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DETERMINANTS OF INDIA'S EXPORT PERFORMANCE IN ENGINEERING PRODUCTS, 1960–79

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I. INTRODUCTION

In recent years, there has been a growing realization among Indian economists and policymakers that in order to significantly accelerate the rate of economic growth in India in the years ahead, a rapid growth in exports is necessary, and this requires, besides incentives for exports, a general upgradating of cost effectiveness and product quality in Indian industry.[1] In this context, a quantitative analysis of the determinants of India's export performance and in particular of the effect of productivity increase on export performance would be valuable. This is attempted in the present paper in respect of India's engineering exports. The definition of engineering exports adopted here is a narrow one, covering only machinery and transport equipment, i.e., product code 7 of the Standard International Trade Classification (SITC). Engineering exports are selected for the analysis because (i) their growth over the last two decades has been quite impressive,[2] and (ii) in any future plan to boost India's exports, this category of exports should occupy a very important place.[3]

The plan of the paper is as follows. Section II presents a brief review of econometric models of export performance using time-series data and reports the findings of earlier studies on export function estimation for India's engineering exports. The export function chosen for the present analysis is discussed in Section III. The data and the measurement of variables are discussed in Section

1 *Economic Survey* for 1983–84 observes: "A dynamic export performance ultimately requires a dynamic industrial sector, and it is only when Indian industry begins to show improved efficiency, cost effectiveness and technology upgradation on a broad front that India's export performance will improve sufficiently" [16, 1983–84 edition, p. 76]. Similarly, *Economic Survey* for 1984–85, while discussing the need for attaining a high rate of growth of exports in the context of the Seventh Plan, points out that improved export performance is not simply a matter of designing appropriate incentives for exporters, while leaving the industrial sector, as it is, suffering from high cost and low quality; it requires a general upgradation of cost effectiveness and product quality in Indian industry [16, 1984–85 edition, p. 85]. Also see [16, 1985–86 edition, p. 99] [21].

2 However, in recent years, the performance of engineering exports has been poor. Engineering exports fell by 14.9 per cent in 1982–83, 13.5 per cent in 1983–84, and 13 per cent in 1985–86.

3 In the Seventh Five-Year Plan, total merchandise exports (at constant prices) are projected to grow at the rate of about 7 per cent per annum between 1984–85 and 1989–90. Engineering exports are projected to grow at the rate of about 17 per cent per annum in the same period. See [21, Vol. 1, pp. 63–64].

IV. The estimates of the export function are presented and discussed in Section V. The final section summarizes and concludes.

II. MODELS OF EXPORT PERFORMANCE

Econometric models of export performance using time-series data generally have their underpinning in the theory of balance-of-payment adjustment.[4] The basic question asked is whether devaluation (or depreciation) will improve the trade balance. A typical export demand function at the aggregate level is specified as

$$X=f(P, Y), \tag{1}$$

where X is export demand, P relative export price (the ratio of home country's export unit value index to a weighted average of competing countries' unit value indices, the weights being the relative export shares), and Y a weighted aggregation of real income of the importing countries. To explain export performance at a disaggregate level, say, for an individual product, the income variable Y is often replaced by world demand or world exports (W).

The export demand function is generally specified in a log-linear form and estimated applying the ordinary least-squares (OLS) technique. This, however, yields biased estimates of the parameters since the supply-side is not taken into account.[5] While some attempts have been made to estimate the export demand and export supply functions in a simultaneous equations framework,[6] many studies have included demand-side and supply-side determinants of export performance in the same regression equation. In the study of Pomfret [30] for exports of manufactures from Israel, for example, the export function has been specified as

$$X=f(R, U, Q, W), \tag{2}$$

where X denotes exports (volume), R effective exchange rate, U capacity utilization (a measure of domestic demand pressure), Q industrial production, and W world trade in manufactured goods. Clearly, equation (2) is neither an export demand function nor an export supply function. Such models have accordingly been termed as export function or *export determination model.*

Export functions, similar to equation (2), have been estimated in a number of earlier studies, including Henry [13] and Tyler [39]. For India's engineering exports, such functions have been estimated by Bhagwati and Srinivasan [2], Harinarayana [12], and Riedal, Hall, and Grawe [33].

Bhagwati and Srinivasan take export performance as a function of domestic production, domestic demand pressure (for which domestic gross real investment is taken as a proxy), and a dummy variable to capture the effect of the devaluation.[7]

[4] See [14].

[5] For a discussion, see [14] [25] [26] [8].

[6] See, for example, [9].

[7] In June 1966, Indian rupee was devalued by 57.5 per cent. At that time, however, many export subsidies were reduced, and export duties imposed on some traditional items. The resulting net devaluation on trade account has been estimated at 21.6 per cent for exports and 42.3 per cent for imports. See [2, p. 97].

They estimate the export function for two time periods, 1950–51 to 1969–70 and 1950–51 to 1970–71. They find a significant positive effect of domestic production and a significant negative effect of domestic demand pressure on export performance. They also find evidence suggesting that the devaluation may have favorably affected export performance.

Harinarayana specifies the export function in terms of world demand (measured by the real engineering exports of the OECD countries), the price ratio of India's engineering exports relative to her competitors (based on unit value indices), and domestic demand pressure (measured by deviations from an exponential trend in production). The time period covered in the study is 1960–61 to 1974–75. The estimated export function indicates that world demand is a major determinant of India's engineering exports. Domestic demand pressure and relative price are not found to have a significant effect on export performance. Harinarayana also estimates export function for major product classes and for different regions or markets. The results obtained are, in general, similar to those for aggregate engineering exports.

Riedal, Hall, and Grawe take export performance (measured by the ratio of exports to output) as a function of relative price computed from the rupee-dollar exchange rate, wholesale price indices in India and the United States and the net ad valorem export incentive rates, and domestic market conditions which is represented by domestic profitability and domestic demand pressure. The period covered in the study is 1968 to 1978. Export functions have been estimated for thirty manufacturing industries, of which ten belong to engineering. The results for engineering industries do not reveal any significant relationship between relative price and export performance, but indicate that domestic market conditions strongly influence exports. Domestic profitability is found to have a significant adverse effect on export performance in nine industries, and domestic demand pressure in the remaining one.

Also mentionable here is the study of Rao [31] in which inter-product differences in export performance of engineering products from India have been analyzed by means of cross-sectional regression. Export functions have been estimated for 1965, 1968, 1972, and 1975. An inverse relationship is observed between labor intensity and export performance (contrary to what one would expect from the factor proportion theory of trade). Export promotion measures (import replenishment, cash compensatory support, etc.) are found to be important in determining export performance. Other major determinants of India's engineering exports are found to be external demand, export obligation, and domestic production.

III. EXPORT FUNCTION FOR THE ANALYSIS

A major focus of this analysis being on the effect of productivity increase on export performance, total factor productivity (TFP)[8] has been taken as an explanatory

[8] For a discussion on the concept and measurement of total factor productivity, see [27] [22] among others.

variable in the export function chosen.[9] Other variables included in the export function are cumulative output (as a measure of learning), exchange rate, world demand, and domestic demand pressure.[10]

TFP indices show the effect of technological progress on the overall efficiency in the use of resources. Also, improvements in X-efficiency and efficiency gains emanating from the exploitation of scale economies are reflected in TFP indices. All these are important in determining the price competitiveness of a country's exports. TFP indices, however, fail to capture changes in product quality, defined broadly to include design, delivery time, after-sales-service, marketing, and packaging which determine the non-price competitiveness of exports.[11] Evidently, improvements in non-price competitiveness of exports can contribute substantially to their growth, and it is important to take this into account in the analysis of export performance. To capture this aspect, cumulative output has been taken as an explanatory variable in the export function. Cumulative output is commonly used in empirical studies as a measure of learning[12] and it may be assumed reasonably that improvement in product quality and hence in non-price competitiveness is to a large extent a result of the learning process.[13]

The rationale for including world demand and domestic demand pressure in the export function is easily seen. The former affects export performance from the demand side and the latter from the supply side. Exchange rate, like TFP, is a determinant of the price competitiveness of exports.

For estimation purposes, the relationship between exports and its determinants is assumed to be log-linear, as most earlier studies have done. A trend variable is also included in the export function with a view to capture the influences of

[9] Though the need for including total factor productivity in the formulation of theory and in the empirical investigation of determinants of trade has been recognized in the trade literature, as one can see from the survey of Stern [37], there have been very few empirical studies on the effect of total factor productivity growth on export performance. Two studies in which an attempt has been made in this direction are by Stryker [38] and Weiser and Jay [41]. It may be added that the influence of technology on trade has been examined in a number of earlier studies, but technological influences have been represented generally by R & D expenditure or the ratio of scientists and engineers in total employees.

[10] A potentially important factor which has not been included in the export determination model is the rate of export incentives. There are two reasons for this. First, available data on export incentives are grossly inadequate to construct a satisfactory time-series on the rate of export incentives for engineering products for the period under study. Secondly, some empirical analysis of the effect of export incentives on export performance, which was carried out using whatever little data are available, yielded quite discouraging results.

[11] See [35].

[12] See, for example, [36] [3]. It should be pointed out that cumulative output is associated with only certain processes of learning, while other learning processes may depend on time elapsed. A distinction may therefore be made between autonomous and induced learning. For a discussion on these and other related issues, see [36] [4].

[13] Though the importance of learning for export expansion is widely recognized, there is hardly any empirical study of this relationship (especially in the context of developing countries). In the survey of Stern [37], only one study is mentioned in which the relationship between learning and exports has been examined. This is the study of Klein [23] for American drug firms.

TABLE I

TIME-SERIES ON ENGINEERING EXPORTS AND THE EXPLANATORY VARIABLES, 1960–79

Year	Export Quantity Index (1968=100)	Index of World Demand (1960=100)	Total Factor Productivity Index (1960=100)	Exchange Rate (Rs. per U.S.$)	Cumulative Output Index (1960=100)	Domestic Demand Pressure[a]
	(1)	(2)	(3)	(4)	(5)	(6)
1960	8.1	100.0	1.0000	4.762	100.0	0.938
1961	8.9	109.2	1.0124	4.762	121.3	0.960
1962	11.9	112.1	1.0202	4.762	147.9	1.063
1963	12.1	128.8	1.0279	4.762	177.3	1.058
1964	22.2	139.3	1.0478	4.762	212.5	1.150
1965	28.6	158.5	1.0823	4.762	254.8	1.267
1966	42.8	178.7	1.0507	6.359	291.9	1.024
1967	47.1	184.7	1.0682	7.500	328.1	0.929
1968	100.0	237.6	1.0557	7.500	367.3	0.938
1969	131.0	283.3	1.1221	7.500	410.3	0.962
1970	166.0	281.3	1.1298	7.500	455.6	0.956
1971	144.0	295.7	1.1549	7.501	503.8	0.959
1972	156.0	325.3	NA	7.594	552.8	0.923
1973	188.0	381.3	1.2300	7.742	608.4	0.996
1974	386.0	483.3	1.2654	8.102	664.4	0.956
1975	325.0	573.1	1.2005	8.376	721.9	0.934
1976	373.0	642.0	1.2666	8.960	789.2	1.048
1977	397.0	677.1	1.2837	8.739	856.1	0.997
1978	486.0	652.3	1.2936	8.193	926.8	1.012
1979	473.0	664.2	1.2717	8.126	999.7	1.002
Trend growth rate (% per annum)	23.5	11.2	1.5	3.7	11.7	NC[b]

[a] Ratio of production index to trend value.
[b] Not computed.

some of the omitted factors. Let X denote quantity (index) of engineering exports, A total factor productivity, L cumulative output, E exchange rate, W world demand for engineering exports, D domestic demand pressure, and T time (year). Then, the export function may be written as

$$X=f(A, L, E, W, D, T). \quad (3)$$

IV. DATA AND MEASUREMENT OF VARIABLES

For estimating the export function, data have been drawn from various sources. The time period covered for the analysis is 1960 to 1979. At the time TFP estimates were prepared for the study, results of *Annual Survey of Industries* (ASI) [17] were not available for years after 1979. This is the reason for not extending the analysis to a more recent year. One problem encountered in combining data from various sources is that while some of the series are available in financial years

(April to March), others are available in calender years.[14] Correcting for this discrepancy is not easy and it has therefore not been attempted. It is hoped that this discrepancy in the data would not affect the results seriously.

Time-series on engineering expors and the explanatory variables chosen for the analysis are shown in Table I. The quantity index of India's engineering exports is shown in column (1). It has been obtained from Wolf [42, Tables SA-3 and SA-4] and *Report on Currency and Finance* [32]. In column (2) an index of world demand for engineering exports is given. It is computed as a weighted average of quantity indices of global engineering exports to different regions. It takes into account the rate of expansion of different markets and the distribution of India's engineering exports to these markets. For computing this index, nine regions (markets) are considered.[15] Let W_t denote the index of world demand for engineering exports for year t, X^*_{it} global engineering exports at constant prices[16] to region i in year t, and S_{it} the share of the ith region in India's engineering export[17] in year t. Then, the computation procedure for the index of world demand is given by the following equation:

$$\ln(W_{t+1}/W_t)=\sum_i \bar{S}_i \ln[X^*_{i(t+1)}/X^*_{it}], \quad (4)$$

where

$$\bar{S}_i=[S_{it}+S_{i(t+1)}]/2,$$
$$\sum_i S_i=1.$$

The base year figure W_0 is taken as 100, and the rest of the series is obtained with the help of the formula given above.

Estimates of TFP are presented in column (3). Methodological details of TFP measurement are provided in the Appendix. Suffice it to note here that the basic data for this purpose have been drawn from ASI, and for measuring TFP, the translog index based on a four-input production model has been used.

Data on exchange rate (rupees per U.S. dollar) have been taken from *International Financial Statistics* [15]. The rates are shown in column (4). These are annual averages. In column (5), an index of cumulative output is shown. This is based on industrial production indices published in *Statistical Abstract* [20].

14 The time-series on exports is in financial years. Thus, for an explanatory variable, which is in calendar years (e.g., exchange rate), the regression model implicitly assumes a lagged response by a quarter.

15 These are: (1) the United States, (2) Canada, (3) Western Europe, (4) Japan, (5) Australia and New Zealand, (6) developing Africa, (7) West Asia, (8) Southeast Asia, and (9) Eastern Europe.

16 Data on global engineering exports to different regions (U.S. dollar f.o.b.) are obtained from the United Nations, *Yearbook of International Trade Statistics.* These have been deflated using unit value indices for SITC 7 (available for developed and developing countries separately) from the United Nations, *Statistical Yearbook.*

17 For computing shares of different regions in India's engineering exports, data have been drawn from Engineering Export Promotion Council, *Handbook of Export Statistics.* A limitation of these data is that they relate to total engineering exports including metal products.

Production indices of nonelectrical machinery, electrical machinery, and transport equipment are first combined (using weights given in the data source) into a production index for engineering, and then the cumulative total of this index from 1951 is used to construct the index of cumulative output.

Fitting a trend to the production index for engineering mentioned above, and then taking the ratio of actual production index to the trend value, a measure of domestic demand pressure has been obtained. This is shown in column (6). In many earlier studies, domestic demand pressure has been measured this way.[18]

V. THE RESULTS

Regressing $\ln X$ on $\ln A$, $\ln E$, and $\ln W$, where X, A, E, and W denote respectively exports (volume), total factor productivity, exchange rate (rupees per U.S. dollar), and world demand, the following equation is obtained (t-values in parentheses):

$$\ln X = -6.1 + \underset{(0.68)}{2.04} \ln A + \underset{(3.80)}{2.02} \ln E + \underset{(2.15)}{1.15} \ln W,$$

$$n=19, \quad R^2=0.974, \quad F=190.0.$$

The coefficients of E and W are positive and statistically significant at 1 and 5 per cent level respectively. A positive relationship between exports and these two variables is to be expected because an expansion in the world market for engineering exports should enable Indian firms to export more and an increase in the rupee-dollar exchange rate should improve the price competitiveness of India's exports. The coefficient of A (the productivity variable) is positive, as one would expect; but it is not statistically significant. The statistical insignificance of the coefficient of A may be due to errors in the measurement of TFP. It may also be a consequence of multi-collinearity since $\ln A$ is highly correlated with $\ln W$ (0.97) and $\ln E$ (0.83).

It is interesting to note that the coefficients of A and E are very close. This is perhaps not surprising since, other things remaining the same, a 1 per cent increase in TFP (and hence a 1 per cent decrease in the cost of production) should have more or less the same effect on the price competitiveness of Indian exports (and therefore on the export volume) as a 1 per cent increase in the rupee-dollar exchange rate. Indeed, it seems reasonable to take the product of A and E as a measure of price competitiveness (denoted by C) and use this variable in the estimation of the export function (which is equivalent to assuming that the coefficients of A and E are equal). When this is done, the following equation is obtained (t-values in parentheses):

$$\ln X = -6.1 + \underset{(3.30)}{2.02} \ln C + \underset{(3.92)}{1.16} \ln W,$$

$$n=19, \quad R^2=0.974, \quad F=304.0.$$

18 See, for example, [1] [39] [30]. For a discussion on some theoretical issues concerning the domestic demand pressure hypothesis, see [5].

The use of variable C in place of variables A and E does not result in any appreciable reduction in the explanatory power of the model, as may be seen by comparing the values of R^2. The coefficients of C and W have the expected positive sign and both are statistically significant at 1 per cent level.

In a different specification of the export determination model, the ratio of India's exports (X) to the world exports variable (W) is taken as the measure of export performance. This implicitly involves the assumption that, other things remaining the same, a 10 per cent increase in world exports (demand) would lead to a 10 per cent increase in exports from India, i.e., the elasticity of India's exports with respect to world exports is unity. This is not an unreasonable assumption to make; also, it is empirically supported by the two estimated regression equations presented above, since the coefficient of ln W is near unity in them. Regressing ln (X/W) on ln A and ln E, the following equation is obtained (t-values in parentheses):

$$\ln(X/W) = -5.6 + \underset{(2.46)}{2.84} \ln A + \underset{(5.05)}{2.16} \ln E,$$

$$n=19, \quad R^2=0.915, \quad F=86.0.$$

The coefficients of A (total factor productivity) and E (rupee-dollar exchange rate) are positive, as expected, and statistically significant. Also, the two coefficients are fairly close to each other in numerical value. Replacing the two variables A and E by their product, which is denoted by C, the following equation is obtained:

$$\ln(X/W) = -5.9 + \underset{(13.43)}{2.34} \ln C,$$

$$n=19, \quad R^2=0.914.$$

The coefficient of C is positive and statistically significant at 1 per cent level. The replacement of variables A and E by their product results in virtually no reduction in the explanatory power of the model.

Although the coefficient of determination (indicator of the explanatory power of the model) is quite high, it must be realized that both variables ln (X/W) and ln C are subject to a strong trend. Thus, for properly assessing the effect of changes in price competitiveness on export performance, it is important that the effect of trend be eliminated. When this is done by introducing a trend variable (T), the following equation is obtained (t-values in parentheses):

$$\ln(X/W) = -6.8 + \underset{(3.31)}{1.85} \ln C + \underset{(0.92)}{0.028}\, T,$$

$$n=19, \quad R^2=0.918.$$

The coefficient of C is positive and statistically significant at 1 per cent level. It may therefore be inferred that the price competitiveness variable which combines the effect of productivity advance and exchange rate variation is an important determinant of export performance.

TABLE II

DETERMINANTS OF EXPORT PERFORMANCE IN ENGINEERING PRODUCTS: REGRESSION RESULTS

Explanatory Variables	Regressions			
	(1)	(2)	(3)	(4)
ln$C$	1.336* (2.505)	0.911 (0.955)	1.066 (1.901)	0.583 (0.056)
ln$W$	0.364 (1.064)	0.372 (1.062)	1.045 (1.693)	1.303 (2.002)
ln$L$	1.088** (3.201)	1.257** (2.696)	1.514** (3.262)	2.023** (3.176)
ln$D$		−0.600 (−0.544)		−1.288 (−1.152)
T			−0.113 (−1.313)	−0.152 (−1.660)
Const.	−6.776	−6.958	−4.737	−4.424
R^2	0.985	0.985	0.986	0.988
$\bar{R}^2$	0.982	0.981	0.983	0.983
F	323.2	231.1	254.5	208.6

Notes: 1. $n=19$; dependent variable: ln$X$.
2. t-values in parentheses.
3. X=exports (volume); $C=A \cdot E$ where A=total factor productivity and E=exchange rate; W=world demand; L=cumulative output; D=domestic demand pressure; and T=time.

** Statistically significant at 1 per cent level.
* Statistically significant at 5 per cent level.

Some of the other regression equations estimated are presented in Tables II and III. In all these equations, the product of A and E, which is denoted by C and interpreted as a measure of price competitiveness, has been used as an explanatory variable. Tables II and III differ with regard to the specification of the model. In Table II, the volume index of exports (X) is taken as the dependent variable and world exports (W) is taken as an explanatory variable. In Table III, the ratio of India's exports to world exports (X/W) is taken as the dependent variable.

It is seen from the tables that the coefficient of C is positive, as expected, in all the regression equations presented and statistically significant at 5 per cent level in two of them. Thus, the results presented in the tables tally with the regression equations presented above in regard to the effect of changes in price competitiveness on export performance.

The coefficient of L (cumulative output) is positive, as one would expect, in all the regression equations presented in the tables and statistically significant at 1 per cent level in most of them. This shows that cumulative output, which may be interpreted as a measure of non-price competitiveness arising from the learning process, is an important determinant of export performance in engineering products.

TABLE III

DETERMINANTS OF EXPORT PERFORMANCE IN ENGINEERING PRODUCTS: REGRESSION RESULTS

Explanatory Variables	Regressions			
	(1)	(2)	(3)	(4)
lnC	1.026	0.541	1.088*	0.317
	(1.881)	(0.543)	(2.269)	(0.370)
lnL	0.630*	0.830	1.504**	1.888**
	(2.507)	(1.946)	(3.533)	(3.424)
lnD		−0.691		−1.105
		(−0.588)		(−1.086)
T			−0.108*	−0.115*
			(−2.401)	(−2.557)
Const.	−6.981	−7.186	−4.833	−5.005
R^2	0.938	0.939	0.955	0.959
$\bar{R}^2$	0.930	0.927	0.946	0.947
F	121.2	77.6	106.8	81.3

Notes: 1. $n=19$; dependent variable: $\ln(X/W)$.
2. t-values in parentheses.
3. The variables are as defined in Table II.

** Statistically significant at 1 per cent level.
* Statistically significant at 5 per cent level.

The coefficient of the domestic demand pressure variable (D) is negative, as one would expect, but not statistically significant. In this regard the results presented in Tables II and III are similar to the results of Harinarayana [12]. It may be mentioned here that in both studies domestic demand pressure has been measured by the deviation from the trend in production. Bhagwati and Srinivasan [2] have used a different variable to represent domestic demand pressure, namely domestic gross real investment, and found this measure of demand pressure to have strong negative influence on export performance. A more sophisticated measure of domestic demand pressure (which takes into account growth of different sectors and real disposable income and uses an input-output matrix) has been used by Riedal, Hall, and Grawe [33]; but they have not found any significant relationship between export performance and domestic demand pressure. Their results, however, show that domestic profitability,[19] which is a broader measure of the influence of domestic market conditions, has a strong negative influence on exports. It may be pointed out further in this connection that in a number of studies on India's engineering exports, including Ratil [29], Wadva and Sharma [40], Nayyar [28], and Frankena [6], the authors have concluded that the industrial recession of the late 1960s greatly helped in attaining a rapid growth in

[19] This is defined as the ratio of the wholesale price index in a given industry to a weighted average of wholesale price indices of the sectors supplying the industry. The weights are based on input-output coefficients.

engineering exports in this period. This is clearly in line with the domestic demand pressure hypothesis.

One possible reason for not finding a significant negative relationship between domestic demand pressure and export performance is that the measure of domestic demand pressure used here is rather crude. As pointed out earlier, it is computed by fitting a trend to the time-series of production and taking the ratio of actual production to the trend value. The ups and downs in production need not, however, reflect only or primarily changes in domestic demand pressure. These may occur for other reasons, such as variation in the availability of power and other essential inputs, and work stoppages arising from labor trouble. If production is low because of power shortage, this would surely not raise exports.

In the last two regressions in both tables a trend variable (T) is included with a view to capture the influence of some of the omitted factors. The coefficient of T is negative in all the regressions presented and statistically significant in some of them. It may be inferred that the omitted variables whose influence is picked up by T, had as a group an adverse effect on the growth of engineering exports from India. Two potentially important factors, which are not included (explicitly) in the regression model and which must have had an adverse effect on India's engineering exports, are (i) price and non-price competitiveness of engineering exports from competing countries, and (ii) trade restrictions imposed by certain importing countries. It would not be wrong to say that the negative coefficient of the trend variable reflects in part the influence of these two factors.

To sum up, the regression results presented above indicate that world demand, cumulative output, exchange rate, and total factor productivity are important determinants of India's export performance. There is some evidence to suggest that domestic demand pressure affected export performance adversely.

Limitations of the analysis should be noted here and the results viewed with appropriate reservations. First, there are deficiencies in the measurement of variables and in the data used for this purpose. Secondly, the export determination model takes into account only one side of the relationship between export performance and productivity, namely the effect of productivity increase on exports, and disregards the other side of the relationship, namely the effect of export growth on productivity, which is probably as important. Perhaps, a simultaneous equations model would have been better. Also, the possibility of a lagged response in exports has not been explored. Thirdly, some potentially important determinants of India's engineering exports (such as export incentives, and price and non-price competitiveness of engineering exports from competing countries) have not been included in the export function. Finally, there is high correlation among the explanatory variables, so that the regression results might have been affected by multi-collinearity.

VI. SUMMARY AND CONCLUSION

This paper examined the effect of productivity increase on India's export performance in engineering products. The influence of other export determinants, such as world market condition, exchange rate, and domestic demand pressure, were also analyzed. The analysis was carried out at the aggregate level by estimating an export function using time-series data for the period 1960–79. The results indicated that world demand, cumulative output (as a measure of the learning process), exchange rate, and total factor productivity are important determinants of export performance. There was some evidence to suggest that domestic demand pressure affected export performance adversely.

The finding that world demand is an important determinant of export performance and increase in world demand was a major source of growth in engineering exports is in agreement with the findings of Harinarayana [12] and Rao [31]. From this finding, it follows that, though engineering exports from India constitute a very small fraction of the global engineering exports (and even of engineering exports from developing countries), slow growth in world demand may become a serious constraint on the expansion of India's engineering exports. There is little that the government can do to influence the world demand. But, by orienting the export strategy to those products and markets in which the growth in demand is relatively faster, export performance can be improved.

The finding of a significant positive relationship between export performance and the product of total factor productivity and the rupee-dollar exchange rate (which is interpreted as a measure of price competitiveness) is at variance with the findings of Harinarayana [12] and Riedal, Hall, and Grawe [33], who have found the price variable unimportant in explaining variations in exports. On the basis of the findings of this study, it seems that for raising substantially the growth rate of engineering exports from India it is very important to pay much greater attention to the price competitiveness of India's exports. Indian engineering products can become more price competitive in the international market if the engineering industry becomes more efficient in the use of resources, costs of inputs used in the engineering industry fall, or the exchange rate changes favorably (or a combination of all the three occurs). This has implications for government policies relating to technology, scale of production (connected with the question of scale economies), imports of intermediate inputs, and exchange rate.

A major focus in this paper was on the hypothesis that higher productivity leads to better export performance. But, strong empirical support was not provided to this hypothesis by the analysis presented in the paper. This, however, does not imply that the hypothesis is wrong and the current emphasis on technology upgradation and cost reduction, with a view to boost exports, is misplaced. It may be added here that the explanation for not finding a strong positive relationship between productivity and export performance possibly lies in deficiencies in the data and measurement of variables and in the fact that productivity increase was not a major source of growth in engineering exports in the 1960s and 1970s.

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APPENDIX

MEASUREMENT OF TOTAL FACTOR PRODUCTIVITY IN ENGINEERING INDUSTRY

For measuring total factor productivity (TFP) in engineering industry, basic data have been drawn from *Annual Survey of Industries* (ASI) [17]. Time-series on output and inputs for engineering industry have been formed for years 1973 to 1979 by aggregating two-digit industries 35 (nonelectrical machinery), 36 (electrical machinery), and 37 (transport equipment) of the National Industrial Classification, which *Economic Survey* [16] has been using since 1973. For earlier years, 1960 to 1971,[a] equivalent industries have been aggregated.

The translog index,[b] which provides discrete approximation to the Divisia index, has been used for the measurement of TFP. Also, a four-input (capital, labor, material, and energy) production model has been used rather than the conventional two-input model in which capital and labor are taken as two factors of production and value added is taken as the measure of output. It is well known from the econometric literature that the use of value added form yields biased estimates of TFP. Also, TFP index based on a four-input model seems more appropriate in a study dealing with export performance, since it provides a satisfactory treatment of gains incompetitiveness arising from a more efficient use of material and energy input.

[a] ASI data are not available for 1972. Thus, TFP could not be estimated for this year.
[b] For a discussion on this index of TFP, see [10] [7], among others.

Let L denote labor, K capital, M material input, E energy input, Z output, and T time (year). Then, the production model may be written as

$$Z = f(L, K, M, E, T).$$

The translog index is based on the assumption that the function $f(\ )$ is of the transcendental logarithmic form. It also assumes constant returns to scale and competive equilibrium. Let $S_i(T)$ denote the income share of the ith factor in year T. The translog index of technical change $\bar{g}$ can be written as

$$\bar{g} = [\ln Z(T) - \ln Z(T-1)] - \bar{S}_L[\ln L(T) - \ln L(T-1)] \\ - \bar{S}_K[\ln K(T) - \ln K(T-1)] - \bar{S}_M[\ln M(T) - \ln M(T-1)],$$

where

$$\bar{S}_i = [S_i(T) + S_i(T-1)]/2, \qquad i = L, K, M, E.$$

The TFP index $A(T)$ is obtained by taking $A(0)$ as 1.0 and using the approximation

$$\ln [A(T)/A(T-1)] \cong \bar{g}.$$

The measurement of output and inputs may be taken up next. A measure of output is formed by adding together value added, depreciation, and value of materials and fuels consumed. Defining output this way ensures that the incomes of the four factors add up to the value of output. To correct the output series for price change, the wholesale price index of machinery and transport equipment has been used.

Total emoluments, which comprises wages, salaries, and money value of benefits, has been taken as the income of labor. Deducting total emoluments from gross value added, the income of capital input has been obtained. Incomes of material input and energy input are given by their values. Dividing factor incomes by output, the income shares have been computed.

Number of employees has been taken as the measure of labor input. Gross fixed assets at constant prices has been taken as the measure of capital input.[c] This has been computed by the Perpetual Inventory Method. A bench-mark estimate of fixed capital for 1960 has been made using gross-net ratios (for 1960) given in the study of Hashim and Dadi [11] and the ratio of replacement value to purchase value of fixed assets computed from this study. Gross-net ratio for land has been taken as unity. The estimate of fixed capital for 1960 comes to Rs. 293 crores. Given the bench-mark estimate, the fixed capital series is obtained with the help of the following equation,

$$K_t = K_{t-1} + I_t - \delta K_{t-1},$$

where K_t is fixed capital stock at the end of year t, I_t is the real gross investment in fixed assets made during year t, and δ is the annual rate of discarding which

[c] The methodology of capital measurement adopted here is similar to that adopted in Goldar [7, pp. 124–25] for two-digit and three-digit industries.

has been taken as 2 per cent.[d] Real gross investment in fixed assets has been computed from the figures on fixed capital reported in ASI (which gives the book-value of fixed assets at the end of the year) in the following way,

$$I_t=(B_t-B_{t-1}+D_t)/P_t,$$

where B_t is the book-value of fixed assets at the end of year t, D_t depreciation allowances made during year t, and P_t the price deflator for fixed capital goods (base 1960).

The price index of capital goods P_t has been computed as a weighted average of construction and machinery (domestic and imported) price indices.[e] These prices have been taken from Lal [24]. Since, in Lal's study, the price indices have not been provided for years after 1972, the price indices of construction and machinery have been extended to 1979 using price indices from other sources. Thus, the construction price index has been extended using the implicit deflator for construction in *National Accounts Statistics* [19], the domestic machinery price index using the wholesale price index of machinery, and the imported machinery price index using the unit value index for imported machinery.

Deflated values of materials and fuels consumed have been taken as measures of material and energy input. The deflator for energy input is formed by taking a weighted average of wholesale price indices of coal, electricity, and petroleum products. The deflator for material input is formed by taking a weighted average of wholesale price indices of fifteen major categories of products. The weights for this purpose have been taken from input-output tables, as Gollop and Jorgenson [10] have done while estimating TFP for American industries. Two input-output tables[f] have been used, one for the year 1964–65 which is used for constructing deflators for the period 1960–70, and the other for the year 1973–74 which is used for constructing deflators for the period 1970–79. The deflators for the two periods have been joined and the base shifted to 1960.

[d] The same rate of discarding has been used for estimating capital stock series for aggregate industry in Goldar [7]. Since a four-input model is used here, capital gets a relatively low weight in the TFP estimates compared to the conventional two-input model. Thus, if a slightly higher or lower rate of discarding is chosen, the TFP estimates will not change much.

[e] In Goldar [7], price indices of construction, domestic machinery and imported machinery have been combined using fixed weights. Capital goods price index for this study has been constructed using changing weights to take into account the variation in the shares of these three categories of assets in fixed investment.

[f] These have been taken from [34] [18].