An Analysis on the Determinants of Indian Machine tool Exports[1]

Abstract

This paper analyses the determinants of India's machine tool exports during 1980-2005. The study used a simultaneous equation framework where three-stage least square (3SLS) estimation technique is employed to accommodate two-way relationship between export price and quantity. The result showed that Indian machine tool exports are largely determined by demand side factors. Among them, the real exchange rate and world demand are significant. The presence of skilled labour and domestic prices seem to have some significant influence at the supply side. This suggests that the nature of external demand along with a depreciating currency could have a significant impact on the prospects of India's machine tool export performance.

JEL Classification: F1, F14, L61, C32.

Introduction

In this paper, we try to identify the factors determining Machine tool exports from India during 1980-2005. The first section of the paper reviews some of the major studies on the determinants of India's export performance. Section 2 provides the methodology of the study and estimation procedure. In Section 3 estimation result and its interpretation are given. The final section summarizes the entire discussion and discusses some of the major findings of the study.

1. Export determination: The literature

The determinant of trade flows comes under the realm of estimating price/income elasticity of trade flows. Apparently, trade determination follows an assessment of the effects of currency depreciation on a nation's current account. The underlying framework is elasticity approach on trade balances. Since elasticity varies considerably across countries along with variance in its significance, there is no consensus on the impact of real devaluation on trade balance. A similar disagreement can be found in Indian context.

Basically, there are two diverging views regarding the sources of India's export performance. One prominent view considers the influence of restricted trade policy regime and the resulting biases towards exports. The second view focuses on the

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importance of demand side factors such as world income and stresses the trivial role of relative prices. The econometric investigations have also failed to reach a consensus regarding the relative merit of demand and supply side factors. According to Sinha Roy (2004) this is primarily due to model misspecification, different estimation procedures or the period of study. A summary of some important empirical works on determination of Indian export is given in table 1.

Table 1 Review of major Export determinant studies in India

Author	*Period*	*Objective*	*Data Source*	*Methodology*	*Major Findings*
Riedel *et al* (1984)	1968-78	Aggregate	Secondary	Single equation (OLS)	Strong negative influence of Domestic demand, along with relative prices
Arize (1990)	1973-85	Aggregate	Secondary	Simultaneous equation (2SLS)	Highly responsive to relative price changes
Virmani (1991)	1970-86	Aggregate	RBI and other secondary information	OLS	Price and World demand are significant while domestic demand is insignificant
Aksoy and Tang (1992)	1970-88	Aggregate	Secondary	Single equation (OLS)	Supply constrained, relative price is Significant but world demand is insignificant
Srinivasan (1998)	1963-94	Aggregate	MOF, RBI, Yearbook of International Statistics	Non-structural eclectic model	World demand and relative Prices are significant.
Sharma (2000)	1970-98	Aggregate	DGCI&S, IFS, WDI, Handbook of Statistics on Indian Economy (RBI) and Economic Survey.	Simultaneous equation (2SLS)	Export is elastic to exchange rate movement and domestic demand has a negative impact.
Sinha Roy (2004)	1960-99	Aggregate	DGCI&S, NAS, RBI and IMF.	ECM and FIML.	Export is largely driven by demand side factors.
Goldar (1989)	1969-79	Engineering	ASI, Report on currency and Finance, IFS, Statistical Abstract.	OLS	World demand and Real exchange rate are significant.
Rath and Sahoo (1990)	1970-88	Capital Goods	Report on Currency & Finance, IFS, Monthly bulletin of Trade Statistics, UNCTAD, NAS, Bureau of labour Statistics, USA	Simultaneous model (3SLS)	World demand and relative profitability are significant.
Sinha Roy (1995)	1970-84	Capital Goods	DGCI&S, ASI, DST, NAS.	Single equation (OLS)	Export promotion policies
Kareem (2000)	1970-87	Machinery	DGCI&S, Monthly Statistics of Production (CSO), ASI OECD National Accounts, National Account & Statistics Yearbook UN.	Single equation (OLS)	World demand is significant for most of the industries while the significance of domestic demand and import substitution varied across products.

A look at these studies clearly reveals the wide disagreements in the literature. It also shows that there are only few studies that have addressed export determination at disaggregate level. An understanding of the influence of demand and supply factors at a particular industry level is useful as most often aggregate export performance mask sector specific variations. Also most of the earlier studies were done during the restrictive trade regime.

1.1 Determinant of Machine Tool Export- Demand and Supply Factors

Indian machine tool exports have shown better growth performance since late 1990s. For instance, the exponential growth rate was 7 percent during 1980-91, which raised to12 percent during 1991-05. Moreover most of these machines were exported towards advanced regions like OECD. But over the years, India has not emerged as a major producer of advanced machines like CNC varieties as her export basket is still dominated by low and medium technology intensive commodities[1]. In this context it would be instructive to understand what governs India's machine tool exports over the years.

For the analysis purposes we have converted the nominal machine tool export value into constant price series by deflating the nominal value of machine tool export by unit value index of machine tool export i.e., export is expressed in real value term[2]. The construction of unit value index is based on Paasche index and the base year of the series is 1993=100. The value and quantity data for machine tool export is collected from Monthly statistics of foreign trade of India, published by Directorate General of Commercial Intelligence and Statistics (DGCI&S), Calcutta, and UN COMTRADE provided by UNCTAD, Geneva. An examination of the series confirms our earlier finding of an upward trend in machine tool exports since 1990s (see Appendix A3). Now, let us discuss the various demand and supply side factors.

1.1.1 Demand Side Factors

Usually, the demand for export is specified as a function of a country's price competitiveness and a foreign (domestic) activity factor with the assumption of a small open economy. Here the significant price variable affecting export competitiveness is relative price of exports and world demand or income as the scale variable.

a) Real Effective Exchange Rate (REER)

In international market the demand for India's machine tools depends upon the relative price differences of India and its competitors. This relative price advantage is often identified in terms of real exchange rate variation. As per the trade theory, we know that currency depreciation make Indian machine tools cheaper relative to its competitor in the world market. This will raise demand for India's product resulting increased exports, *ceteris paribus*. Therefore, a depreciation of rupee relative to its

competitors is expected to increase the competitiveness of Indian machine tools in the foreign market[3].

Generally, there are two methods of calculating REER. (1) The traditional method based on purchasing power parity theory and (2) the modern approach based on the distinction between tradable and non-tradable goods[4]. We have used the modern approach as the short run validity of the former is often questioned. The rationale behind the modern approach is that the cost differentials between the countries are closely related with the relative price structures in those economies. A depreciation of the REER increases the relative profitability of producing tradable goods, thereby inducing resources to move from non-tradable to the tradable sector and vice versa. Under the assumption that price of tradable will be equal across the world, the real exchange rate is defined as,

$$RER = P_t^x / eP_t^w$$

Here, P^x represent price of tradable and is proxied by unit value index of Indian machine tool exports. P^w represent price of non-tradable and is proxied by producer price of capital goods industries at the world level[5]. e is the exchange rate of the domestic economy with respect to the trading partners economies calculated in terms of numerate as the SDR. In order to incorporate multilateral trade scenario we have constructed a real effective exchange rate (REER).

In order to construct the REER, we first calculated the bilateral real exchange rate with respect to the twelve trading partners of India. The multilateral or real effective exchange rate of rupee is the weighted average of the bilateral rate, were weight being the 1993 share of India's machine tool export for these twelve trading partner countries. Thus, REER computed represent industry specific real exchange rate as opposed to the general one used in a number of previous empirical studies. The data for producer price series of capital goods were collected from Statistical Yearbook, UNCTAD.

The REER for machine tool export from 1980-2005 is shown in figure A4 in the appendix. An examination of its movement reveals that its pattern has been different from the macro level exchange rate. It is showing significant appreciation, with fluctuation till 1996. Since then, the rate has been continuously depreciating and we have to note that it was during this period that a real upward trend in machine tool exports occurred.

b) World demand (WD)

Apart from relative price effect, the demand is also influenced by condition prevailing in the world market. Theory assumes that world income could have positive or negative impact on the export of domestic economy but generally we assume it to be positive[6]. That is, higher the level of foreign real income, larger would be the foreign demand for a nations export, *ceteris paribus*. The measurement of world demand variable has often been varied across studies. Generally, three income measures are used in the literature, GNP or GDP, industrial production, world real export or import of major export destination of particular products (Kareem, 2000). In this study, we have used the total world export of capital goods as a proxy for world demand. This will indicate the rate of expansion of different markets and the distribution of India's export of machine tools into these markets.

In order to construct the index, we have selected 22 major capital good export destination of India in 1993. These countries are selected from different regions[7]. Countries were grouped into five regions, i.e. European Union, North America, Asia and Oceania, Asia and Africa. First three regions represent OECD and the last two are developing countries. Since the structure of demand is different in these regions we have normalized the data series by using export share as weights. That is, total capital good exports of these regions were weighted according to the relative share of each region in India's total export basket during 1993. The world demand for machine tool is represented by the aggregate of these weighed series. The data on capital goods industry, which corresponds to 71, 72, 73 codes under SITC rev2 and 3 were collected from UN COMTRADE online database provided by UNCTAD. The figure A5 in the appendix shows that world demand for machine tool exports have increased steadily during 1980-2005. Here, we expect that world demand would have a positive impact on Indian machine tools exports.

1.1.2 Supply Side Factors

There is a great deal of controversy in modelling export supply function. Not surprisingly, most of the previous studies have generally not considered the supply variables explicitly and assumed supply elasticity to be infinite. On the supply side, we can identify the following factors as the major determinants.

a) Relative Price (RP)

On the supply side, export decision mainly depends upon relative price changes, i.e. export price relative to domestic prices. This reflects relative profitability of selling in foreign markets. We expect that an increase in the relative price will have a favourable impact on the incentive for machine tool manufacturers to engage in exports i.e., the ratio should be above unity. On the other hand, a better domestic price reduces this incentive and domestic manufactures will be interested in catering domestic demand, *ceteris paribus*[8].

For machine tool exports we have taken relative price as the ratio of prices of machine tool export to domestic prices (P^x/P^d). The price of machine tool export is measured by the unit value index and the domestic price of machine tool by wholesale price of machinery and machine tools. Both are at 1993=100 base year. The wholesale price series is available from Office of the Economic advisor, Ministry of commerce, Government of India. An examination of relative price movement shows that the ratio was above unity for most of the period, but it is showing a declining trend since the late 1990s (see figure A6 in the appendix). We hypothesis that relative price of export to have a positive impact on machine tool exports.

b) Domestic Demand

For Indian tools, the pressure from domestic market is very important. As domestic demand pressure increases, selling at home market becomes more profitable than at abroad. Also, domestic demand signifies the cyclical effect, as the industry is very sensitive to them. Here the hypothesis is that during high domestic demand pressure, firms will operate at full capacity and will export little, while during domestic recession capacity utilisation will be low and firms will attempt to export as much machines as possible.

Domestic demand for machine tools is measured by apparent consumption for Capital goods[9]. The apparent consumption is measured by deducting capital good exports from total absorption of capital goods (Production + Import). The production data is collected from Annual survey of Industries (ASI) and trade data is from UN COMTRADE. It is expected that apparent consumption would be lower at the time of low domestic demand and hence boost machine tool exports. Figure A7 in the appendix

shows that, domestic demand for machine tools have significantly increased during 1990s.

c) Technological Capability (T)

As Amsden (1985) pointed out, technological capability in machine tool industry includes the selection of new technology, its implementation, the operation of the production facilities so implemented, their adaptation and improvements, the potential to develop new process and products. Since machine tools are diverse in terms of designs and specification, supply of competent skilled engineers are very important. Therefore, we expect that technological development would a positive impact on machine tool exports.

To capture technological capability of machine tool sector we have taken two indicators, R&D intensity and skilled workforce[10]. In Indian context, R&D intensity indicates not only major innovative effort but also minor product changes at the shop floor level. The R&D intensity is measured by taking the share of R&D expenditure incurred by machine tool sector in total production. The data on R&D expenditure is available from R&D statistic, published by Department of Science and Technology (DST).

In order to supplement technological capability measure, we have taken one additional variable i.e., the number of skilled labourers in machine tool sector. As discussed earlier, the nature of technology in machine tool sector requires competent engineers and workers in order to improve the exported product. To measure the skill intensity we followed the method adopted by Bosshardt and Vishwasrao (1999). They defined skilled manpower as the percentage of skilled workers to unskilled workers. It is proxied by (Employees-Workers)*100/Employees. Data were collected from Annual survey of Industries (ASI). The proportion of skilled workforce in total labour force has remained around 30 to 35 percent (see figure A8 in the appendix). We expect that both these factors to have a positive impact on machine tool export from India[11].

Policy factors

As noted earlier, supply capability is directly related to the policy regime prevailing in the country. We expect that trade liberalisation will help domestic machine tool manufactures to expand their scale and provide an incentive system for

better export. We have chosen dummy variable to represent the effect of trade liberalisation. Dummy variable takes the value of zero for the year prior to 1985 and one thereafter[12].That is, $D85_t$ = 1 if ≥1985 otherwise 0. We have taken 1985 as the year in which trade liberalisation initiated because it was during this period that the tariff structure and import duty for capital goods and particularly for machine tools were rationalised.

2. Estimation

Generally, the analysis of export determination comes under two types of models. One is perfect substitution model where it is assumed that domestically produced goods are perfect substitutes for foreign goods. Since this assumption is highly restrictive, we follow the second method, which is the imperfect Substitute model. This model assumes that import and exports are not perfect substitute for domestic good. The model predicts that imperfect substitutability between domestic and export product enables domestic and export prices to differ from one another (Goldstein and Khan, 1985).

2.1 Specification of the model

The analysis of machine tool exports determinant incorporates both demand and supply side factors. The model can be presented as

$$MTEX_t = f\,(REER_t, WD_t\, RP_t, DD_t\, RD_t, SK_t) \quad \text{-------} \quad (1)$$

Where,

$MTEX_t$ = Total real machine tool exports from India.

$REER_t$ = Real effective exchange rate (1985=100)

WD_t = World demand

RP_t = Relative price in (1993=100)

DD_t = Domestic demand

RD_t = R&D intensity

SK_t = Skilled labour force

t = denotes time.

We know that while modelling trade behaviour the choice of appropriate functional form is often controversial in trade literature. Generally a log linear model is preferred due to their generally superior fit and ease of interpretation[13].

Therefore, the logarithmic transformation of the estimated model is

$$ln\, MTEX_t = a_0 + a_1 ln\, WD_t + a_2 ln\, REER_t + a_3 ln\, RP_t + a_4 ln\, DD_t + a_5 ln\, SK_t + a_6 ln\, RD_t + \mu_t \quad \text{---------} \quad (2)$$

Since we are taking the log of the variables, the estimated coefficient represents relevant elasticities. We expect $a_1 > 0$, $a_2 < 0$, $a_3 > 0$, $a_4 < 0$, $a_5 > 0$, $a_6 > 0$.

In the above specification there are two endogenous variables, real export and price. Failure to account this will give rise to simultaneous equation bias[14]. As a result, we cannot rely on OLS method. Alternatively we can estimate the model by two methods. One, solve the model to obtain reduced form, and then estimate by OLS. Second way is to use simultaneous equations method. In this method we can either use two-stage least squares (2SLS) or three-stage least square (3SLS) estimation techniques[15]. We have used 3SLS.

The demand function for Indian machine tool export is specified as

$$MTEX^d_t = f\,(REER_t, WD_t) \quad \text{----------} \quad (3)$$

Here, $MTEX^d$ is real machine tool exports demanded, REER = P^x/eP^w is the real effective exchange, P^x is the price of machine tool export, eP^w is exchange rate multiplied by world price of capital goods.

Equation 3 can be re-written as

$$MTEX^d_t = f\,(P^x_t/eP^w_t, WD_t) \quad \text{----------} \quad (4)$$

$$or \;\; MTEX^d_t = g\,(P^x_t, eP^w_t, WD_t) \quad \text{----------} \quad (4a)$$

The logarithmic transformation of the model gives

$$lnMTEX^d_t = a_0 + a_1 lnP^x_t + a_2 lneP^w_t + a_3 WD_t + \mu_t \quad \text{----------} \quad (5)$$

Since equation 5 is specified in logarithms, α_1+ α_2 and α_3 are (relative) price and income elasticites of machine tool export demand. In the estimation, we expect $\alpha_1 < 0$, α_2, $\alpha_3 > 0$.

The machine tool export supply is specified as a function of relative prices, domestic demand and technological capability. The export supply function can be written as

$$MTEX^s_t = f(RP_t, DD_t, T_t) \qquad \text{---------- (6)}$$

Here $MTEX^s_t$ is the machine tool export supplied, RP is the relative price of machine tool exports expressed as price of machine tool export relative to domestic price (P^x/P^d), DD is domestic demand and T is technological capability which is measured by R&D intensity and skilled workforce (RD and SK).

Equation 4 can be re-written as

$$MTEX^s_t = f(P^x/P^d_t, DD_t, RD_t, SK_t) \qquad \text{---------- (6.a)}$$

In a log linear form,

$$lnMTEX^s_t = \beta_0 + \beta_1 lnP^x_t + \beta_2 lnP^d_t + \beta_3 lnDD_t + \beta_4 lnRD_t + \beta_5 lnSK_t + \nu_t \quad \text{--------} \quad (7)$$

with $\beta_1, \beta_4, \beta_5 > 0$ and $\beta_2, \beta_3 < 0$

The simultaneous estimation requires the equation to be normalized with respect to prices (Goldstein and Khan, 1978). Therefore, the inverse supply function is

$$lnP^x_t = \gamma_0 + \gamma_1 lnMTEX^s_t + \gamma_2 lnP^d + \gamma_3 lnDD_t + \gamma_4 lnRD_t + \gamma_5 lnSK_t + \nu_t \quad \text{------ (8)}$$

Where $\gamma_0 = -\frac{\beta_0}{\beta_1}$, $\gamma_1 = \frac{1}{\beta_1}$, $\gamma_2 = \frac{\beta_2}{\beta_1}$, $\gamma_3 = \frac{\beta_3}{\beta_1}$, $\gamma_4 = -\frac{\beta_4}{\beta_1}$, $\gamma_5 = -\frac{\beta_5}{\beta_1}$

Since, $\beta_1, \beta_4, \beta_5 > 0$ and $\beta_2, \beta_3 < 0$, we expect that $\gamma_1, \gamma_2, \gamma_3 > 0$ and $\gamma_4, \gamma_5 < 0$.

In this model we assume that when demand equals supply, export and prices get determined simultaneously. That is there is no adjustment lags in the system and the equilibrium values are determined instantaneously.

$$\text{In equilibrium,} \qquad MTEX^d_t = MTEX^s_t = MTEX_t$$

For empirical estimation we will use OLS for equation (2) and 3SLS for equation (5) and (8). 3SLS is a full information estimator in which generalized least square estimation is applied to the system of equation. It is a combination of two stage least squares and seemingly unrelated regression. It provides consistent estimates for

linear regression models with explanatory variables correlated with the error term. To quote Pindyck and Rubinfeld (1991) "the estimation procedure involves three stages. In the first stage, the reduced form of the model system is estimated to obtain instruments. The fitted values of the endogenous variables are then used to get 2SLS estimates of all the equation in the system and then the residuals of each equation are used to estimate the cross equation variance and covariance. In the final stage, generalized least square parameters are applied in the estimate of the error variance covariance matrix". Compared to 2SLS, 3SLS are more consistent and efficient as it uses the covariance matrix of disturbances leading to smaller standard errors (Pindyck and Rubinfeld, 1991).

3. Estimation Results

The estimation results using single equation method and simultaneous equation method are given in table 7, 8(a) and 8(b) respectively. In the first case, we have estimated the export determination model using OSL disregarding simultaneity bias. The estimation model is equation (2). The estimation result is given in table 2.

Table 2 OLS estimation results

Variable	Coefficient
WD	0.96 (1.85) **
REER	-1.2 (2.79) **
RP	-0.03 (0.07)
DD	0.55 (1.57)
SK	-0.31 (0.25)
RD	0.10 (0.77)
D85	0.19 (0.70)
R^2	0.92
D.W	1.23

** Significant at 5% level
Figure in parenthesis are *t* statistic

The result shows that the model is able to explain 92 percent of variation in the dependent variable. The DW static showed that it fall under non-conclusive region and therefore the presence of serial correlation couldn't be confirmed. An examination of the coefficient reveals that only world demand and real effective exchange rate are significant (at 5 percent level)[16]. The income elasticity of export is close to unity (0.96) implies that a 10 percent increase in world demand leads to 9.6 percent rise in India's machine tool export. This result indicates that demand factors are significant for machine tool exports.

But as we noted before, the presence of simultaneity among the variables can bias OLS results. This may be the reason for the unexpected sign for some of the coefficients. As a result, we estimated the export determination model using 3SLS and the results are given in table 3 (a) and 3 (b).

Table 3 (a) Coefficients of 3SLS Estimation *(Demand)* Dependent Variable: MTREX

Variable	Coefficient
P^x	-2.11 (7.03) **
eP_t^w	1.13 (3.42) **
WD	0.75 (0.38) **
D85	0.58 (1.97) **
R^2	0.83
D.W	1.79

** Significant at 5% level
Figure in parenthesis are t statistic

Table 3 (a) indicates the estimated result of the demand for machine tool exports (equation 5). The result shows an improvement over OLS estimation. The model is able to explain 83 percent of variation in the depended variable. All the variables have expected signs and are significant at five percent level. The coefficients of relative price was found to be more than unity which implies that a 10 percent depreciation of real exchange rate relative to its trading partners would rise India's machine tool exports by 11 percent. The income coefficient is less than unity (0.8 which is lower than 1.0 in the OLS estimation). That is a 10 percent increase in world demand raises machine tool export by 8 percent. Also, the liberalisation dummy is significant which reveals that policy shift has induced a favourable impact on the demand for machine tools in the world market.

An examination of supply equation reveals that the model is able to predict 84 percent of variation (see table 3.b). The result shows that all variables except R&D intensity has expected signs but only domestic price and skilled variables are significant (at 5 and 10 percent respectively). Since export is found to be responsive to the domestic prices, it can be argued that improved domestic profitability might act as a significant deterrent for domestic manufactures to go for export business. Among other factors, the significance of skilled workforce (although at 10 percent level) is noteworthy. This shows the importance of enhancing the supply of trained workers to improve the technological base of the industry.

Table 3(b) Coefficients of 3SLS Estimation *(Supply)* Dependent Variable P_x

Variable	Coefficient
MTREX	0.68 (1.28)
P^d	1.20 (5.21) **
DD	0.52 (1.15)
SK	-0.56 (1.47) *
RD	0.09 (1.3)
D 85	0.21 (1.23)
R^2	0.84
D.W	1.79

** Significant at 5 % level,* Significant at 10 % level
Figure in parenthesis are t statistic

The empirical analysis clearly shows that export performance of Indian machine tool is largely driven by the demand side factors like REER and world demand. The changed policy regime was found to have reduced constraints on the demand side by correcting real exchange rate misalignments. Currency depreciation is found to have notable impact on improving export performance and competitiveness of machine tools. A depreciating currency along with growing demand can provide Indian manufacturers the incentive to supply machines at the world market. This confirms the findings of the earlier studies like Goldar (1989), Rath and Sahoo (1990) and Kareem (2000) for capital or engineering good industries and Virmani (1991) Srinivasan (1998), Sharma (2000) and Sinha Roy (2004) for aggregate export industries that world income and exchange devaluation are significant determinant for Indian Exports.

At the supply level, the industry has to improve its technological capabilities by way of supplying and training quality workers. This will help Indian machine tool manufactures the ability to meet the changing demand from its user industries. Since machine tool is basically skill intensive, trained workers are necessary to improve and develop better products. This will also help in boosting in-house R&D effort of the industry. In order to sustain the export market and to increase its market share the industry needs to raise its technological competence. In this context, government can assist machine tool manufacturers by way of building better education system and necessary infrastructure to facilitate linkage between various institutions.

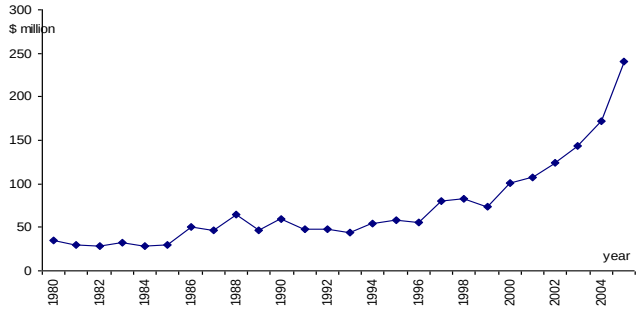
4. Conclusion

In this paper, our aim was to analyse the factors determining machine tool export performance of India. The export of machine tools witnessed significant expansion during nineties. But the export basket did not exhibit much dynamism as India exported simple to medium technology tools towards OECD countries. In order to understand the factors that determine the export of machine tools we begin with an analysis of existing empirical literature. The literature survey showed that most of the earlier studies have not properly delineated various demand and supply side factors and generally adopted single equation estimation procedure. In contrast, the present study has identified several plausible factors under demand and supply side. We have used a simultaneous equation framework and estimated the model using 3SLS.

The empirical findings reveal the predominance of demand side factors such as world demand and real exchange rate in influencing machine tool exports. Among the supply variables, we found that the export price and domestic demand is largely insignificant whereas the number of skilled workforce and domestic price have some marginal influence. The analysis also shows that trade liberalisation has acted as a major instrument through correcting the distortion in real exchange rates. We can argue that given the demand condition, a better export performance of Indian machine tools can be sustained through maintaining a competitive price level and improving industries technological competence.

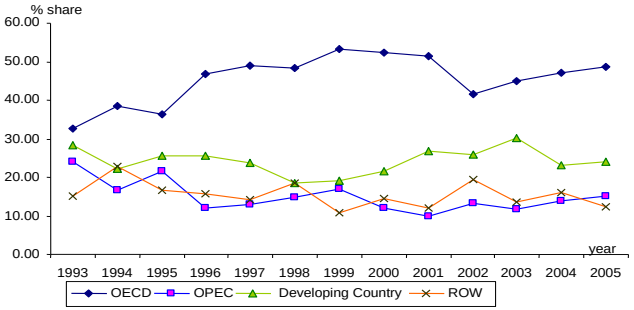
Appendix

Figure A 1 Machine tool Export (1980-2005)



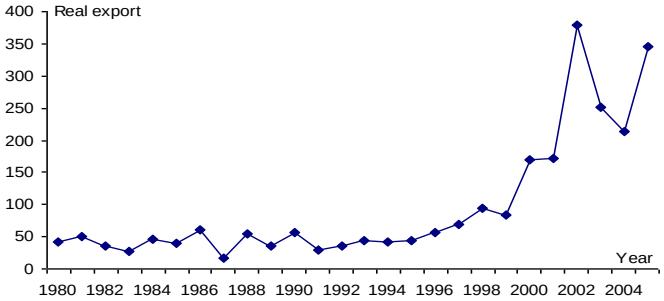
Source: Own calculation based on UN COMTRADE.

Figure A 2 Destination of Machine tool Export 1993-05 (% Share)



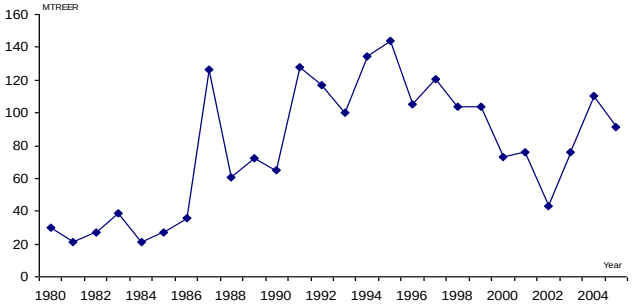
Source: Own calculation based on UN COMTRADE and CMIE, Foreign trade Review.

Figure A 3Machine tool Real Export (1980-2005)



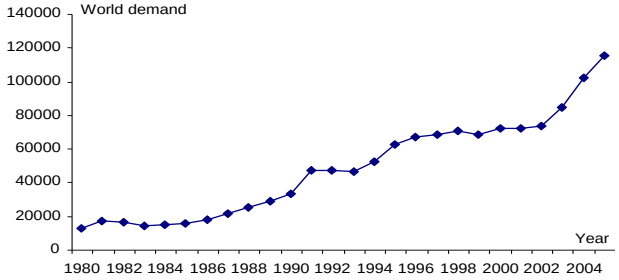
Source: Own calculation based on UN COMTRADE.

Figure A 4 Real Effective Exchange rate (1993=100)



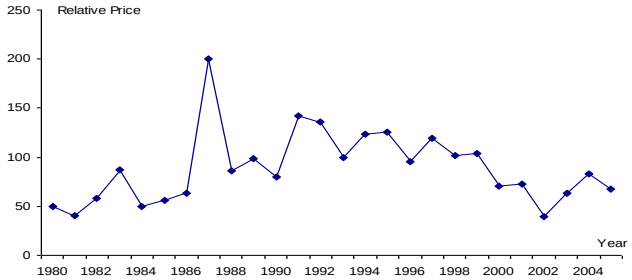
Source: Own calculation based on Statistical Yearbook UN COMTRADE, and DGCI&S.

Figure A 5 World Demand



Source: Own calculation based on UN COMTRADE

Figure A 6 Relative Price



Source: Own calculation based on UN COMTRADE, DGCI&S, Office of economic Advisor, GOI.

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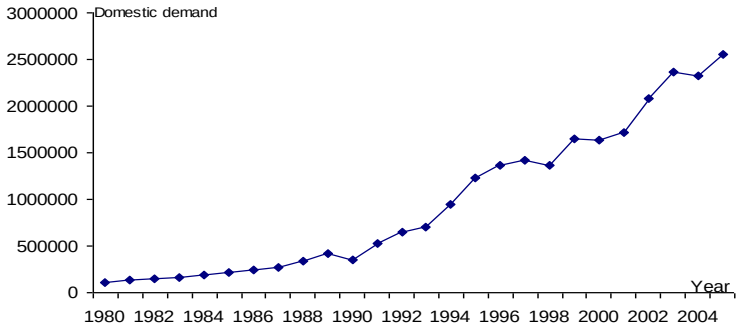
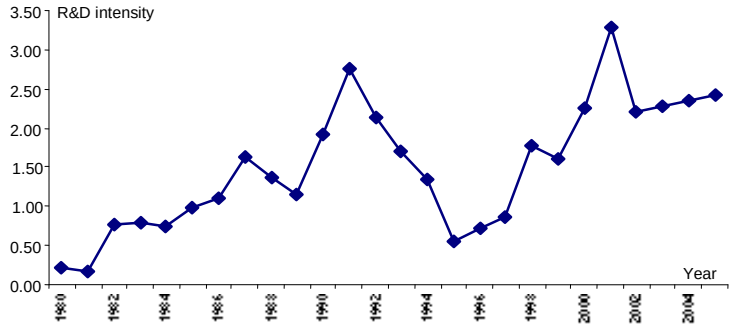
Figure A 7 Domestic Demand



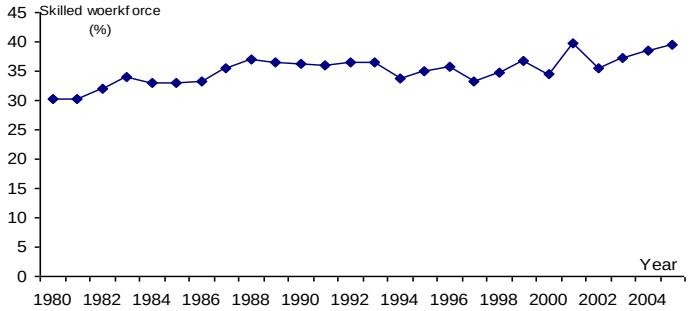
Source: Own calculation from Annual Survey of Industries, CSO.

Figure A 8 R&D intensity



Source: Own calculation from Annual survey of Industries, CSO R&D statistics, DST.

Figure A 9 Skilled labour force



Source: Own calculation from Annual Survey of Industries, CSO

Notes

[1]For a detailed description of Indian Machine tool production and trade, see Kumar (2004), Rijesh (2007).

[2] The choice of price index in international economics is controversial. Trade analyst have generally preferred to use unit value indices compared to any other price measures as they are readily available from trade statistics and are easy to calculate (Goldstein and Khan, 1985). Unit value index measures the average price of a particular basket in a commodity group. One of the main problem with this index is that, it can be biased when we use it in aggregate trade data and most often overstate price changes since the index is a reflection of changes in prices and quantity. But the issue is less complicated when applied to a single product category like machine tools.

[3] There are conflicting arguments regarding the role of exchange rate in influencing India's export performance. Studies by Bhagwati and Srinivasan (1975) and Srinivasan (1998) using single equation model and Arize (1990), Viramani (1991), Joshi and Little (1994) and Sinha Roy (2004) using simultaneous equation framework showed that Indian exports are highly responsive to changes in relative prices. But Lucas (1988) and Sarkar (1994) showed that the responsiveness of prices varies across product groups exported.

[4] For a detailed discussion of these two approaches and its relative merits, see Edwards (1989) and Trivedi (1996).

[5] We have to rely on producer price of capital goods instead of machine tool prices as the latter is not readily available for most of the countries. Another proxy is to use import unit value of major trading partners of India. But this was also discarded as there was no time series data on machine tool quantity since 1980 for most of the countries.

[6] World income will have a negative impact on a countries export if the increase in world income were associated with a faster growth of production than consumption of importable. This can result if exports of a country are a residual demand for the rest of the world (Goldstein and Khan, 1978).

[7] These countries are Australia, Brazil, Canada, China, France, Germany, Italy, Indonesia, Japan, Kenya, Korea, Malaysia, Netherlands, Pakistan, Singapore, Spain, Sweden, Switzerland, Thailand, Turkey, UK and USA. In country selection, we have excluded OPEC region because of data discontinuity since 1980.

[8] Goldstein and Khan (1985) showed that relative price plays an important role in the export demand function for developing countries. The price elasticity was high for total export and disaggregates exports. Sato (1977) and Funke and Holly (1992) challenged this view by showing insignificant role of price elasticity among most of the industrialised countries. The elasticity was found to be varying across countries. For developing countries, Goldstein and Khan (1982) found significant price responsiveness for their exports. But later study by Khan and Knight (1988), Riedel (1988), and Panagariya (2001) did not find any conclusive evidence.

[9] Kareem (2000) has also used apparent consumption for measuring domestic demand pressure for his analysis on the determinant of India's machinery exports during 1970-87.

[10] Due to non-availability of time series data we did not took foreign direct investment, technology imports or output measures such as patents to represent technological capability in machine tool sector.

[11] Studies that examined the impact of technology on trade flows have generally taken R&D expenditure or patent as independent variable (see Lall 1986), Kumar, and Siddharthan, (1994). There are specific studies which investigated the influence of skilled workforce on trade pattern.

[12] Measurement of trade liberalization is often encountered with methodological issues. The usual practice is to quantify it in terms of outcome measure such as trade intensity (share of total trade in GDP) or trade restrictions such as tariff or non-tariff barriers. These measures are highly problematic and difficult to measure. Rodrik and Rodriguez (2001) argue that openness measures are highly correlated with other economic variables in the regression equation. Simple tariff averages underweight high tariff rate because the corresponding import level tend to be low. If tariff and non-tariff barriers are substitutes, simple tariff averages will be a poor proxy. This has made researchers to use dummy variables, which reflect structural change resulting from trade policy changes.

[13] See Houthakker and Magee (1969) and Goldstein and Khan (1985)

[14] This arises because the export volume and price in the demand and supply relationship are correlated with the error terms. Thus, single-equation estimates of the price and income elasticities can be a weighted average of 'true" demand and supply elasticities and therefore can be biased downward (Goldstein and Khan, 1985).

[15] see Morris and Khan (1978) and Goldstein and Khan (1985) for the advantage and disadvantages of using 3SLS.

[16] Since the variables we have included in the model corresponding to theoretical formulation, the relevant test is one tailed. That is, we are particularly interested in the sign of coefficient and t statistic. For instance, if we are testing the inverse relationship, to reject Ho against the negative alternative we must get a negative t statistic. A positive t ratio, no matter how large provides no evidence for the alternative (For more details see, Wooldridge (2003)

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