An Analysis on the Determinants of Indian Machine tool Exports

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Abstract

This paper analyses the determinants of Indian machine tool exports during 1980-2005. The study has 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 driven by demand side factors. Among them, real exchange rate and world demand were found to be significant. On the other hand, domestic prices and skilled labour force was found 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 determinant factors of Indian Machine tool exports during 1980-2005. In the first section, a brief overview of the performance machine tool exports is given. Section 2 reviews some of the major export determinant literature in the context of India. Section 3 provides the methodology of the study and estimation procedure. The 4th section provides the estimation result and its interpretation. The final section summarizes the entire discussion and exemplifies some of the major findings of the study.

1. Machine tool Export Performance (1980-2005)

A machine tool is a stationary, power-driven machine used to cut, shape, or form materials such as metal. It consists of range of products from simple bench-top lathes to large machining centers. Generally, the term is used to denote tools that cut or drill, press or shear, or otherwise shape hardened materials into specific forms. Machine tools are considered to be indispensable to the production and repair of the various new machines being introduced in all branches of society. Since machine tools produce capital goods, which are required in the production of manufactured goods; the industry has strategic importance as well as linkages with the rest of the sectors. Naturally, Indian planners had initiated various measures to develop and foster machine tool production in India.

The period of protective policy regime began to relax during mid 1980s. It was during this period most of the leading competitive exporters across the world moved up the value chain and began to manufacture technology intensive machine tools. Unfortunately India failed to grab this opportunity owing to its narrow export basket and concentration in the production of conventional machines (Mehta, 1990). Apart from that uncompetitive price setting lowered world preference for Indian tool products. Plausibly most of the Indian firms considered export as a residual activity during this period.

The late 1980s saw a revival in Indian machine tool export. The export intensity stood at 14 percentages in 1988. Subsequently there was an improvement in terms of trade and trade balance. But the growth of export fluctuated during this period as Indian tools failed to penetrate into the advanced capitalist markets[i]. As India moved

towards more open trade regime in the nineties, machine tool export registered steady rise. The momentum started during mid 1990s and a real spurt in export growth is visible since 1999 onwards (see figure A1 in the appendix). In dollar terms, export was 48 million in 1991, which increased marginally around 50-60 till 1996 and jumped to 80 million in 1997. Thereafter it increased progressively and by 2005, India exported 240.7 million worth machines abroad. An examination of the exponential growth rate of machine tool exports during 1980-2005 reveals that the growth rate was significantly higher during the nineties (12 percent) compared to what was recorded in the eighties (7 percent) (see table 1).

Table 1 Growth rates of Machine tool Exports

Period	Growth Rate
1980-91	6.6**
1991-05	11.9**

** Significant at 5 percent level

Since machine tools are complex and heterogeneous, it is important to know the product profile of its exports. Therefore, we categorized the available trade statistics into some major groups and find out its corresponding share in total export of machine tool from India. We first categorized machine tools into two major sub categories, namely metal cutting and metal forming machines (see table 2). We can see that Indian machine tool export is primarily concentrated in metal cutting variety. But during the nineties its share has shown a sharp decline. In 1980s, the export of metal cutting machines was 55 percent, which declined to 45 percent in 1990 to 20 percent in 2000 and further to14 percent in 2005. Metal-forming machines, which was only 7 percent in the eighties increased marginally to 9 percent in 2000 and 10 percent in 2005.

Table 2 Share of Metal cutting and Metal Forming Machines in India's Machine tool Exports (%)

Year	1986	1992	1994	1996	1998	2000	2004	2005
MC	52.78	40.57	36.66	26.73	23.83	19.51	14.79	13.56
MF	3.57	11.4	7.4	8.75	9.05	9.01	10.72	10.48

Note: MC= Metal Cutting Machine tools, MF= Metal Forming Machine tools.
Source: Own calculation based on SITC Rev 2, code 7361, 7362, UN COMTRADE.

Table 3 provides information regarding machine tool export according to different types. We can see that lathes, milling machines and grinders share has reduced considerably over the years. On the other hand, the shares of tool holders and accessories have increased. Also, the share of forging, hammering and die-casting machines has shown a marginal rise. But, on the whole the export basket has not shown any radical shifts. Indian tool basket is primarily consisting of low to medium

technology intensive products. Although the share of CNC in total export increased from 6.9 percent in 1989 to 9.1 percent in 1997, it has declined since then and reached 3.2 percent in 2005 (see table 4).

Table 3 Machine tool export composition (Share in %)

Year / Products	1989	1992	1994	1996	1998	2001	2005
Lathes	21.3	15.8	11.9	8.1	8.7	7.6	6.2
Drilling/ Boring	2.87	3.51	2.62	5.55	2.15	1.47	2.75
Milling	14.47	8.06	5.66	6.59	4.80	3.37	0.87
Grinding, Sharpening & Honing, Lapping	6.22	7.33	5.23	4.12	3.21	4.07	1.93
Shaping, Broaching, Gear Cutting, Sawing	1.41	6.56	11.47	2.67	4.08	2.99	3.02
Forging, Hammering, die-stamping	6.58	11.40	7.40	8.75	9.05	11.47	10.48
Machining centre, single/multistation	1.0	0.1	0.1	0.6	0.3	1.0	0.9
Parts and accessories for machine tools	27.4	27.8	25.6	34.7	42.3	50.2	55.0

Source: Own calculation based on SITC rev 3, and HS 1992; UNCTAD, COMTRADE.

Table 4 Share of CNC machines in total machine tool Exports (%)

Year	1989	1991	1993	1995	1997	1999	2001	2003	2005
Share	6.9	6.9	6.5	4.5	9.1	2.3	3.2	3.5	3.2

Source: Own calculation based on SITC rev 3, UNCTAD COMTRADE online database

If we look at the direction of machine tool exports we can see that during the early nineties the demand for machine tools suffered due to the collapse of USSR. Developing countries share continued to decline till 1998, thereafter it increased marginally (see figure A2 in the appendix). One of the significant trends in export destination is that since mid 1990s, Indian export is catering towards OECD countries. The share of OECD has increased from 32.6 percent in 1993 to 48.5 percent in 2005. During 1999-01 the share was within 50-to55 percent range. The share is almost stable over the years and recent period have shown an increasing trend. The share of developing countries has remained around 30-20 percent over the years. This indicates that since mid 1990s, rise in export is largely driven by demand from advanced developed countries.

An examination of individual countries share shows that, over the year's ten countries namely, USA, UAE, Germany, Belgium, Italy, Singapore, china, Indonesia, Bangladesh, Sri Lanka accounts for the largest consumer of Indian tools. There too, five countries (USA, UAE, Germany, Belgium and Italy) accounted for more than 40 percent of the total export supplied. For instance, during 1993, these countries had a share of 33 percent, which rose to 44 percent in 2005. The major type of machines that

India supply to these countries are of simple variety such as capstan turret, central lathe, die casting and tool holders and machine tool accessories (Exim Bank, 1996).

In order to supplement the above findings, an examination of the nature of market diversification (concentration) of machine tool trade during 1993-05 is made on the basis of Hirschman (H) index of concentration. Countries were clubbed into three main groups, OECD, OPEC and developing countries and in some cases the sub groups have also reported. The H index is based on the following formula[ii].

$$H_i = \sqrt{\left(x_i / X_t\right)^2}$$

Here, x_i / X_t is the share of group i in India's total export of machine tools. A lower index signifies market concentration and vice versa. The results are reported in table 5.

Table 5 Export Concentration Index (1993-05)

Year	1993-96	1996-99	1999-02	2002-05
I. O E C D	0.780	0.990	1.000	0.910
a) E U	0.280	0.420	0.490	0.470
b) North America	0.440	0.450	0.440	0.380
c) Asia & Oceania	0.050	0.140	0.070	0.060
II. O P E C	0.380	0.280	0.260	0.270
III. Developing Country	0.510	0.440	0.470	0.520
a) Asia	0.370	0.320	0.310	0.310
b) Africa	0.140	0.110	0.150	0.200

Source: Same as figure: A2

The result reveals that India's export basket is not diversified over the years and is concentrated towards advanced regions. At the disaggregate level; Indian tools are catering towards EU. The market of machine tool export has been fairly constant in OPEC and Asia in the developing region. This may be an indication of the nature of comparative advantage and specialisation pattern of Indian tools. Since machine tools have large diversity, no country is 100 percent self-sufficient in its production. Countries that are moving to technology superior products may find it uneconomical to produce machines, which are relatively simple and labour intensive. Most of the OECD countries are on the forefront of technologically superior products, which have higher income elasticity and better prospects for long-term growth. Therefore, they demand simple products and accessories from developing countries like India and China.

With this background, let us examine what factors determine India's machine tool exports during 1980-2005.

2. 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. From an econometric point of view, the elasticities approach is based on estimating the import and export demand functions and to verify whether Marshall- Lerner- (Robinson) conditions holds. 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.

Essentially, there are two divergent 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 export performance. The second view stresses the irrelevance of relative prices and the relative merit of world demand. The former emphases the influence of supply capabilities while the latter on external demand conditions. The same disagreement can be found in some of the empirical exercises. The econometric investigations also have failed to reach a consensus regarding the relative merit of demand and supply side factors. According to Sinha Roy (2004) these divergent results arise due to misspecification of the model, different econometric techniques used and period of study. A summary of some important empirical works on export determination in India is provided in table 6.

The literature surveyed clearly shows that Indian export is influenced by a variety of demand and supply side factors. This shows that any empirical work on India's export performance have to consider this otherwise the results may be biased. The literature also indicates that there are hardly any studies on determinants of India's export at industry level. An understanding of the influence of demand and supply factors at disaggregate level is useful since most often export performance at aggregate level may mask sector specific variations. Moreover, most of the studies at disaggregate level have confined to a period where Indian manufactures main concern was to meet the demand from domestic market. This has changed since economic liberalisation as meeting the external demand is considered as a feasible strategy for industrial development.

Table 6 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 is 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.

2.1 Determinant of Machine Tool Export- Demand and Supply Factors

For the analysis purpose, we have converted the nominal export value into constant price series i.e., machine tool export is expressed in real value term [iii]. This is done through deflating the nominal value of machine tool export by the unit value index of machine tool export[iv]. The unit value is obtained by dividing its export value by quantity. The construction of unit value index is based on Paasche index. The base year of the unit value index 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.

2.1.1 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. Therefore in our analysis we have included these two

variables. The significant price variable affecting export competitiveness is relative price of exports and the scale variable is world demand or income.

a) Real Effective Exchange Rate (REER)

In international market, Indian machine tool producers face competition from domestic manufacture in the importing country as well as producers from rest of the world. Here, 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[v].

Generally, there are two methods of calculating REER. One is based on purchasing power parity theory (the traditional method) and the other is based on the distinction between tradable and non-tradable goods (the modern approach)[vi]. We have used the modern approach for the empirical analysis 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 good industries at the world level[vii]. e is the exchange rate of the domestic economy with respect to the trading partners economies calculated in terms of numerate as the SDR. One shortcoming of this definition is that it takes into account only bilateral trade. Hence, 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 for India's machine tool export is also influenced by condition prevailing in the world market. In a protected regime, it was believed that the nature of demand from advanced countries might not be conducive for the growth prospects of Indian machine tools. Therefore export activity was largely neglected. As mentioned earlier this has changed since trade liberalisation as it is believed that every nation can find something worthwhile to produce and sell in the international market. We earlier noted that Indian machines are catering towards advanced OECD countries.

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[viii]. 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, as a proxy for world demand we have used the total world export of capital goods. This will indicate the rate of expansion of different markets and the distribution of India's export of machine tools into these markets (Goldar, 1989).

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[ix]. 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 good 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.

2.1.2 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 infinite supply elasticity. It is generally argued that the supply capability depends upon the development strategy adopted by the government (Sinha Roy, 2004). On the supply side, we can identify the following variables, which can have major impact on Indian machine tool exports.

a) Relative Price (RP)

In 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*[x].

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

Since most of the studies on Indian export have not reached a consensus on the importance of relative prices, several studies have taken some non-price factors into account. In the case of Indian tools one significant factor is domestic demand pressure. When domestic demand pressure increases selling at home market becomes more profitable than selling abroad. Also, domestic demand signifies the effect of cyclical change, which is a basic feature of this industry. 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[xi]. 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)

Another key factor affecting the supply capability is the technological capability. 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 (Amsden, 1985). 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[xii]. In Indian context, R&D intensity indicates not only innovative effort but also minor product changes to suit local demand as well as quality improvements. 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[xiii].

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[xiv]. 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.

3. 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).

3.1 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[xv].

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.[xvi]. As a result, we cannot relay 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[xvii]. 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

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

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

The logarithmic transformation of the model gives

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

Since equation 5 is specified in logarithms, $\alpha_1 + \alpha_2$ and α_3 are (relative) price and income elasticites of machine tool export demand. In the estimation, we expect $\alpha_1 < 0$, $\alpha_2, \alpha_3 > 0$.

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

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

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

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

In a log linear form,

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

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.

In equilibrium, $\quad MTEX^d_t = MTEX^s_t = MTEX_t$

For empirical estimation we will use OLS for equation (2) and 3SLS for equation (5) and (8). 3SLS involves the application of generalized least square estimation to the system of equation. 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 (Pindyck and Rubinfeld, 1991). 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).

4. 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 7.

Table 7 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)[xviii]. 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 8 (a) and 8 (b).

Table 8 (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 8 (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 8 (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 8(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

Finally, a look at the price elasticities of machine tool exports reveals that exports have been significantly responsive on the demand side (see table 9).

Table 9 Price Elasticity of Machine tool Exports

Price Elasticity of Demand	-2.1
Price elasticity of supply	1.5

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.

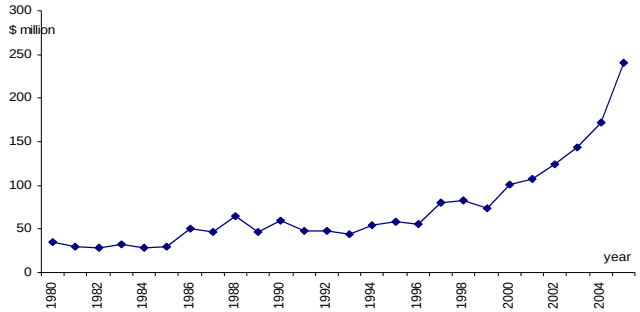
5. Conclusion

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 export performance has to be understood by properly delineating various demand and supply side factors. Most of the empirical studies on India's exports failed to address this issue and used single equation estimation procedure. In contrast, the present study used a simultaneous equation framework and estimated the model using 3SLS.

The empirical findings reveal the predominance of demand side factors like world demand and real exchange rate in influencing machine tool exports. Among the supply variables, the influence of skilled workforce and domestic price was found to have significant influence while the export price and domestic demand was found to be insignificant. The analysis also shows that trade liberalisation has acted as a major instrument through correcting the distortion in real exchange rates. Given the demand condition, a better export performance of machine tools depends upon maintaining a competitive price level and improving its technological capabilities.

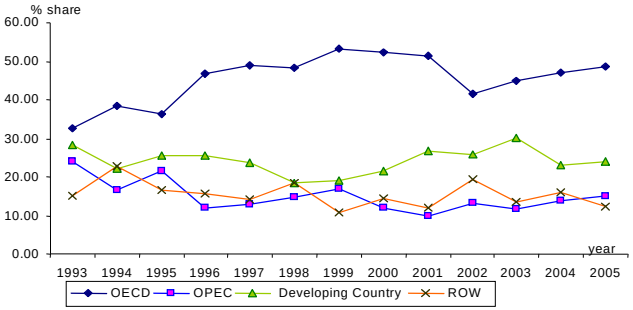
Appendix

Figure A 1 Machine tool Export (1980-2005)



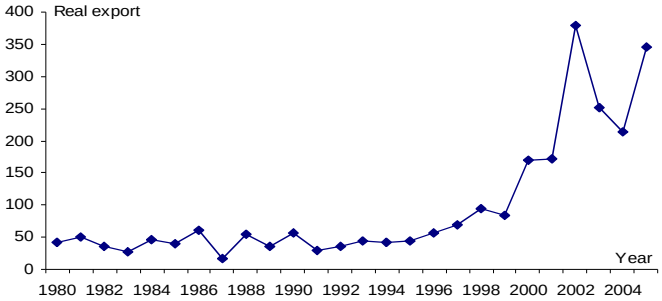
Source: Own calculation based on UN COMTRADE.

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



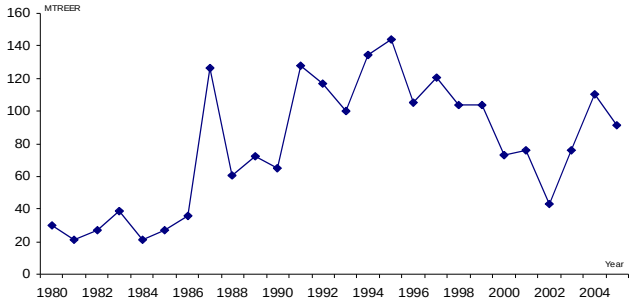
Source: Own calculation based on UN COMTRADE and CMIE, Foreign trade Review.

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



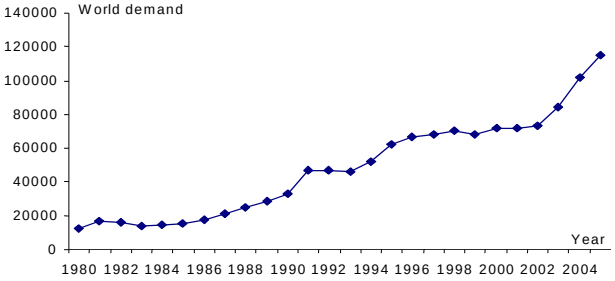
Source: Own calculation based on UN COMTRADE.

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



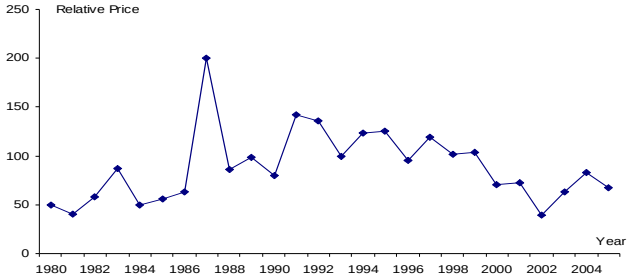
Source: Own calculation based on Statistical Yearbook UN COMTRADE, and DGCI&S.

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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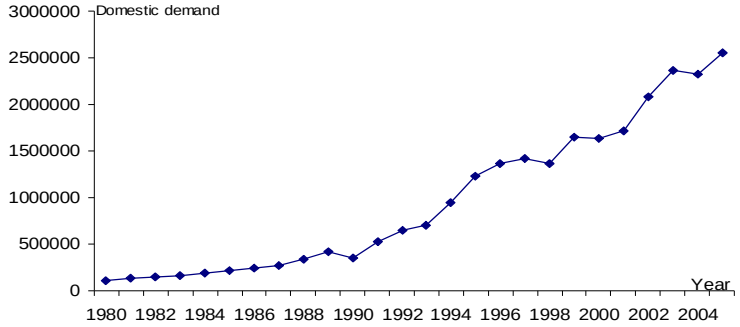
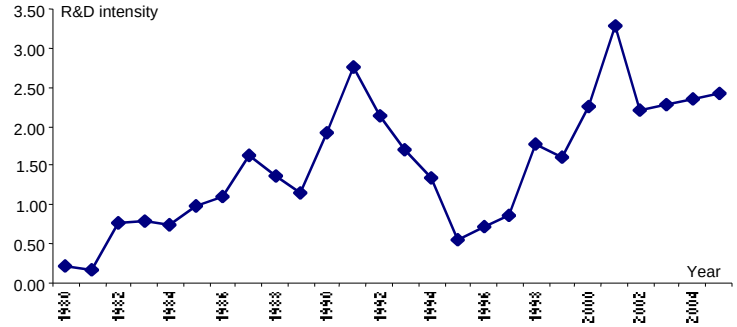
Figure A 7 Domestic Demand



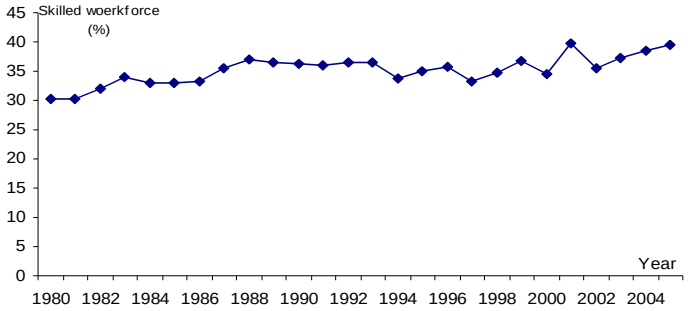
Source: Own calculation from Annual Survey of Industries, CSO.

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

i For a description of the development of Indian export prior to 1991, see Dua, (1992), Suvrathan (1991), Mathews (1988).

ii The calculation of the index is based on Bernard *et al* (2003).

3 We can use the value of export as the depended variable as the volume price elasticity of demand is equal to the value elasticity minus one (See Goldstein and Khan, 1985).

iv 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.

v 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.

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

vii 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.

viii 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).

ix 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.

x 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.

xi 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.

xii 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.

xiii 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.

xiv 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.

xv See Houthakker and Magee (1969) and Goldstein and Khan (1985)

xvi 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).

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

xviii 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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