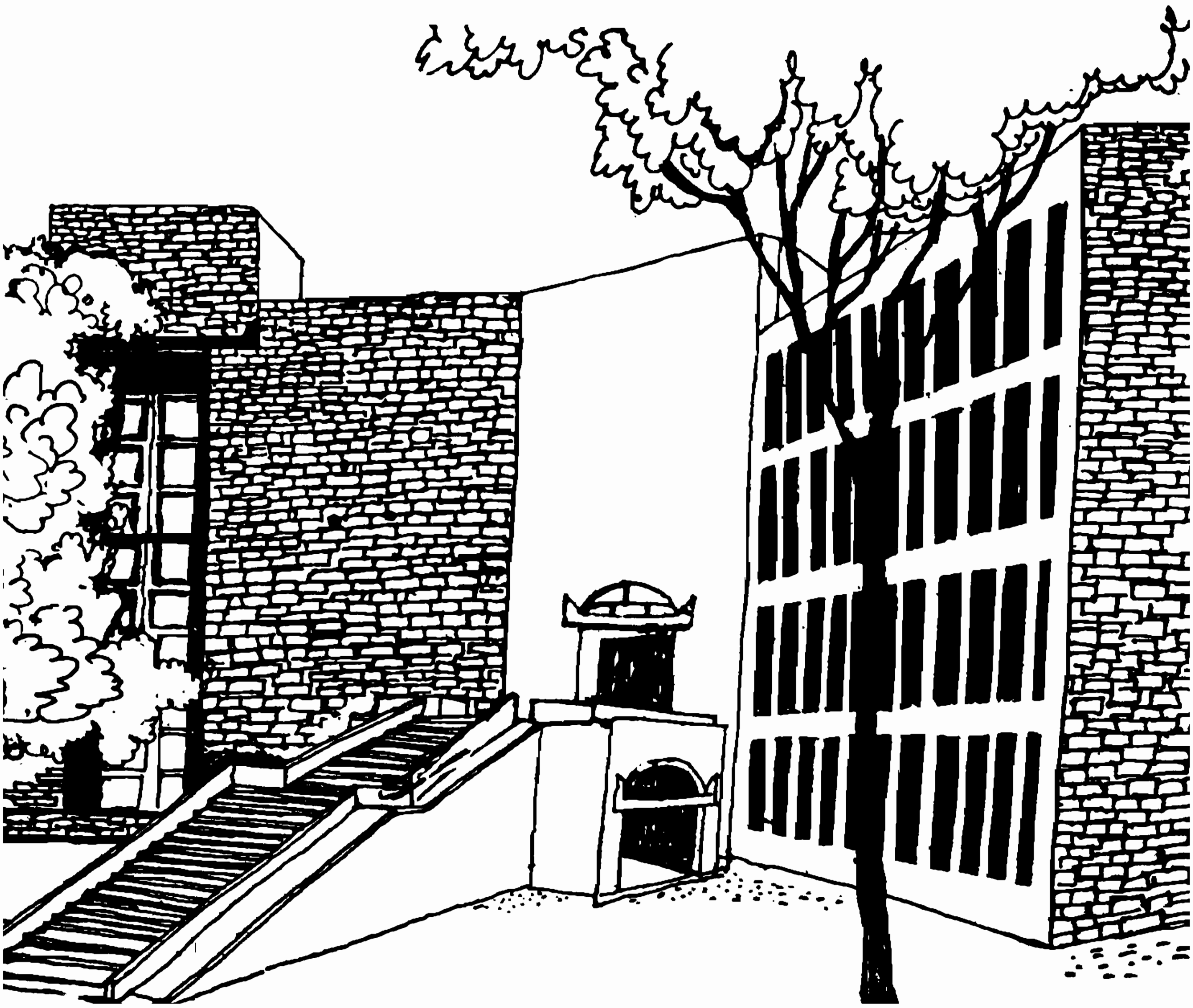

DETERMINING LAGS IN EXPORT SUPPLY FUNCTION IN INDIA

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Abstract

This paper considers a partial adjustment model of the export supply function in Indian economy at the aggregate level. A minimum of one month and a maximum of 12 months is considered as the plausible range of the length of lags in export supply in India with respect to both the independent variables - domestic production and real effective exchange rate. Instead of the distributed lag model, a specific lag in the two independent variables is simultaneously considered in the paper. Different lags in the two variables would yield alternative models for export supply in India. Since the methodology based on nested model is not likely to work efficiently in such cases, an alternative procedure is suggested here to select the most appropriate model which amounts to determining the lengths of the lags in the two independent variables in the export supply function. The paper uses monthly data on Indian exports and other variables for the period January 1982 to July 1993. It appears from the selected model that in Indian economy export supply response lags by 12 months with respect to domestic production and 5 months with respect to real effective exchange rate changes. The extra-sample forecast accuracy of the chosen lag model compares very favorably with the one based on ARIMA model. The estimates of the elasticity of export supply with respect to exchange rate changes before 5 months are 0.52 in the short run and 1.11 in the long run. It is hoped that the suggested method in the present paper is likely to work more efficiently than the nested model method of selecting the most appropriate regression model whenever a choice has to be made from among a set of highly collinear alternative independent variables.

Determining Lags in Export Supply Function in India

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I. Introduction

Exports represent excess supply from the originating country. The supply response for the exports, therefore, depends on forces determining both the domestic demand and domestic supply at the given price level. Alternatively, exports from a country can be viewed as imports of the destination countries which represent the excess demand in those countries. The export demand response would, therefore, consider forces operating in the destination countries. This distinction is crucial. If it is ignored, it can lead to misleading conclusions. Some studies on determinants of exports do not explicitly recognize such a distinction [e.g., Tyler (1973), Pomfret (1975), Ghosh (1990)]. However, there are other studies which clearly make the distinction between export demand and export supply response. [e.g., Wadhwa (1974), Ali (1984, 1987)]. In the present environment where a lot of emphasis on the export growth is placed in the country, a closer look at export supply behavior is necessary. This is not to undermine the importance of factors governing export demand. They are important, but most of them are not within our direct control. On the other hand, most of the factors governing export supply are supposed to be within our control.

To keep the investigation at manageable level with a sharp focus on the methodological aspects, we consider in the present paper only export supply function for Indian economy at the aggregate level. It is generally postulated that export supply would depend on the domestic production and price incentives available to the exporters. The main price incentive available to the exporter is in terms of the effective exchange rate of the Indian rupee in terms of other currencies. Thus, if these two factors are closely monitored through appropriate domestic policies to influence domestic production and through exchange rate policies, export supply in the system can be effectively managed. However, as is well-known the supply response of exporters takes time. It lags behind the actual changes in the policy. This happens because exports are recorded not when the orders are received by the exporters but when the consignment is made. This lag in the response of the exports is on account of both of the basic determinants, viz the production and the effective exchange rate. Since exports are excess supply, the existence of excess of domestic production over domestic demand is a pre-condition for exports. If domestic demand remains stable, increased exports can result only when the production increases in the economy. However, as soon as the production increases in the system, exports do not necessarily increase. There might be lags involved on account of official formalities to be completed if the increased production is on account of export orders already received. On the other hand, increase in production could be in anticipation of increased export orders which may require some additional marketing efforts. What is the exact length of such a lag between a change in production and a change in exports is an empirical question. It could be one month, two months or even 12 months.

Similarly, the lagged response of the exports to the changes in the effective exchange rate is well recognized in the literature. The celebrated J-curve hypothesis, now discussed even in textbooks (See for instance, Dornbusch & Fischer, 1990), postulates that quantity response of exports (as well as imports) to the depreciation or appreciation of the currency typically takes longer time depending on the institutional arrangements, legal framework and the structure of the economy. The export response usually lags behind changes in the real effective exchange rate of the currency. Again the exact length of the lag is an empirical question.

In the present paper, we address these empirical questions of determining the lengths of the lags in export supply response to the production as well as effective exchange rate variations in India. Monthly data on exports and all other variables for the period 1982 to July 1993 are used in the study. The next section is devoted to the discussion of the basic regression model used for estimating the export supply function. The third section outlines the criteria used for identifying the most appropriate lags in the export supply function. The fourth section presents results and summaries of findings of the study.

2. Regression Model

The basic regression model for export supply function is taken to be:

1) $X^*_t = a + b_1 P_{t-j} + b_2 R_{t-i} + U_t$

Where X^*_t is natural logarithm of desired level of exports in period t;
P_{t-j} is natural logarithm of domestic production in period t-j ;
R_{t-i} is natural logarithm of the exchange rate in period t-i;
U_t is the random error term, and, a, b_1, and b_2 are parameters.

Following the partial adjustment model, we can take

2) $X_t - X_{t-1} = c(X^*_t - X_{t-1})$

Where X_t and X_{t-1} are the natural logarithms of actual or realized exports in period t and t-1 respectively and c is the partial adjustment coefficient.

From (1) and (2), we can derive

3) $X_t = a\,c + b_1\, c\, P_{t-j} + b_2\, c\, R_{t-i} + (1-c)\, X_{t-1} + c\, U_t$

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Equation (3) is our basic export supply function. The parameter ($c.b_2$) represents short run elasticity, and b_2 gives the long run elasticity of export supply with respect to exchange rate changes after i months. In this equation, i and j are the unknowns representing the lengths of the lags in exchange rate and production. How to determine these unknowns is the basic problem addressed in the present paper. Before we discuss the methodology followed to resolve this problem, we may briefly explain the measurement and data sources of the variables used in the study.

Exports are measured in current (fob) rupee values. The basic source for monthly data on exports is DGCIS, and are taken from CSO's publication on *Monthly Abstract of Statistics* and *Monthly Review of Indian Economy* of CMIE. Exchange rates are measured in terms of export weighted real effective exchange rates (REER) which are obtained by considering weighted average of exchange rates of Indian rupee with 13 major currencies, the weights being determined by the value of exports to the respective countries, and then correcting the nominal effective exchange rate so obtained by the inflation rates prevailing in the countries in question. The data on REER on monthly basis are obtained from various volumes of the *Journal of Foreign Exchange and International Finance*. The exchange rates are measured as the foreign currency per Indian rupee. Thus, depreciation of Indian rupee would make our R decrease and appreciation of the rupee would make our R increase. Finally, the domestic production in the Indian economy on monthly basis is measured by the index of industrial production. This is done because: (i) data on industrial production is available on monthly basis whereas other production data are not available in satisfactory form on monthly basis; (ii) of late, there have been structural shifts in Indian exports in favor of industrial or manufactured goods which by now accounts for more than 70% of our total exports; and (iii) industrial production is likely to be much more elastic than other productions in the Indian economy. The data on index of industrial production are obtained from the *Monthly Abstract of Statistics* (CSO) and *Monthly Review of Indian Economy* (CMIE).

3. Methodology

In order to identify the most appropriate or optimal values of the unknowns i and j which represent the lags in the exchange rate (R) and production (P) variables in our regression model, we may approach the problem from the model specification angle. Since we have defined our basic regression model in equation (3) as having unique values of i and j, we may consider equation (3) with alternative plausible values of i and j as defining alternative regression models. The choice of the most acceptable model, and hence the optimal values of i and j, may then be made by fitting a comprehensive nested model. In the present case, however, the nested model is not likely to work. This is because, alternative models imply different lags in the same variables. When all these different lags are considered together in the nested model, they are most likely to give rise to the problem of multicollinearity since both the variables (R and P) are likely to be autoregressive showing considerable autocorrelation. If multicollinearity is serious, the nested model methodology becomes ineffective and unreliable in identifying the most acceptable model. (See, Gujarati, 1988; p.413-4). We may therefore, have to rely on a different methodology to identify the most acceptable model and hence the optimal values of the lags in R and P.

At the outset, we may note that our model based on economic theory must have a better prediction performance than the prediction based on autoregression of the dependent variable series. This in itself is an important criterion to short-list alternative models based on different combinations of plausible lags in R and P variables. We have considered a minimum of one month and a maximum of 12 months lag in both exchange rate and production variables as plausible range of lags for export supply function in India. In order to measure extra-sample prediction performance, the latest observations from 1993 are reserved. Conservatism dictates that the best autoregressive model has to be chosen for comparing the extra-sample prediction performance. Accordingly, the most appropriate ARIMA model is considered for generating extra-sample forecasts. [For details on the ARIMA, see Makridakis et al. (1983)]. For comparing the performance of models on extra-sample predictions, we have considered three most frequently used measures of forecast accuracy, viz. Mean Square Error (MSE); Theil's U_1 Statistics; and Average Absolute Error (AAE). [For details, see Maddala, 1977; pp.343-47].

Out of all those alternative regression models based on equation (3) above which satisfy our first criteria of generating better extra-sample prediction than the best ARIMA model, we may choose the model that performs the best in terms of intra-sample prediction performance. In other words, the model with minimum residual sum of squares (RSS) out of those qualifying by our first criterion, is identified to be the most acceptable model. The values of i and j in the selected model would then provide the most appropriate lags in the exchange rate and production variables in the export supply function. In practice, however, it is easier to generate first the matrix of RSS for all possible combinations of the lags in the two variables over the plausible range of lags in both R and P. One can, then, identify the model with lag combination having the least RSS. The test of extra-sample prediction performance can then be applied only to the identified model having the least RSS. If the model fails to meet the test, the model with the second lowest RSS can be tried and so on.

4. Results

As discussed in the previous section, it was more practical to generate the RSS matrix for models with alternative lag combinations.

Table-1 : 12 x 12 Matrix of RSS

P / R	L1	L2	L3	L4	L5	L6	L7	L8	L9	L10	L11	L12
L1	2.0890	2.0406	2.0889	2.0779	2.0724	2.0294	2.0201	2.0300	1.9186	2.0075	2.0393	1.7997
L2	2.0750	2.0221	2.0755	2.0691	2.0526	2.0165	2.0057	2.0101	1.9035	1.9809	2.0164	1.7629
L3	2.1488	2.0840	2.1509	2.1415	2.1282	2.0681	2.0683	2.0729	1.9495	2.0373	2.0681	1.7905
L4	2.1515	2.0787	2.1553	2.1443	2.1340	2.0846	2.0634	2.0796	1.9551	2.0342	2.0684	1.7748
L5	2.1439	2.0657	2.1481	2.1384	2.1275	2.0836	2.0737	2.0673	1.9557	2.0301	2.0563	1.7623
L6	2.1841	2.0921	2.1852	2.1708	2.1612	2.1115	2.1086	2.1142	1.9725	2.0690	2.0907	1.7768
L7	2.1698	2.0797	2.1713	2.1553	2.1447	2.0996	2.0962	2.1085	2.9838	2.0480	2.0858	1.7684
L8	2.1701	2.0693	2.1715	2.1506	2.1383	2.0895	2.0927	2.1049	1.9871	2.0675	2.0741	1.7739
L9	2.2203	2.1078	2.2136	2.1916	2.1730	2.1170	2.1196	2.1397	2.0140	2.1085	2.1318	1.7855
L10	2.1891	2.0858	2.1833	2.1584	2.1445	2.0851	2.0865	2.1062	1.9902	2.0794	2.1094	1.7933
L11	2.2303	2.1134	2.2195	2.1886	2.1689	2.1110	2.1071	2.1263	2.0027	2.1019	2.1330	1.8175
L12	2.2564	2.1513	2.2433	2.2152	2.1903	2.1255	2.1277	2.1420	2.0126	2.1115	2.1501	1.8270

Note : P and R represent production and exchange rate variables respectively. L1, L2,...,L12 represent lags in the variable concerned by one month, two months and so on.

Source: Computed on the basis of equation (3) in the text by considering different values of i and j.

Table-1 presents a 12 x 12 matrix of RSS for the total 1 of 144 plausible combinations of lags in exchange rate (R) and production (P) based on regression equation (3) above. As can be readily observed from the table-1, the lag of 12 months for variable P (P_{t-12}) along with the lag of 5 months for variable R (R_{t-5}) turns out to be the equation with the least RSS estimate out of the 144 alternatives considered. The second lowest RSS estimate is given by the equation using 12 months lag in variable P (P_{t-12}) and 2 months lag in variable R (R_{t-2}). The estimated regression equations for these two combinations of lags are reported below:

Model-1 :Estd. $X_t = 1.9501 + 0.52865\ X_{t-1} + 0.72508\ P_{t-12} - 0.52245\ R_{t-5}$

t-Values : (1.5293) (7.5979) (5.0701) (3.3276)

$R^2 = 0.9601$; Adj. $R^2 = 0.9591$; $F_{(3,116)} = 930.933$;

Durbin's h Statistic = 1.19; rho = - 0.0704.

Model-2 :Estd. $X_t = 2.3141 + 0.52841\ X_{t-1} + 0.67267\ P_{t-12} - 0.54860\ R_{t-2}$

t-Values : (1.6736) (7.5795) (4.5354) (3.3201)

$R^2 = 0.9601$; Adj. $R^2 = 0.9591$; $F_{(3,116)} = 930.551$;

Durbin's h Statistic = 1.005; rho = - 0.0592.

It can be seen from these estimates that in both the equations, all the parameters except constant term and Durbin's h statistic are statistically highly significant with expected signs. The short run elasticity of export supply with respect to exchange rate turns out to be 0.52 to 0.55 in both the equations. The long run elasticity estimate is also around 1.1 to 1.2 in the two regressions. The stability of these parameter estimates enhances the confidence in our results. As per our methodology we have also generated the extra-sample prediction from these two regression equations (Model-1 and Model-2) for early months of 1993. Their forecast accuracy by alternative measures are reported in *Table-2* below.

In order to determine the lags in the two variables - R and P, as per our methodology, we have to compare the extra-sample prediction performance of these equations with the one based on the autoregressive method, viz. the most appropriate ARIMA model.

For generating the forecast, we have applied the ARIMA model to the same data set, viz. January 1983 to December 1992 (i.e. 120 observations). A general ARIMA model is written as

$$\text{ARIMA } (p,d,q)\ (P,D,Q)^s$$

Where

p =	No.of non-seasonal Auto Regressive (AR) parameters
d =	No.of non-seasonal Differencing
q =	No.of non-seasonal Moving Average (MA) Parameter.
P =	No.of Seasonal Auto Regressive (SAR) parameter
D =	No.of Seasonal Differencing
Q =	No.of Seasonal Moving Average (SMA) parameter
s =	Period of Seasonality

The forecasting equation for the general ARIMA Model can be written as

$$(1-\alpha_1 B^1 - \dots - \alpha_p B^p)\,(1-\beta_1 (B^s)^1 - \dots - \beta_P (B^s)^P)\,(1-B)^d\,(1-B^s)^D X_t =$$
$$=(1-a_1 B^1 - \dots - a_q B^q)\,(1-b_1 (B^s)^1 - \dots - b_Q (B^s)^Q)e_t.$$

Where

B^i =	Backward Shift Operator, i= 1,2,....
α_j =	Coefficient of AR, j= 1,2,...,p.
β_k =	Coefficient of SAR, k= 1,2,...,P.
a_m =	Coefficient of MA, m= 1,2,...,q.
b_n =	Coefficient of SMA, n=1,2,...,Q.

The most appropriate model identified for our time series on exports was ARIMA $(0,1,1)\ (0,1,1)^{12}$. The model was validated on the basis of following criteria:
Mean Square Error (MSE)
Absolute Standard Error of the parameters
Asymptotic Correlation Matrix of the Estimated Parameters
Plot of Autocorrelation Function and Partial Autocorrelation Function of the residuals.

Forecasting equation for the best ARIMA model is

$$(1-B)\,(1-B^{12})\,X_t = (1-0.475\ B)\,(1-0.504\ B^{12})e_t$$

Std. Error = (0.087) (0.094)

If we expand this equation we will get the following:

$$\text{Estd. } X_t = X_{t-1} + X_{t-12} - X_{t-13} + e_t - 0.475\, e_{t-1} - 0.0504\, e_{t-12} + 0.2394\, e_{t-13}$$

Using the above forecasting equation we have generated extra-sample forecast. The forecast accuracy of the ARIMA model by alternative measures are reported in *Table-2*.

Table-2: Forecast Accuracy of Alternative Models

Model	Period of Forecast	MSE	Theil's U1	AAE*
Model-1	Jan-Apr 93	0.0095	0.000018	440
Model-2	Jan-Apr 93	0.0161	0.000023	596
ARIMA	Jan-Apr 93	0.0293	0.000024	848
Model-1	Jan-Jly 93	0.0153	0.000017	576
ARIMA	Jan-Jly 93	0.0285	0.000031	790

Source: Computed.
Note: * Mean of the actuals for the period Jan-Apr 93 is 5352, and that of Jan-Jly 93 is 5317.

It can be easily observed from *Table-2* that the two alternative models based on equation (3) above perform much better than the ARIMA models in terms of forecast accuracy measured by all the three different criteria. However, between the two alternative models (Model-1 and Model-2) based on equation (3) above, as we have noted earlier, the one (Model-1) with 12 months lag in production (P) and 5 months lag in exchange rate (R) variables has the lowest RSS and hence is our choice for the most acceptable model for export supply function for the Indian economy. Incidentally, its performance even in terms of the extra-sample forecast is also better than the second best alternative model (Model-2) according to our RSS criterion.

Another interesting observation from *Table-2* is that the extra-sample forecast performance of our chosen model continues to be better than the ARIMA model when the period of extra-sample forecast increases. Different measures of forecast accuracy, however, show different directions of movement in the forecast performance of our selected model and the ARIMA model.

Finally, we may also note that the result of the comprehensive nested model incorporating all the 12 lags of both the variables, viz. R and P suggests that the most appropriate model for export supply function in India is the one with 12 months lag in P and 2 months lag in R, since the coefficients of only these two lags turn out to be statistically significant at 5% level of significance. These results are, however, subject to distortions on account of serious multicollinearity problem arising out of the autoregressive nature of the two variables. The high degree of correlation between the 5 months lag and 2 months lag in exchange rate (R) variable makes the choice between these two alternatives very difficult. This is evident from the results when we nested only these two lags in R with the 12 months lag in P and the lagged dependent variable in the model. Both the lags in exchange rate turned out to be insignificant statistically while the other variables were significant. In view of this limitation of the nested model approach, our suggested methodology of determining the appropriate lags in the independent variables in a function appears to be a reasonable solution. Moreover, as our results show in *Table-2*, the forecast performance of the selected model based on our method is distinctly better than the one selected on the basis of the nested model method. This is borne out irrespective of the measure of the forecast accuracy used. It is hoped that our model is likely to work more efficiently than the nested model method of selecting most appropriate regression model whenever the question of determining the lags in independent variables is confronted. More generally, the suggested method in this paper is likely to be more efficient in all situations where a choice has to be made from among a set of highly collinear independent variables to specify the most appropriate regression model based on economic theory.

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